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**REVIEW ARTICLE**

# Narrative Review on Cognitive Difficulties in Children with Agenesis of the Corpus Callosum and Its Impact on Learning

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## Abstract

Agenesis of the corpus callosum (ACC) is a rare congenital neurological condition. The absence of the corpus callosum, the major commissural pathway that interconnects the left and right hemispheres, leads to a wide range of interconnected cognitive difficulties. This narrative review synthesises the recent evidence to identify cognitive difficulties and their impact on learning among children with ACC. Peer-reviewed empirical studies published in English between 2015 and 2025 were identified using a combination of keywords related to condition, outcome, and target population through electronic databases, including Google Scholar and PubMed. The review examined studies focused on cognitive and learning difficulties in individuals under 18 years of age with ACC. The exclusion criteria were non-English secondary or grey literature, employed adult or mixed samples, and non-cognitive medical outcomes published outside the period from 2015 to 2025. A total of 12 studies met the requirements and were synthesised thematically to identify patterns, categorise cognitive domains, and summarise key findings. The review highlighted difficulties in higher-order cognition, memory and attention, language and communication, inhibitory control, and social cognition as key cognitive difficulties in children with ACC. Delayed attainment of educational milestones, divergence from mainstream education, and deficits in collaborative learning dynamics were identified as the impact of cognitive difficulties on learning among children with ACC. These findings underscore the importance of understanding ACC-related cognitive difficulties and their impact on learning among educational stakeholders to inform effective interventions, create student-friendly learning environments, and support both social and academic integration for neurodivergent children.

***Keywords:*** agenesis of corpus callosum, cognitive difficulties, impact on learning

# 1 | Introduction

The corpus callosum (CC) is the largest white matter structure and commissural pathway. It is located beneath the cerebral cortex, arching over the lateral ventricle within the medial longitudinal fissure (Goldstein et al., 2017; Mooshagian, 2008). This large C-shaped structure contains over 200 million axons and functions as the primary commissural pathway (Goldstein et al., 2017; Mooshagian, 2008). It facilitates interhemispheric communication by transmitting cognitive, motor, and sensory information between left and right cerebral hemispheres (Goldstein et al., 2017; Mooshagian, 2008). The CC expands rapidly during infancy. Its development is complete by age 4, with growth continuing at a much slower rate until nearly 30 years of age (Goldstein et al., 2017; Mooshagian, 2008). The anomalies in the formation of the CC connectivity during gestation result in agenesis of the corpus callosum (ACC) and can be identified as four main versions: partial or complete, and isolated or complex (Edwards et al., 2014; Paladini et al., 2013; Paul, 2011; Paul & Brown, 2016; Rotmensch et al., 2020; Wu & Chen, 2024). ACC is a rare congenital cerebral malformation. The prevalence estimate is approximately 1 in 4,000 live births, which is roughly equivalent to 2.5 per 10,000 births (Ballardini et al., 2018; Guadarrama-Ortiz et al., 2020; Paul et al., 2007).

Developed countries in the West, such as Canada (Tsai & Shinar, 2023) and Italy (Chiappedi & Bejor, 2010), and the East, such as Japan (Miki et al., 2016) and China (Zhou et al., 2015), have conducted empirical studies and effective interventions due to early identification of ACC through advanced neurological facilities. A study conducted in Canada highlighted key components of ACC for child-expectant parents (Tsai & Shinar, 2023). It specifically highlighted the genetic nature, highly variable prognosis, and the importance of genetic testing, fetal Magnetic Resonance Imaging (MRI), and multidisciplinary counseling associated with early identification of ACC (Tsai & Shinar, 2023). Furthermore, the importance of rehabilitative interventions and counseling was highlighted by a study conducted in Italy (Chiappedi & Bejor, 2010). It emphasised effective interventions, including physiotherapy, speech therapy, neuropsychological support, and targeted training areas such as cognitive rehabilitation and social skill training in children with ACC (Chiappedi & Bejor, 2010). Similarly, a case report from Japan highlighted the importance of multidisciplinary evaluation and long-term follow-up for ACC complicated with ocular albinism (Miki et al., 2016). It further emphasised the genetic basis of the condition and visual impairments associated with multi-system developmental abnormalities (Miki et al., 2016). A study in China highlighted similar findings, underscoring the sensitivity of ACC-associated congenital factors and the requirement for long-term follow-up (Zhou et al., 2015). Conversely, developing countries in Asia, such as Pakistan, have reported small-scale cohort studies due to limited neurological facilities (Rashid et al., 2025). These emphasised the greater severity and poorer cognitive outcomes of complete ACC and the relatively favourable prognosis of partial ACC (Rashid et al., 2025). However, they have failed to emphasise the importance of neuropsychological interventions and follow-ups compared to the studies from developed countries. Despite a wealth of global epidemiological data, empirical studies in Sri Lankan literature remain limited. ACC has been identified incidentally during assessment of comorbidities (Ekneligoda & Perera, 2022; Gamage, 2022; Seneviwickrama et al., 2023). A recent case report describes an 18-year-old male patient with complete ACC and benign hydrocephalus who presented to the Teaching Hospital, Karapitya, Sri Lanka (Samaranayake et al., 2025). It further emphasised the importance of early diagnosis and the necessary interventions for ACC (Samaranayake et al., 2025).

Locally, due to subtle clinical presentations, misdiagnosis, and limitations of neuroimaging, children with ACC may initially be identified only when cognitive difficulties emerge during schooling (Samaranayake et al., 2025). Cognitive difficulties are impairments across domains of cognition, including memory, attention, language, communication, planning, reasoning, perception, comprehension, and decision-making, ranging from mild to severe (Dhakal & Bobrin, 2023). Due to the rarity and limited literature of ACC, a potential knowledge gap may exist among educational stakeholders such as teachers, child and educational psychologists, policy-makers, and curriculum

developers, leading to academic displacements, persistent social stigma, and missed opportunities for children.

This narrative review is guided by two main research questions: What cognitive difficulties can be identified among children with ACC? How do these difficulties impact their learning and academic performance? Two main research objectives drive the current narrative review. First, to synthesise existing research evidence to identify the cognitive difficulties, and secondly, to describe the impact of cognitive difficulties on learning in children with ACC.

### *Significance of the Study*

This review is significant for educational stakeholders, such as teachers, child and educational psychologists, educational policymakers, and curriculum developers. For teachers, understanding cognitive difficulties can inform appropriate instructional strategies and the development of tailored educational plans and structures for children with ACC. For psychological professionals, current research highlights the importance of effective interventions that address the particular cognitive impairments, thereby supporting both academic and social integration. Educational policymakers and curriculum developers can use this knowledge to design student-friendly learning environments, resources, facilities, and teacher training programs that accommodate the needs of neurodivergent children.

## 2 | Methods

A literature search was conducted through the following two major electronic databases: Google Scholar and PubMed. The main search concepts were related to the condition (‘corpus callosum agenesis’, ‘ACC’, and ‘callosal abnormalities’), outcomes (‘cognitive domains’, ‘impairments’, ‘difficulties’), and the targeted population (‘children’, ‘adolescents’, and ‘school-age’). Boolean operators (and/or) were applied to refine the search results. The inclusion criteria comprised peer-reviewed journal articles published from 2015 to 2025, including children, adolescents, and school-age juveniles diagnosed with ACC, empirical research (case reports and cohort studies) reporting cognitive and learning difficulties in ACC, and articles available in English. The exclusion criteria focused on non-English secondary or grey literature, presenting non-cognitive medical outcomes, published outside the period from 2015 to 2025, and employing adult or mixed populations. The search initially identified 98 articles. After removing duplicates and screening titles and abstracts, 31 full-text articles were assessed for eligibility. The 12 studies that met the inclusion and exclusion criteria were synthesised for the current review. In the initial stage of the screening process, title screening was conducted to exclude studies not relevant to the scope of the current study. In the second stage, the abstracts of the remaining articles were reviewed to ensure that the search remained within the inclusion and exclusion criteria. Finally, the full-text review was conducted to confirm final eligibility, assess methodological quality, extract detailed data, and synthesise findings. A narrative literature review approach was used to synthesise findings. Data from the selected studies were extracted, and key information was synthesised into thematic categories. The findings were coded and categorised based on recurring concepts and outcomes, and codes were grouped into broad themes. This allowed for similar patterns across studies. The identified themes included difficulties in higher-order cognition, language and communication, memory and attention, inhibitory control, and social cognition as the cognitive difficulties in children with ACC. Delayed attainment of educational milestones, divergence from mainstream education, and deficits in collaborative learning dynamics were identified as themes of the impact of cognitive difficulties on learning. They formed the basis of the narrative synthesis presented in the findings

## 3 | Results

### *The Cognitive Difficulties in Children with ACC*

#### *Difficulties in Higher-Order Cognition*

A case study conducted in Italy described a child aged 7 years and 2 months with isolated and complete ACC who demonstrated difficulties with problem-solving, non-literal language, idiom comprehension, and novel sensory-metaphor comprehension (Melogno et al., 2021). The child demonstrated less effective competencies in binding ideas, reduced capacity to build complex interactions among concepts, and generated less accurate and detailed answers (Melogno et al., 2021). A cross-sectional comparative study in Australia included nine children with ACC and a group of typically developing children aged 8-17 years (Siffredi et al., 2018). Nearly half of children with ACC experience academic, executive, intellectual, and behavioural difficulties compared with typically developing children, even when general intellectual ability falls within the normative range (Siffredi et al., 2018). They frequently struggled with tasks that demand cross-model information integration, adaptive reasoning, and flexible problem-solving strategies within novel situations (Siffredi et al., 2018). Their brain anomalies and complete ACC were associated with poor mathematical performance and executive functioning (Siffredi et al., 2018).

Complications in problem-solving, cognitive flexibility, and abstract thinking were identified as major difficulties in higher-order cognition in children with ACC (Melogno et al., 2021; Siffredi et al., 2018). When responding to multistep problems, they got stuck because multiple data integrations were impaired (Melogno et al., 2021; Siffredi et al., 2018). The Tower of London test, a well-known planning and problem-solving task, demonstrated slower planning speed, more rule violations, unnecessary moves, difficulty in holding multiple steps in mind, struggle to anticipate outcomes, and organised actions, and lower overall accuracy in solving problems in children with ACC compared to neurotypical children (Siffredi et al., 2018). This is further supported by Su and colleagues, who demonstrated impaired semantic problem-solving, lower rates of consecutive correct responses, and reduced semantic similarity to target words across things among adults with ACC (Su et al., 2023). It clarifies that these difficulties are not limited to the early stages of brain development but continue into the later stages if effective interventions are not implemented. Collectively, both studies highlighted that children with ACC struggle with complex cognitive tasks and understand abstract concepts. However, while Siffredi and colleagues found academic and cognitive difficulties in broader academic performance, Melogno and colleagues focused on distinct linguistic structural difficulties (Melogno et al., 2021; Siffredi et al., 2018). This may be attributed to sample size and scope: while Siffredi and colleagues looked broadly at a group of school-aged children and tried to map out a general psychological profile across multiple domains, Melogno and colleagues focused on a single case study, which specifically focused on figurative language, which cannot easily generalise to all children with ACC (Melogna, et al., 2021; Siffredi et al., 2018). This highlights a critical research gap in large-scale multi-centre cohort studies to systematically investigate whether above linguistic difficulties associated with higher-order cognitive processes are universal or highly idiosyncratic phenotypes.

### *Difficulties in Language and Communication*

A cohort study investigated language and regular communication operations involving fifteen individuals with ACC aged 8-15 years in Australia (Moser et al., 2024). They demonstrated poor receptive and expressive language along with complete ACC, higher social risk, and lower non-verbal IQ (Moser et al., 2024). A single case report of a 10-year-old girl with complete and isolated ACC in Austria demonstrated associated developmental surface dyslexia and dysgraphia (Bartha-Doering et al., 2024). Although accurate grapheme-phoneme conversion was demonstrated, the reading and spelling of irregular words were impaired (Bartha-Doering et al., 2024). A case report in India focused on a 3-year-old girl who was prenatally diagnosed with complete and complex ACC and demonstrated speech and language impairments, including weak conversational skills, limited vocabulary growth, speech and language delays, and grammar difficulties (Anuroopa & Shinde, 2025).

Although all the above studies have demonstrated significant speech, language, and communication difficulties and highlighted how they affect the ability to handle academic and functional learning tasks, they have investigated distinct dimensions of language and communication. It ranges from identifying

childhood developmental delays to adolescent learning disabilities, which collectively expose broader overarching language dysfunctions in children with ACC. The results demonstrated that these children experienced difficulties in language and communication, especially comprehending figurative language such as idioms, which was congruent with higher-order cognitive difficulties (Siffredi et al., 2018). This is further supported by a previous study, which demonstrated that children with ACC could not easily understand non-decomposable idioms, as the phrases do not contribute to the overall meaning (Huber-Okrainec et al., 2005). For example, interpreting "Don't count your chickens before they hatch" as meaning about chickens instead of the figurative meaning "Don't assume success before it actually happens". Children with ACC demonstrated poor receptive and expressive language skills, as confirmed by both previous studies (Andrews et al., 2019) and later studies (Bartha-Doering et al., 2024). Although comprehension remained within normal limits in many cases, they inherited impaired performance in verbal fluency and naming (Bartha-Doering et al, 2024). The difficulties in nonverbal communication among these children begin in infancy, reflecting blunted emotional expressions and lower vocal reactivity (Turner et al., 2023). These difficulties progress with developmental stages, though they manifest differently at different stages. They often retained core vocabulary and grammar but experienced difficulties in non-literal interpretations, conversational turn-taking, and emotional prosody (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Moser et al., 2024). They demonstrated reading difficulties during the non-word reading task and impairments in writing tasks, including spelling and handwriting errors (Bartha-Doering et al., 2024). However, the above attributions may manifest outwardly as dyslexia (difficulty with reading, writing, and spelling) or dysgraphia (difficulty with writing) due to the overlapping symptomatology (Bartha-Doering et al., 2024). An accurate understanding of the above difficulties and effective interventions is significant in the academic setting. A critical empirical gap is that current literature fails to provide longitudinal data on how extant educational frameworks apply to unique interhemispheric disconnection characteristics of ACC, and characterising distinct neuro-educational requirements of children with ACC.

### *Difficulties in Memory and Attention*

A study was conducted among nine individuals with ACC in Australia to investigate the functional organisation of working memory; participants exhibited altered functional activation patterns during working memory tasks (Siffredi et al., 2017). Instead of the balanced network distribution in neurotypical development, an asymmetric recruitment bias in the hemispheres was identified during slower processing and poor memory functions (Siffredi et al., 2017). A study conducted in France, involving 25 children with ACC to evaluate long-term neurodevelopmental outcomes, indicated that difficulties in academic assessment and working memory deficits became more salient in middle childhood, even though normative development existed earlier (Folliot-Le Doussal et al., 2018). A neuropsychological evaluation involving 38 school-aged children with ACC, conducted in Italy, indicated impaired memory abilities and several frequencies of neurological and neuropsychological impairments, which are significantly observable in the teenage years among participants (Romaniello et al., 2021).

All these studies have tracked the outcomes of isolated ACC, where missing CC is the only primary brain anomaly detected (Paul et al., 2007). They demonstrated that some children with ACC can have typical or near-typical development; others experience clear memory challenges. However, these studies inherit a variety of methodologies, including functional Magnetic Resonance Imaging (fMRI) studies (Siffredi et al., 2017), early clinical prognosis (Folliot-Le Doussal et al., 2018), and long-term follow-ups (Romaniello et al., 2021). Siffredi and colleagues (Siffredi et al., 2017) focused on hidden neurobiological mechanisms; others (Folliot-Le Doussal et al., 2018; Romaniello et al., 2021) have focused on outward functions of memory and attention rather than real-time brain imaging. Results indicated that children with ACC demonstrated impairments in working memory associated with sustaining and manipulating verbal information under distractions (Siffredi et al., 2017). The previous MRI examinations confirmed impaired activation of neural systems, which specialised for verbal encoding and face processing during working memory tasks (Erickson et al., 2014; Paul & Brown, 2016). Adults with ACC exhibit similar difficulties in both verbal and visual memory tasks during

integrating information, as demonstrated by the Wechsler memory scale (Paul & Brown, 2016). As an example, a student with ACC may recall a simple math formula but struggle to recall data to complete a complex math assignment. This underlies the difficulty in recalling the integrated information. These difficulties are not isolated but are interconnected with several cognitive domains (Siffredi et al., 2018). The findings of the California Verbal Learning Test-Children's Version (CVLT-C) demonstrated difficulties with verbal learning, memory, and information recall, indicating challenges in long-term verbal memory retention (Paul & Brown, 2016). These difficulties may hinder academic performance and classroom interactions, where recalling information is essential for engagement and social interactions.

### *Difficulties in Inhibitory Control*

A comparative study conducted in Hungary involving children between 6 and 8 years reported that children with ACC have diminished abilities of mental state understanding, where their own expression and perspective needed to be inhibited (Lábadi & Beke, 2017). A case study in India of a 7-year-old boy with completed ACC and comorbidities demonstrated normal intelligence, with impulsivity resulting in deteriorated academic functioning (Mathur et al., 2023). Another case study in India examined the neurological-cognitive-emotional processes of a 7-year-old girl with partial ACC with comorbidities, who demonstrated inhibition and attentional disengagement (Jacob & Gupta, 2022). A comparative study conducted in Australia used the inhibitory control assessment and brain MRI scans, demonstrating that children with ACC exhibited weaker inhibitory control than neurotypicals, especially when suppressing responses was required (Soon et al., 2024).

Children with ACC often display impulsive responses (actions without forethought) and low vigilance (a state of insufficient attention and alertness), which leads to problems in focus and attention maintenance (Jacob & Gupta, 2022; Lábadi & Beke, 2017; Mathur et al., 2023; Soon et al., 2024). As an example, a student with ACC may begin solving a problem without fully understanding the instructions. Once engaged, students may continue in an incorrect approach and struggle to adjust and correct themselves. They may lose attention after a few minutes, leading to errors, forgetting important steps, or skipping parts of the problem. In addition, they may struggle to wait for their turn in a collaborative task. Attention deficit hyperactivity disorder (ADHD), a neurodevelopmental disorder with persistent inattention, hyperactivity, and impulsivity, has similar behavioural outcomes compared to ACC with neurobiological differences (Jacob & Gupta, 2022; Lábadi & Beke, 2017; Mathur et al., 2023; Soon et al., 2024). Fronto-striatal and frontoparietal circuit dysfunctions, and small striatal and related subcortical volumes, lead to cerebral dysregulation in ADHD, while a cerebral disconnection basically remains with ACC (Cubillo et al., 2012). Without neuroimaging, ACC can hardly be identified, but ADHD is commonly recognised through cognitive behavioural symptoms and treated in standard academic settings (Cubillo et al., 2012). As documented in distinct case studies (Mathur et al., 2023), ADHD features can occur alongside ACC, making it methodologically challenging to isolate where academic dysfunction is a direct expression of ADHD or ACC. Therefore, there is a notable limitation in specialised non-imaging cognitive behavioural screening protocols capable of differentiating ADHD and ACC in academic settings. That leaves educators ill-equipped to recognise the unique neuroeducational needs of children with ACC.

### *Difficulties in Social Cognition*

Children with ACC struggled to interpret external emotional signals and mental states, understand complex interpersonal situations, and figure out the thoughts, beliefs, or emotions of others (Lábadi & Beke, 2017). The inability to suppress egocentric bias (the inability to sidestep one's perspective) led to misinterpretations in social interactions (Lábadi & Beke, 2017). These impairments impacted social functioning. Children with ACC struggled to interpret nonverbal social cues, respond appropriately to others' emotions, and navigate complex social scenarios (Siffredi et al., 2018).

Although children with ACC remain in the normative intelligence range, they struggle in social interactions, displaying empathy, understanding others' emotions, feelings, and thoughts, social cues, and social perspectives, resulting in social withdrawal, misinterpretation of others' intentions, and trouble in forming and maintaining peer relationships (Frith & Frith, 2005). This was further confirmed by previous studies, which demonstrated impaired emotion recognition, sarcasm understanding, appreciation of social norms, and interpretation of social cues in visual versus textual formats with adult participants (Brown et al., 2021; Symington et al., 2010). This further indicates that the above difficulties are developmental and persistent, and are linked to underlying brain structure rather than to age-specific components. These socio-cognitive difficulties overlap with characteristics of autism spectrum disorder (ASD) (a neurodevelopmental disorder with sensory processing, social interactions, and repetitive behaviours), and Down's syndrome (a genetic condition with intellectual disabilities and developmental delays) (Hantzsch et al., 2023; Ryuzo et al., 2014). Although ACC does not directly cause them, there is an association between them, demonstrating parallel symptomatology (Hantzsch et al., 2023; Ryuzo et al., 2014). These similarities, especially relying on observable behaviours, can create major difficulties in accurate diagnosis. In educational settings, teachers and school psychologists may classify children with ACC under broader ADHD or ASD special education frameworks without neuroimaging confirmation. Therefore, these interventions may omit support for callosal-specific processing deficits such as interhemispheric transfer limitations. Consequently, there is a systematic gap in establishing multidisciplinary diagnostic protocols that combine brain imaging techniques such as fetal or postnatal MRI, alongside detailed neuropsychological profiling (Aquino et al., 2025; Palmer & Mowat, 2014; Siffredi et al., 2013). Future empirical research must address how often educational misclassifications exist in educational support systems and identify evidence-based approaches to recognise and assist children presenting with atypical neurodevelopmental trajectories.

## *The Impact of Cognitive Difficulties on Learning in Children with ACC*

### *Delayed Attainment of Educational Milestones*

Children with ACC experience age-related multisystem developmental delays, including difficulties in sensory integration, linguistic skills, and bimanual and basic motor coordination (Anuroopa & Shinde, 2025; Lábadi & Beke, 2017; Mathur et al., 2023). Inability to attain age-related developmental milestones prevents them from reaching educational milestones such as grade retention, which hinders educational goals compared to their typical colleagues (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Lábadi & Beke, 2017; Mathur et al., 2023; Romaniello et al., 2021).

The inability to reach educational milestones within the current academic paradigm is not merely a result of intellectual deficiencies but of unique dimensions of cognition in children with ACC (Siffredi et al., 2018). The educational milestone is a specific benchmark of knowledge, skills, and cognitive abilities tied to academic progress that a student is expected to master at a particular stage in schooling (Kern & Friedman, 2008). Among children with ACC, slow information-processing speed was a primary obstacle in reaching age-appropriate abilities (Bartha-Doering et al., 2024). These children fail to comprehend rapid instructions, leading to pedagogical lag characterised by poor reading fluency, writing, and inability to complete assessments within the stipulated timeframe, similar to children with ASD and ADHD (Jacobson et al., 2013; Kritsotakis & Morfidi, 2025). As the educational curriculum advances, abstract thinking and metaphor use automatically expand (Daniel et al., 2005). However, these children understand concepts through literal interpretations, even at advanced stages of academic development (Moser et al., 2024). They bypass the abstract thinking competencies (Moser et al., 2024) that are typically developed in a neurotypical child during the formal operational stage, which occurs around 10-12 years (Daniel et al., 2005). Therefore, the children with ACC experience difficulties in reaching educational milestones, which impacts their overall education.

### *Divergence from Mainstream Education*

Although children with ACC demonstrated basic educational abilities in preschool, significant weaknesses were noticed at the beginning of primary school (Melogno et al., 2021; Siffredi et al., 2018). Therefore, the transition from mainstream education to specialised education became imperative. Due to not attending the age-appropriate milestones compared to neurotypicals, the deprivation of competitive learning environments was experienced (Melogno et al., 2021; Siffredi et al., 2018). The individualised curriculum, educational accommodations, and rehabilitation programs were required within a specialised environment to reach normative levels (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Lábadi and Beke, 2017; Mathur et al., 2023; Romaniello et al., 2021).

As the children with ACC are unable to reach educational milestones due to the emergence of cognitive difficulties during primary school, they diverge from mainstream education into special education (Anuroopa & Shinde, 2025; Melogno et al., 2021; Siffredi et al., 2018). Therefore, previous studies indicated the importance of individualised curricula, educational accommodations, and rehabilitation programs to reach normative levels (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Lábadi & Beke, 2017; Mathur et al., 2023; Romaniello et al, 2021). The emergence of behavioural problems, experiencing sensory and social overload, rigid teaching methods, strict behavioural policies, and a focus on conformity over accommodation leads to difficulties in surviving within mainstream education (Zahid et al., 2023). The inability to remain competitive with neurotypical children leads to a sense of exclusion among neurodiverse colleagues (Cook, 2024). Therefore, these children necessitate a transition into specialised education. However, that shift encompasses a dual impact. Obtaining individualised education, programs compatible with cognitive level, adequate attention due to a low student-teacher ratio, specialised resources such as speech therapy, occupational therapy, sensory integration, and reduced academic stress provide distinct advantages to these students (Damyanov, 2024). In contrast, loss of peer modeling, stigmatisation and labeling, reduced academic challenges, impairment in social integration, perceived social isolation, and limited higher academic goals represent significant disadvantages (Damyanov, 2024).

### *Deficits in Collaborative Learning Dynamics*

Children with ACC demonstrated unoccupied and solitary play, hitting others due to poor inhibitory control, lagging behind other students in class, and poor social language skills (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Lábadi & Beke, 2017; Mathur et al., 2023; Romaniello et al., 2021). Therefore, impairment in collaborative learning, suboptimal interpersonal interactions, failure to grasp hidden curriculum, and hindrance in practical education were significantly identified (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Lábadi & Beke, 2017; Mathur et al., 2023; Romaniello et al., 2021).

Collaborative work brings several benefits to education, including social constructivism, critical thinking, and social-emotional learning (Ansari & Naseer, 2024). However, children with ACC experienced deficits in collaborative dynamics in typical academic environments (Lábadi & Beke, 2017; Siffredi et al., 2018). They experience social isolation during group-based projects due to difficulties in interpersonal communication (Siffredi et al., 2018). Not only in academic work, but they also lack meaningful relationships with colleagues due to an inability to identify nonverbal cues, which is underlined by pragmatic language impairments (Siffredi et al., 2018). The difficulties with higher-order cognition, such as processing speed and abstract thinking, make it difficult to synthesise multi-dimensional facts that arrive from multiple directions in group projects (Harvey, 2019). This hinders functional parity with neurotypical colleagues in collaborative environments. While the lack of inhibitory control manifests as aggressive behaviour (Mathur et al., 2023), which contributes to social rejection and isolation, unoccupied and solitary play (Anuroopa & Shinde, 2025) manifests in the same way as children with ASD. Collectively, these cognitive impairments hinder social skills and impact the collaborative work that is essential in education.

The current body of research highlighted that children with ACC exhibit widespread impairments across multiple cognitive domains. Evidence retrieved from both paediatric and adult samples indicated that the above impairments are observable not only in the early stages of development but also persist into adulthood. It highlighted that ACC-related impairments are persistent rather than limited to a single developmental stage. Some studies have employed structured activities and standardised tasks (Paul & Brown, 2016) to elicit these impairments in children, and other studies have employed neuroimaging techniques (Siffredi et al., 2017) to reveal altered functional organisations and the neural basis of observed deficits. Importantly, impairment in a single domain was rarely identified; rather, they were interconnected within several cognitive domains. Furthermore, the cognitive impairments in children with ACC frequently overlapped with several neurodevelopmental disorders, leading to complications in assessment and interventions.

### Limitations

The current review successfully synthesised existing research evidence to identify cognitive difficulties faced by children with ACC, including difficulties in higher-order cognition, language and communication, memory and attention, inhibitory control, and social cognition. Subsequently, the review identified and described the impact of cognitive difficulties on the learning of children with ACC, such as delayed attainment of educational milestones, divergence from mainstream education, and deficits in collaborative learning dynamics. The results may be beneficial for educational stakeholders such as teachers, child and educational psychologists, policymakers, and curriculum developers to implement appropriate interventions, teacher training programs, and student-friendly learning environments. Although they have provided valuable insights, several inherent limitations persist. First, the majority were small cohort studies with limited participants (Folliot-Le Doussal et al., 2018; Lábadi & Beke, 2017; Moser et al., 2024; Siffredi et al., 2017; Siffredi et al., 2018; Soon et al., 2024), and others were case reports (Anuroopa & Shinde, 2025; Bartha-Doering et al., 2024; Jacob & Gupta, 2022; Mathur et al., 2023; Melogno et al., 2021). The limited sample size and single-case studies limit the generalisability. In addition, the studies presented with comorbidities such as ADHD (Mathur et al., 2023), dyslexia, and dysgraphia (Bartha-Doering et al., 2024) hinder the understanding of unique conditions to ACC. The majority of studies represent Western culture (Bartha-Doering et al., 2024; Folliot-Le Doussal et al., 2018; Lábadi & Beke, 2017; Melogno et al., 2021; Moser et al., 2024; Romaniello et al., 2021; Siffredi et al., 2017; Siffredi et al., 2018; Soon et al., 2024), which emphasises the need for multicultural data for a comprehensive understanding. While some studies focused on multiple domains of cognition (Folliot-Le Doussal et al., 2018; Jacob & Gupta, 2022; Romaniello et al., 2021; Siffredi et al., 2018), others focused on a single domain (Anuroopa & Shinde, 2025; Melogno et al., 2021; Moser et al., 2024; Siffredi et al., 2017; Soon et al., 2024). Furthermore, the majority of studies demonstrated cross-sectional data (Anuroopa & Shinde, 2025; Lábadi & Beke, 2017; Moser et al., 2024; Siffredi et al., 2017; Siffredi et al., 2018; Soon et al., 2024), instead of two follow-up studies (Folliot-Le Doussal et al, 2018; Romaniello et al., 2021), which limited the understanding of age-related neuroplasticity and the evolution of cognitive difficulties. Finally, unlike a systematic review, the selection and synthesis of the included literature of this narrative review may be subject to author bias.

## 5 | Conclusions

ACC is a rare congenital cerebral malformation. Due to the subtle clinical presentations, missed diagnosis, and scarcity of neuroimaging, this condition is initially identified when cognitive difficulties emerge during schooling. This narrative review was guided by two main research questions: what cognitive difficulties can be identified among children with ACC, and how do these difficulties impact their learning? The identified themes for cognitive difficulties in children with ACC included difficulties in higher-order cognition, language and communication, memory and attention, inhibitory control, and social cognition. Delayed attainment of educational milestones, divergence from mainstream education, and deficits in collaborative learning dynamics were identified as the impact of

cognitive difficulties on learning among children with ACC. The results indicated that the cognitive impairment associated with ACC is not limited to a single domain but is interconnected with several domains. They overlapped with several neurodevelopmental disorders and remained throughout the advanced developmental stages in life. Future researchers should prioritise the following areas to address the existing research gaps. There is a critical need for large-scale cohort studies and long-term follow-ups to monitor neuroplasticity, cognition, and educational fluctuations. Future studies should focus on investigations to distinguish symptoms between ACC and comorbidities such as ADHD and ASD. Given the current scarcity of empirical data within the Sri Lankan context, future studies should expand into multicultural and underrepresented contexts. To better understand specific functional impairments, both multi-domain cognitive assessments and in-depth analysis of single domains should be performed. Finally, the current narrative review underscores the importance of understanding the cognitive difficulties of ACC and their impact on learning for educational stakeholders to develop effective educational interventions, create student-friendly learning environments, and support both social and academic integration.

## Author Contribution:

The sole author was responsible for conceptualization, literature review, analysis, interpretation of the literature, and manuscript writing.

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