Revista Românească pentru Educație Multidimensională
ISSN: 2066-7329 | e-ISSN: 2067-9270
Abstracting & Indexing | Clarivate Analytics - Web of Science (WoS); EBSCO; Google Scholar; ICI Journals Master List - Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Philpapers; KVK; WorldCat; CrossRef; J-GATE

2025, Volume 17, Issue 2, pages: 712-731 | https://doi.org/10.18662/rrem/17.2/1002
Submitted: March 27, 2025 | *Accepted for publication:* May 2, 2025

Examining Stuttering in Preschool Children from the Perspective of Speech Therapy and Neurology

Nataliia VASYLIEVA [1]
Tetiana MARIEIEVA [2*]
Liudmyla ZAHORODNIA [3]
Valeriia MELIKHOVA [4]
Yaryna TANIAVSKA [5]
Oksana DZHUS [6]

[1] PhD of Biology, Associate Professor, Department of Physical Therapy and Occupation Therapy, Kherson State University, Kherson, Ukraine; https://orcid.org/0000-0002-7104-1737; nataliavasileva85@gmail.com
[2] Candidate of Pedagogical Sciences (PhD), Associate Professor, Department of Preschool Pedagogy and Psychology, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Hlukhiv, Ukraine; https://orcid.org/0000-0002-5664-4070; mareeva.tan@gmail.com
[3] Doctor of Pedagogical Sciences, Full Professor, Head of Preschool Pedagogy and Psychology Chair at Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Hlukhiv, Ukraine; https://orcid.org/0000-0002-2217-1041; l.zagorodnya69@gmail.com
[4] Candidate of Pedagogical Sciences, Associate Professor, Department of Special Pedagogy at Kherson State University, Kherson, Ukraine; https://orcid.org/0000-0002-1105-849X; valeriyav28@gmail.com
[5] Candidate of Pedagogical Sciences, Associate Professor, Department of Pedagogy and Psychology of Preschool and Special Education, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine; https://orcid.org/0000-0003-4270-878X; y.taniavska@chnu.edu.ua
[6] Doctor of Pedagogical Sciences, PhD (Pedagogy), Professor, Head of the Department of Speech Therapy and Innovative Technologies in Inclusion Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine; https://orcid.org/0000-0001-9363-689X; dzhus1.oksana@gmail.com
* corresponding author: mareeva.tan@gmail.com

Abstract: *Stuttering is a speech disorder that can be completely remedied. Its elimination requires active intervention and the consistent application of all necessary measures. Achieving fluent speech in preschoolers with stuttering is a complex and specialized process. The success of speech therapy for children depends on close cooperation among parents, preschool teachers, and speech therapists. This article highlights that the systematic and structured development of coherent speech in preschool children enables them to easily and quickly select appropriate words, articulate thoughts, and speak without pauses or interruptions. Such practices help strengthen proper pronunciation and minimize the risk of stuttering recurrence under adverse conditions. The article also emphasizes the potential of tele-speech therapy as a tool for delivering remote speech therapy services. Finally, it explores key aspects of neurological, psychotherapeutic, and speech therapy approaches to overcoming stuttering in children, along with the conditions required for effective intervention.*

Keywords: *speech disorders, children, speech tempo and rhythm, speech therapy support, types of stuttering, causes of stuttering.*

How to cite: Vasylieva, N., Marieieva, T., Zahorodnia, L., Melikhova, V., Taniavska, Y., & Dzhus, O. (2025). Examining stuttering in preschool children from the perspective of speech therapy and neurology. *Revista Românească pentru Educație Multidimensională, 17*(2), 712-731. https://doi.org/10.18662/rrem/17.2/1002

Introduction

Stuttering is caused by spasms in the muscles of the speech apparatus, leading to disruptions in speech tempo and rhythm. The speech apparatus consists of the respiratory system and diaphragm, the vocal system (including the vocal cords as its primary muscle), and the articulatory system, which includes the lips, tongue, soft palate, and other organs. The spasms responsible for stuttering can occur in different parts of the speech apparatus. In some children, these spasms are localized in the articulatory system, while in others, they affect the vocal or respiratory systems. Based on the nature of the spasms that arise during speech communication, stuttering is classified into three types: clonic, tonic, and mixed.

According to Costa and Kroll (2000), stuttering is defined as a disruption in the normal flow and timing of speech. Developmental stuttering, the most common form, occurs gradually in childhood and is unrelated to acquired brain injury. Persistent stuttering refers to cases where the condition does not resolve spontaneously or through speech therapy. Research also points to a significant genetic component in stuttering. Neuroimaging studies and the observed efficacy of dopamine receptor antagonists suggest that stuttering may have a hyperdopaminergic origin. At the same time, speech therapy remains the primary treatment for stuttering, though in some cases, antidepressants may offer additional benefits.

Organic theories of stuttering emphasize incomplete lateralization or abnormal cerebral dominance (Sander & Osborne, 2019). Chang et al. (2008) view stuttering as a developmental speech disorder that affects approximately 5% of children, with about 70% experiencing spontaneous remission. They also found that adults with persistent stuttering demonstrate deficits in left-hemisphere white matter and reversed right-left brain asymmetry compared to fluent speakers (Chang et al., 2008; 2009). These findings suggest similar developmental differences may exist in children at risk of stuttering (Wager & Smith, 2003).

In children with persistent stuttering, reduced functional activity was observed in left-hemisphere white matter pathways supporting motor control of the face and larynx. However, unlike adults with stuttering, children (both with active stuttering and those in remission) did not show increased activity in right-hemisphere speech areas or differences in right-left asymmetry (Foundas et al., 2013). Instead, stuttering risk in childhood was associated with reduced left grey matter volume, while persistent stuttering was linked to decreased white matter integrity in the left-hemisphere speech system (Mongia et al., 2019).

The anatomical enlargement of right-hemisphere structures observed in adults with stuttering is likely a result of lifelong stuttering rather than an inherent developmental feature. These findings emphasize the role of neuroplasticity in brain development and its significance in understanding persistent developmental disorders in adults (Demchenko et al., 2021; Sarancha et al., 2021).

Sander and Osborne (2019) identify childhood-onset fluency disorder, the most prevalent form of stuttering, as a neurological condition caused by anomalies in brain function that disrupt speech fluency. This condition can have significant psychosocial impacts, including negative self-image, adverse perceptions from others, anxiety, and, in some cases, depression. It affects 5% to 10% of preschool-aged children. Early diagnosis is vital, enabling timely intervention while the brain's compensatory mechanisms are still developing. Early therapy can reduce the likelihood of associated challenges such as social anxiety, impaired social skills, maladaptive coping strategies, and negative attitudes toward communication. Nevertheless, stuttering can persist despite early intervention, affecting approximately 1% of adults (Chesters et al., 2018).

For individuals with persistent stuttering, speech therapy aims to establish effective coping techniques and eliminate ineffective secondary behaviours. Family physicians play a key role in identifying stuttering early, facilitating access to speech therapy, and supporting patients in managing the emotional and social effects of the disorder. Healthcare professionals, such as paediatricians, speech-language pathologists, neurologists, and family physicians, can also serve as advocates by creating supportive clinical environments. They can further support individuals who stutter by educating teachers, coaches, employers, and others about the nature of stuttering and the specific difficulties these individuals face. Early intervention can reduce secondary effects such as social anxiety and impaired social skills (Yairi & Ambrose, 2013).

In addition, the educational context of this study highlights that speech disorders, particularly stuttering in preschoolers, are not only medical or speech therapy issues. They are also significant factors affecting the quality of the educational process in preschool institutions.

Children between the ages of 3 and 6 undergo intense speech, social, and emotional development. At this stage, the presence of stuttering can lead to difficulties in communication with peers and educators. It may also result in lowered self-esteem and limit the child's active participation in educational activities.

Research into the mechanisms behind the onset of stuttering, from both speech therapy and neurological perspectives, makes it possible to

develop effective educational strategies. These strategies include the implementation of adaptive speech therapy programmes within the educational process, the creation of individualised development plans, and the integration of neuropsychological approaches into teaching practices. Together, these measures help to create an inclusive educational environment that meets current standards in pedagogy and child psychology.

Therefore, the findings of this article have direct practical value for teachers, speech therapists, caregivers, and other professionals working in preschool education. They offer deeper insight into speech disorders and support the development of effective educational interventions aimed at the full integration of children who stutter into the learning environment.

In conclusion, stuttering in preschool children is both a neurological and therapeutic challenge, requiring detailed study and a multidisciplinary approach to ensure effective management and support.

Stuttering as a complex developmental issue in children

Stuttering is a complex speech disorder that affects the fluency and rhythm of speech. It usually appears as repeated sounds or syllables, prolonged sounds, or involuntary pauses during speaking. According to the neurophysiological model of speech production, stuttering can result from disrupted interaction between brain areas responsible for speech planning and motor coordination (Chang, 2014). This disorder most often emerges in early childhood, typically between the ages of two and five, and can lead to ongoing challenges in communication.

Stuttering often includes frequent pauses, hesitations, or disruptions in speech. These features can make it difficult for a child to engage effectively with others. Many children who stutter also experience co-occurring motor or cognitive difficulties. These may include problems with coordinating rhythmic movements or with executive functions such as planning and attention (Behas et al., 2019; Weber-Fox et al., 2013). In some cases, involuntary movements, such as tics or gestures, may also occur. Children often use these movements to mask speech blocks or to make speaking easier.

The manifestation of stuttering can vary depending on the linguistic structure of a given language. In tonal languages such as Chinese, stuttering tends to occur more frequently at the onset of syllables or during tone transitions. This differs from Germanic languages, where disfluencies are typically observed at the beginning of words (Chou et al., 2015). These patterns highlight the language-specific nature of stuttering and suggest that its expression is influenced by the phonological characteristics of each language.

Research involving Cantonese speakers who stutter has shown no significant correlation between stuttering and specific lexical tones. This indicates that the tonal properties of Cantonese do not impose additional strain on the speech-motor system. In contrast, features such as syllabic stress in Western languages may increase motor demands during speech production. Consequently, therapeutic approaches originally designed for English speakers, such as speech restructuring, can be effectively adapted for speakers of tonal languages such as Cantonese. Importantly, such adaptations can be implemented without altering how tone is addressed in therapy (Law et al., 2018).

Stuttering can manifest differently in multilingual children, depending on the language. This variation depends on factors such as the context in which the language is used, the level of proficiency in each language, the emotional tone of the situation, and the grammatical complexity of the utterance. Research has shown that some children stutter in only one of their languages while speaking fluently in others. This points to language-specific variability in symptoms. It also emphasizes the need to analyze each language separately when diagnosing and creating a therapeutic approach (Howell et al., 2009).

The causes of stuttering remain a subject of ongoing scientific discussion. Some researchers focus on neurological and genetic factors, while others highlight social and environmental influences, such as family communication style or early speech stimulation (Yairi & Ambrose, 2013). Combining these approaches provides a more complete understanding of stuttering. It is seen as a disorder influenced by the complex interaction of biological, psychological, and social factors (Sasisekaran & Basu, 2017).

In addition to speech disruptions, children who stutter often exhibit other associated symptoms, such as difficulties in the tempo-rhythmic organization of motor skills (Behas et al., 2019; Sheremet et al., 2019). Involuntary movements, tics, or gestures may also appear, which help the child conceal speech pauses and regulate the rhythm of their speech. Over time, children become psychologically fixated on their speech difficulties, potentially developing a fear of speaking, known as logophobia, by the end of preschool age.

Stuttering can be categorized based on its underlying causes into neurotic, neurogenic, or organic types. While the external manifestations of stuttering are similar, the causes and therapeutic approaches differ for each type (Bloodstein et al., 2021).

Neurogenic stuttering typically emerges suddenly and intensely, often associated with heightened emotional sensitivity and early speech

development that outpaces typical age norms. These children rapidly expand their vocabulary, develop grammatical structures in their speech, and exhibit increased verbal activity, good auditory memory, and quick memorization of poems. At the age of three, children experience development in the coordination of speech movements, alongside the formation of verbal thinking. During this sensitive period, language development is particularly vulnerable (Ward, 2010).

Disruptions in the tempo-rhythmic organization of speech may be triggered by emotional and motor overexcitement. The likelihood of stuttering developing in an excitable child with strong language development is much higher than in a calm, slow-paced child. Stuttering can also emerge due to overly strict parenting, excessive demands placed on the child, or language loads that exceed their developmental stage. In some cases, stuttering can be a result of imitating speech pauses from another child or from persistent attempts to force a left-handed child to switch to their right hand. This can lead to an accelerated speech tempo and pauses, which may become ingrained and evolve into stuttering (Smith & Weber, 2017).

Neurogenic stuttering in children typically develops gradually in response to delayed speech development. This group of children often experiences general language delays, with a slow increase in vocabulary, delayed development of sentence construction, and significant difficulty in forming grammatical structures in their native language (Junuzovic-Zunic et al., 2021). These children may also have reduced auditory memory. Both the speech delay and the stuttering stem from a common cause, namely, perinatal damage to the nervous system. Stuttering is likely to emerge when the child begins to form more complex phrases (Eslami Jahromi et al., 2022a).

Organic stuttering results from brain damage that occurs either prenatally, during birth, or at later stages of the child's life. Some forms of stuttering can be hereditary. This type of stuttering tends to progress steadily without relapses or exacerbations. In cases of organic stuttering, logophobia (fear of speaking) does not typically develop. The child is generally unaffected by their stuttering, and it does not impede their ability to communicate.

The therapeutic-pedagogical approach to overcoming stuttering is divided into two components. The first one focuses on therapeutic and health-improving measures, carried out by a doctor. These include administering specialized medications, prescribing therapeutic procedures, physical therapy, and others. The second one involves corrective pedagogical intervention, where all participants, including the child's parents, are involved. Speech therapists and psychologists play a central role in the correctional work. Regular logorhythmic exercises are essential. Preschool teachers also

participate in psycho-pedagogical interventions, following recommendations from speech therapists, psychologists, and doctors.

A study conducted in Norway found that educators are often the first to notice stuttering in children. They also play an active role in ongoing observation and support. However, fewer than 15% of educators have access to clear guidelines for working with these children. This underscores the need for greater awareness and professional training (Kefalianos et al., 2022).

To implement the second block in a broader context, it is crucial to understand the speech therapy and neurological mechanisms behind stuttering in preschoolers. This knowledge is essential for organizing an effective educational process in preschool institutions. Specifically, an understanding of the neurophysiological aspects of speech development allows educators to accurately assess a child's needs and adapt learning tasks to suit their abilities.

From a speech therapy perspective, assessing the extent of impairment in speech rhythm, pace, and articulation helps in selecting appropriate interventions. These may include speech therapy games, relaxation exercises, breathing techniques, and methods focused on improving speech rhythm. For instance, commonly used practices involve rhythmoplastic exercises, breathing exercises, and logorhythmics – an approach that combines speech with movement to promote coordination between the brain's hemispheres.

In the neurological context, understanding the role of the central nervous system in regulating speech is essential. Stuttering is often associated with dysfunction in the motor centres of the cerebral cortex or interhemispheric asymmetry. This understanding forms the basis for incorporating neuropsychological games and tasks aimed at developing motor skills, attention, and cognitive flexibility. These tasks are integrated into the educational process, particularly for children in corrective groups.

In preschool education, the following approaches are actively used for children with speech disorders (see Table 1).

Table 1. Educational strategies for preschoolers with speech disorders

Approach/Programme Title	Description
Inclusive Education	Adapting the learning environment and providing individual pedagogical support for the child.
Early Speech Development Programme for Preschoolers	Integrating speech therapy sessions into the educational process.
Speech Therapy Rhythmic Exercises	Combining speech therapy exercises with music therapy and movement activities.
Corrective-Developmental Classes	Delivered collaboratively by a speech therapist, educator, and psychologist to ensure holistic support for the child.

Source: the authors' own conception

Applying these approaches helps create a comfortable environment for children with speech disorders. This allows them to develop alongside their peers. It also reduces anxiety and improves their success in learning educational material.

Stuttering, one of the most persistent and severe speech disorders, affects not only speech but also various other aspects of a child's life, such as their somatic, neurological, psychological, motor, and personal development.

Khan et al. (2016) examined the effect of aerobic exercises on stuttering, using a treadmill and stationary bike alongside speech therapy sessions. Stuttering often leads to depression, anxiety, behavioural issues, social isolation, and communication difficulties in daily life. The combined approach of aerobic exercise and traditional speech therapy offers the most effective rehabilitation for stuttering.

Sommer et al. (2021) were the first to assess the prevalence of speech disorders in the population using data from medical insurance statistics. A notable increase in the prevalence of speech disorders occurred between 2015 and 2018, with a similar rising trend observed in stuttering. Treatment for stuttering peaked at 6 years of age, the typical age for starting school, with a second peak in the prevalence of stuttering emerging later.

This suggests that stuttering in preschoolers may be an underrecognized issue. Moreover, global factors such as changes in diagnostic criteria, access to medical care, and environmental conditions may contribute to a higher rate of detection.

Speech therapy intervention for stuttering

Speech therapy for stuttering requires regular and systematic sessions over a prolonged period. This approach helps improve speech fluency and reduce stuttering. Therapy should begin with simple exercises that do not disrupt the rhythm of speech and gradually progress to more complex activities in real-life situations.

One effective method for treating stuttering is the use of rhythm exercises in speech therapy. These exercises combine movements and games set to music, with the child required to speak during the activity. This helps develop general motor skills, speech motor skills, coordination, teamwork, and a sense of rhythm and tempo. Additionally, it reduces stiffness and tension while improving the child's attention.

Several speech therapy techniques are used to address stuttering. Language development in this approach follows several stages: 1) the first stage is the preparatory or organizational phase, where children learn to behave appropriately in a group and listen to the calm, concise speech of the therapist; 2) the second stage involves supporting speech, where children perform tasks while simultaneously speaking; 3) the third stage is the final speech phase, where children describe the completed task; 4) the fourth stage involves preliminary speech, where the child discusses what they are about to do; 5) the fifth stage focuses on reinforcing independent speech skills, incorporating all types of speech developed in the previous stages.

Contextual speech therapy, where speech is guided by visible objects or actions, often proves effective for individuals who stutter. When children interact with items or activities, they can easily name what they see or do, as the objects and actions naturally prompt their labels. Over time, visual aids are gradually removed, and children's speech becomes more complex, progressing from short phrases and simple sentences to extended and intricate speech. This method strengthens their ability to speak fluently without relying on visual cues.

Under current conditions, exploring correction methods has proven effective in helping preschool children overcome stuttering. The importance of this process is supported by a thorough comparison and analysis of different speech therapy models. For this reason, the authors of this article have selected two frameworks for examination: the biopsychosocial model of speech and the cognitive-behavioural model of therapy (see Table 2).

Table 2. Comparison of speech therapy models

Comparison criteria	Biopsychosocial model	Cognitive-behavioural model
Approach	Holistic and interdisciplinary	Psychological and analytical
Therapy focus	External and internal factors affecting fluency	Thoughts, emotions, and behaviours
Teletherapy mechanisms	Reduces stress and provides social support	Changes thinking patterns and helps overcome fear
Online format advantages	Less stress, familiar setting	Safe environment for addressing anxiety
Drawbacks	Requires involvement of multiple specialists	May overlook biological or social influences
Recommended age group	Suitable for all age groups	Most effective for children and adolescents
Strengths	Offers a comprehensive understanding of stuttering. Highlights how external factors, such as home environment and parental support, affect therapy outcomes.	Helps address psychological barriers to fluency. Provides clear tools for self-regulation and independent practice.

Source: the authors' own conception

The biopsychosocial model views speech as the outcome of interaction among three key components: biological, psychological, and social. Fluency issues arise when the balance between these components is disrupted.

In the context of teletherapy, this model has specific implications: a) *biological aspect* (online sessions reduce physical strain and stress, which may improve muscle control during speech); b) *psychological aspect* (being in a familiar environment, such as the home, helps lower anxiety levels and can positively affect speech fluency); and c) *social aspect* (regular communication with a therapist via video calls supports the development of communication skills and encourages social inclusion).

The cognitive-behavioural model focuses on how speech fluency is influenced by thoughts, beliefs, and behaviour. Difficulties often stem from fear, negative automatic thoughts, and avoidance patterns.

Teletherapy within this model offers tools to address these challenges through a) *reframing* (helping children replace negative thoughts about their speech with more constructive ones); b) *exposure* (gradually introducing speech situations in a safe setting to reduce fear), and c) *homework* (assigning speaking tasks between sessions to build confidence). An added benefit of online sessions is the ability to record them for self-reflection and progress tracking.

Thus, teletherapy aligns well with both models. If a specialist emphasizes comprehensive child support (including parental involvement, emotional state, and physiological aspects), the biopsychosocial model is more appropriate. If the focus is on overcoming speech-related fears and building confidence, the cognitive-behavioural approach is more suitable.

Eslami Jahromi et al. (2022a) conducted a study to evaluate the effectiveness of tele-speech therapy in treating stuttering. The research involved patients from two rehabilitation centres who participated in therapy sessions via Skype. The findings revealed a 13.8% reduction in stuttering, with 56.6% of participants expressing "high" or "very high" satisfaction with the treatment. This study demonstrated that tele-speech therapy is an effective method for improving speech fluency and reducing stuttering across diverse demographics, including age, gender, and educational backgrounds.

In a separate study, Eslami Jahromi et al. (2022b) examined the advantages and challenges of tele-speech therapy as perceived by stuttering patients and their parents. Among the identified benefits were access to highly skilled therapists across various locations, quicker treatment initiation, and significant time and cost savings. However, the study also highlighted several challenges, including limited technological infrastructure, low-quality video and audio, inefficient communication, insufficient empathy, indirect interactions, and technical incompetence. Despite these obstacles, participants expressed strong interest in tele-speech therapy, emphasizing its ability to enhance accessibility and provide opportunities to select the most suitable therapists. This method offers a promising alternative for managing stuttering and improving speech therapy outcomes.

Boyle (2011) highlighted that effective long-term treatment for stuttering often requires addressing cognitive and emotional factors alongside behavioural components. Mindfulness practices can help reduce avoidance behaviours, enhance emotional regulation, and promote acceptance. Additionally, mindfulness practices improve sensory-perceptual processing and attention regulation, which are critical for the long-term success of stuttering treatment on both psychosocial and sensorimotor levels.

Madeira et al. (2013) introduced the "I Aware My Stuttering" project, which focuses on a smartphone application designed for individuals who stutter. This application allows users to log stuttering-related situations, including the context, the people involved, their reactions, and the user's emotions. It features a reporting module with visual charts to track how stuttering episodes evolve across different variables. This personalized approach helps users monitor and manage their stuttering frequency based on their unique profiles. The application also includes a patient monitoring

feature for speech therapists, enabling them to track progress and tailor therapy accordingly. Together, these tools support the speech recovery process by addressing specific challenges faced by individuals with speech disorders.

Tele-speech therapy services and mobile applications improve access to therapeutic interventions, especially for children and families in remote or underserved areas. Using remote formats reduces the need for frequent visits to specialists, which helps improve adherence to treatment plans. Tele-technologies ensure that speech therapy services continue even when in-person sessions are not possible, such as during pandemics, illness, or travel. This supports steady progress toward achieving therapeutic goals. Mobile applications are designed with children's developmental needs in mind. They include game-like features, visual stimuli, and interactive tasks, which increase a child's engagement in exercises. The playful format encourages repeated practice, an essential part of skill development. Digital tools allow therapists to tailor therapy programmes to meet the individual needs of each child. Built-in monitoring features enable specialists to adjust the intensity and content of sessions in real-time and track the child's progress.

Using mobile and telecommunication technologies also reduces overall treatment costs. This is due to fewer in-person visits, reduced transportation expenses, and less need for additional childcare.

Most mobile applications offer interactive modules for parents. These modules help raise awareness and encourage active involvement in at-home tasks. This approach supports the family-centred care model and ensures that therapeutic skills are transferred to the child's everyday environment.

The neurological perspective on stuttering

According to Chang (2014), over the past two decades, neuroimaging studies have uncovered significant structural and functional brain differences in individuals who stutter. These include atypical asymmetry in the planum temporale, reduced white matter integrity in the left hemisphere (particularly in the arcuate fasciculus), and overactivation in right-hemisphere regions during speech tasks (Ward, 2010; Chang et al., 2009). These discoveries reinforce the understanding that stuttering is a neurological condition. However, most research has focused on adults who stutter, whose brains and behaviours may have developed compensatory adaptations, interpreting findings more complex. Stuttering is believed to result from underdevelopment of the nervous system, resembling a neurodevelopmental disorder, with symptoms appearing more frequently in males than females.

Recent research has shifted toward studying children who stutter, using advanced neuroimaging techniques to explore the functional neuroanatomy and interaction of key brain regions. These studies reveal distinctions between children who stutter and age-matched peers without speech disorders. For example, Chang et al. (2008) found reduced white matter integrity in the left hemisphere's arcuate fasciculus, which plays a critical role in auditory-motor integration during speech. Similarly, the scholars reported atypical activation patterns in children who stutter, with overactivation in right frontal areas and underactivation in left perisylvian regions during speech tasks (Chang, 2014; Chang et al., 2009). Neuroimaging data highlight the roles of neuroplasticity and sex-related differences, which influence speech disorders and offer insights into predicting their future development.

Longitudinal studies suggest that some children exhibit normalization of neural activity as fluency improves, reflecting compensatory mechanisms of brain development (Chang & Zhu, 2013). Additionally, sex-related differences have been documented: boys show greater deviation in neural connectivity related to speech-motor control, which may partly explain the higher prevalence of stuttering in males (Yairi & Ambrose, 2013).

The initial application of electroencephalography (EEG) can be observed in this study, where Vasil'yeva and Shmalei (2013) investigated the coherence of EEG oscillations across multiple frequency bands in preschool boys with neurosis-like stuttering compared to typically developing peers. EEG recordings, taken during rest, revealed heightened electrical activity in the deep brain structures of boys with stuttering. In contrast, healthy boys exhibited fewer coherent connections in the delta frequency range and lower theta coherence between symmetrical regions of the right and left hemispheres. These findings further support the neurological basis of stuttering and provide a foundation for understanding its development. For example, research has revealed that preschool children with neurotic-like stuttering show distinct brain activity patterns compared to their healthy peers. Specifically, these differences occur in frequency ranges linked to speech function and motor control. Such variations suggest an imbalance in the neural networks responsible for speech fluency. This highlights that stuttering is not merely a behavioural problem but also a complex neurological condition.

Weber-Fox et al. (2013) investigated the neural activity underlying semantic and syntactic processing in 27 preschool children who stutter and 27 peers who do not stutter, matched by age, nonverbal IQ, and language abilities. All participants exhibited language skills and non-verbal IQ within the typical range. Event-related potentials (ERPs) were recorded as the children watched cartoons and listened to naturally spoken sentences that

were either grammatically correct or contained semantic or syntactic errors. This study was the first to demonstrate that differences in ERPs related to language processing are evident as early as preschool age. It also provided initial evidence that the atypical lateralization of language functions, previously observed in adults who stutter, begins to emerge at the onset of stuttering development.

Vasil'yeva (2020) also explored changes in the brain's electrical activity in boys with varying tempo-rhythmic speech characteristics during functional tasks. The study employed photostimulation, a method involving rhythmic light flashes at specific frequencies. Using computer electroencephalography (EEG), the research analyzed the neural activity of the brain. The results indicated a reduced response to photostimulation in preschool children who stutter, which was attributed to insufficient inhibitory control of the cerebral cortex over developing subcortical brain structures. This was accompanied by reduced reactivity and functional limitations in the activating system of the brainstem. Such disruptions in speech tempo and rhythm during stuttering created additional strain on neural regulatory mechanisms. These findings were supported by distinct patterns of brain electrical activity observed both during tasks and in a resting state.

Guntupalli et al. (2006) argued that any effective and reliable long-term evaluation of intervention methods must incorporate self-reporting as a key tool. This is because self-reports provide direct insight into the experience of "loss of control" and other hidden behavioural aspects. To complement or enhance self-report data, open measures should be used. Traditionally, therapeutic effectiveness has been measured by counting visible stuttering instances such as repetitions and prolongations. However, stuttering is a complex peripheral speech disorder, as evidenced by neuroimaging studies. The disruption in speech tempo and rhythm observed in stuttering suggests involuntary neural blockages originating centrally. Additionally, unnatural speech patterns, reduced fluency, increased free speech fluency in clinical settings, and unreliable stuttering counts make overt measurements in clinical environments more difficult.

Craig (2003) pointed out that stuttering, which typically begins in early childhood, is a developmental disorder affecting the speech-motor nervous system. It results in involuntary speech disruptions, which can vary in severity depending on emotional status or the surrounding environment. Stuttering often becomes more ingrained and severe as individuals transition into adolescence and adulthood, making it harder to treat. People who stutter often learn to manage their speech and adapt to their condition. However, they may experience social anxiety and fears, which can hinder their access to education

and career advancement. The latest psychological methods and techniques are available to help those who stutter alleviate the psychological distress associated with the disorder.

Ward (2010) explored the relationship between psychogenic and neurogenic stuttering. The study underscored the challenges in differentiating between the two types of stuttering.

Thus, stuttering is a complex condition with both negative and, at times, positive effects. This disorder can lead to personality changes and interfere with communication among peers. Stuttering is a multifaceted condition that requires a new multidisciplinary approach to speech therapy and correction.

In today's neurorehabilitation, non-invasive brain stimulation methods, such as transcranial direct current stimulation (tDCS), are actively researched. This technique involves applying a weak electrical current to the scalp, which helps modulate neural activity in the cerebral cortex. In the case of stuttering, tDCS targets speech-motor areas, particularly the left premotor cortex and Broca's area, to improve speech fluency (Chesters et al., 2018). Preliminary results suggest a reduction in stuttering frequency and greater effectiveness of speech therapy. However, further clinical studies are needed before this technology can be widely implemented.

The detailed study of stuttering-related challenges in children also highlights the potential benefits that can arise from this condition. Stuttering is not only a challenge but also an opportunity to develop important skills and qualities that can benefit individuals throughout life. For example, it can lead to the development of resilience, adaptability, and better communication skills in other areas.

People who stutter often develop specific coping mechanisms that help them manage speech difficulties. They may discover new ways to express their thoughts and feelings through non-verbal communication, such as gestures and facial expressions. This enables them to maintain effective communication despite challenges with speech fluency.

The experience of dealing with stuttering can also foster deep empathy. Many people who stutter face social challenges, which helps them better understand the difficulties others encounter, including those with different language or social barriers. Additionally, the need to adapt to stuttering challenges encourages the development of self-awareness, as individuals learn to understand their own emotions in communication contexts.

In response to the difficulties of stuttering, people may develop unique communication strategies to assist them in challenging social situations. They can become particularly adept at non-verbal communication,

allowing them to maintain effective interaction even without full fluency in speech. This flexibility is valuable in various professional and social contexts.

Finally, people who stutter often become stronger in self-advocacy and self-expression. They learn to assert their rights and interests while overcoming the social stereotypes that often accompany stuttering. This helps build stronger self-esteem and a greater ability to stand their ground in society.

Conclusions

Stuttering in preschool children is a complex disorder that requires a thorough, multidisciplinary approach to diagnosis and treatment. The disorder disrupts speech rhythm and tempo due to spasms in the muscles involved in speech production. It is influenced by both genetic and neurodevelopmental factors, with neuroimaging studies revealing significant differences in the brain structures of children who stutter. These structural differences, such as reduced grey matter and impaired white matter integrity, highlight the neurological basis of stuttering and underscore the importance of early intervention to harness neuroplasticity and support recovery.

Effective treatment must be personalized, taking into account the type of stuttering, whether neurotic, neurogenic, or organic. Speech therapy is a key component of treatment, involving structured exercises to improve fluency, alongside cognitive and emotional support to address the psychological impact of stuttering. The involvement of parents, speech therapists, preschool teachers, and psychologists is crucial to creating a supportive therapeutic environment that not only improves fluency but also helps reduce emotional challenges, such as social anxiety and maladaptive coping mechanisms, which are common in children who stutter.

The integration of the latest technologies, including teletherapy, has been shown to improve access to treatment and enhance its effectiveness. Research indicates that teletherapy can significantly reduce stuttering and increase patient satisfaction, even with some technological limitations. This approach is particularly valuable for families in remote areas, offering flexibility and high-quality care. Additionally, the use of mindfulness techniques and tools such as smartphone applications to track stuttering episodes offers valuable support, promoting self-monitoring and providing therapists with personalized data to better guide treatment.

Physical health interventions, including aerobic exercises, also play a beneficial role in treating stuttering. These interventions help address the physical and psychological aspects of the disorder, improving speech motor skills, reducing anxiety, and promoting overall well-being.

Policy on the use of artificial intelligence tools

The authors of this article confirm that generative AI tools were not used in creating the content of this manuscript, developing its scientific concept, or analyzing and interpreting data. All theoretical concepts, conclusions, and scientific findings presented in the article are the result of the authors' independent intellectual work.

References

Behas, L., Maksymchuk, B., Babii, I., Tsymbal-Slatvinska, S., Golub, N., Golub, V., Chepka, O., Lemeshchuk, M., Dychok, M., Nikitenko, A., Sarancha, I., & Maksymchuk, I. (2019). The influence of tempo rhythmic organization of speech during gaming and theatrical activities on correction of stammering in children. *Journal of Physical Education and Sport*, *19*(4), 1333–1340. https://www.efsupit.ro/images/stories/august2019/Art%20193.pdf

Bloodstein, O., Ratner, N. B., & Brundage, Sh. B. (2021). *A handbook on stuttering.* Plural Publishing.

Boyle, M. P. (2011). Mindfulness training in stuttering therapy: A tutorial for speech-language pathologists. *Journal of Fluency Disorders, 36*(2), 122–129. https://doi.org/10.1016/j.jfludis.2011.04.005

Chang, S. E. (2014). Research updates in neuroimaging studies of children who stutter. *Seminars in Speech and Language*, *35*(2), 67–79. https://doi.org/10.1055/s-0034-1382151

Chang, S. E., Erickson, K. I., Ambrose, N. G., Hasegawa-Johnson, M. A., & Ludlow, C. L. (2008). Brain anatomy differences in childhood stuttering. *NeuroImage, 39*(3), 1333–1344. https://doi.org/10.1016/j.neuroimage.2007.09.067

Chang, S. E., Kenney, M. K., Loucks, T. M., & Ludlow, C. L. (2009). Brain activation abnormalities during speech and non-speech in stuttering speakers. *NeuroImage, 46*(1), 201–212. https://doi.org/10.1016/j.neuroimage.2009.01.066

Chang, S. E., & Zhu, D. C. (2013). Neural network connectivity differences in children who stutter. *Brain: A Journal of Neurology, 136*(Pt12), 3709–3726. https://doi.org/10.1093/brain/awt275

Chesters, J., Möttönen, R., & Watkins, K. E. (2018). Transcranial direct current stimulation over left inferior frontal cortex improves speech fluency in adults who stutter. *Brain: A Journal of Neurology, 141*(4), 1161–1171. https://doi.org/10.1093/brain/awy011

Chou, F. C., Zebrowski, P., & Yang, S. L. (2015). Lexical tone and stuttering loci in Mandarin: Evidence from preschool children who stutter. *Clinical Linguistics*

& Phonetics, 29(2), 115–130. https://doi.org/10.3109/02699206.2014.966393

Costa, D., & Kroll, R. (2000). Stuttering: An update for physicians. *CMAJ: Canadian Medical Association Journal, 162*(13), 1849–1855. https://pubmed.ncbi.nlm.nih.gov/10906923/

Craig, A. (2003). Clinical psychology and neurological disability: Psychological therapies for stuttering. *Clinical Psychologist*, *7*(2), 93–103. https://doi.org/10.1080/13284200410001707543

Demchenko, I., Maksymchuk, B., Bilan, V., Maksymchuk, I., & Kalynovska, I. (2021). Training future physical education teachers for professional activities under the conditions of inclusive education. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 12*(3), 191–213. https://doi.org/10.18662/brain/12.3/227

Eslami Jahromi, M., Ahmadian, L., & Bahaadinbeigy, K. (2022a). The effect of tele-speech therapy on treatment of stuttering: Disability and rehabilitation. *Assistive Technology, 17*(1), 34–39. https://doi.org/10.1080/17483107.2020.1754475

Eslami Jahromi, M., Farokhzadian, J., & Ahmadian, L. (2022b). Two-sided perspective on tele-speech therapy: Experiences of stuttering patients, and their parents. *Assistive Technology, 34*(6), 717–724. https://doi.org/10.1080/10400435.2021.1937378

Foundas, A. L., Mock, J. R., Corey, D. M., Golob, E. J., & Conture, E. G. (2013). The SpeechEasy device in stuttering and nonstuttering adults: Fluency effects while speaking and reading. *Brain and Language, 126*(2), 141–150. https://doi.org/10.1016/j.bandl.2013.04.004

Guntupalli, V. K., Kalinowski, J., & Saltuklaroglu, T. (2006). The need for self-report data in the assessment of stuttering therapy efficacy: Repetitions and prolongations of speech. The stuttering syndrome. *International Journal of Language & Communication Disorders, 41*(1), 1–18. https://doi.org/10.1080/13682820500126627

Howell, P., Davis, S., & Williams, R. (2009). The effects of bilingualism on stuttering during late childhood. *Archives of Disease in Childhood, 94*(1), 42–46. https://doi.org/10.1136/adc.2007.134114

Junuzovic-Zunic, L., Sinanovic, O., & Majic, B. (2021). Neurogenic Stuttering: Etiology, Symptomatology, and Treatment. *Medical archives (Sarajevo, Bosnia and Herzegovina)*, *75*(6), 456–461. https://doi.org/10.5455/medarh.2021.75.456-461

Kefalianos, E., Guttormsen, L. S., Hansen, E. H., Hofslundsengen, H. C., Næss, K. B., Antypas, K., & Kirmess, M. (2022). Early childhood professionals' management of young children who stutter: A cross-sectional study.

American Journal of Speech-Language Pathology, 31(2), 923–941. https://doi.org/10.1044/2021_AJSLP-21-00148

Khan, I., Nawaz, I., & Amjad, I. (2016). Effect of aerobic exercises on stuttering. *Pakistan journal of medical sciences*, *32*(4), 1005–1009. https://doi.org/10.12669/pjms.324.9351

Law, T., Packman, A., Onslow, M., To, C. K., Tong, M. C., & Lee, K. Y. (2018). Lexical tone and stuttering in Cantonese. *Clinical Linguistics & Phonetics, 32*(4), 285–297. https://doi.org/10.1080/02699206.2017.1359851

Madeira, R. N., Macedo, P., Pita, P., Bonança, Í., & Germano, H. (2013). Building on mobile towards better stuttering awareness to improve speech therapy. In R. Mayrhofer, L., Chen, M. Steinbauer, G. Kotsis, & I. Khalil (Eds.), *Proceedings of International Conference on Advances in Mobile Computing & Multimedia (MoMM '13)* (pp. 551–554). Association for Computing Machinery. https://doi.org/10.1145/2536853.2536911

Mongia, M., Gupta, A. K., Vijay, A., & Sadhu, R. (2019). Management of stuttering using cognitive behavior therapy and mindfulness meditation. *Industrial Psychiatry Journal, 28*(1), 4–12. https://doi.org/10.4103/ipj.ipj_18_19

Sander, R. W., & Osborne, C. A. (2019). Stuttering: Understanding and treating a common disability. *American Family Physician*, *100*(9), 556–560. https://pubmed.ncbi.nlm.nih.gov/31674746/

Sarancha, I., Maksymchuk, B., Gordiichuk, G., Berbets, T., Berbets, V., Chepurna, L., Golub, V., Chernichenko, L., Behas, L., Roienko, S., Bezliudna, N., Rassskazova, O., & Maksymchuk, I. (2021). Neuroscientific principles in labour adaptation of people with musculoskeletal disorders. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, *12*(4), 206–223. https://doi.org/10.18662/brain/12.4/245

Sasisekaran, J., & Basu, S. (2017). The influence of executive functions on phonemic processing in children who do and do not stutter. *Journal of Speech, Language, and Hearing Research, 60*(10), 2792–2807. https://doi.org/10.1044/2017_JSLHR-S-17-0033

Sheremet, M., Leniv, Z., Loboda, V., & Maksymchuk, B. (2019). Stan sformovanosti smart-informatsiynoho kryteriyu hotovnosti fakhivtsiv do realizatsiyi inklyuziyi v osviti [The development level of smart information criterion for specialists' readiness for inclusion implementation in education]. *Informatsiyni tekhnolohiyi i zasoby navchannya* [Information Technologies and Learning Tools]*, 72*, 273–285. https://journal.iitta.gov.ua/index.php/itlt/article/view/2561

Smith, A., & Weber, C. (2017). How stuttering develops: The multifactorial dynamic pathways theory. *Journal of Speech, Language, and Hearing Research, 60*(9), 2483–2505. https://doi.org/10.1044/2017_JSLHR-S-16-0343

Sommer, M., Waltersbacher, A., Schlotmann, A., Schröder, H., & Strzelczyk, A. (2021). Prevalence and therapy rates for stuttering, cluttering, and developmental disorders of speech and language: Evaluation of German health insurance data. *Frontiers in Human Neuroscience, 15*, Article 645292. https://doi.org/10.3389/fnhum.2021.645292

Vasil'yeva, N. (2020). Neirofiziolohichni mekhanizmy lohonevrozu u ditei doshkilnoho viku pry funktsionalnykh navantazhenniakh [Neurophysiological mechanisms of logoneurosis in preschool children during functional stress]. *Nauka i osvita* [Science & Education], *3*, 13–19. http://dspace.pdpu.edu.ua/handle/123456789/10380?locale=uk

Vasil'yeva, N. O., & Shmalei, S. V. (2013). Coherent relations in ongoing encephalograms of preschool boys with neurosis-like stammering. *Neurophysiology, 45*, 468–476. https://doi.org/10.1007/s11062-013-9396-z

Wager, T. D., & Smith, E. E. (2003). Neuroimaging studies of working memory: A meta-analysis. *Cognitive, Affective & Behavioral Neuroscience, 3*(4), 255–274. https://doi.org/10.3758/cabn.3.4.255

Ward, D. (2010). Sudden onset stuttering in an adult: Neurogenic and psychogenic perspectives. *Journal of Neurolinguistics, 23*(5), 511–517. https://doi.org/10.1016/j.jneuroling.2009.06.001

Weber-Fox, C., Hampton Wray, A., & Arnold, H. (2013). Early childhood stuttering and electrophysiological indices of language processing. *Journal of Fluency Disorders*, *38*(2), 206–221. https://doi.org/10.1016/j.jfludis.2013.01.001

Yairi, E., & Ambrose, N. (2013). Epidemiology of stuttering: 21st century advances. *Journal of Fluency Disorders, 38*(2), 66–87. https://doi.org/10.1016/j.jfludis.2012.11.002