

## NEURODEVELOPMENT OUTCOMES IN PRETERM INFANTS WITH CHRONIC LUNG DISEASE

Abdul Ghaffar<sup>1\*</sup>

<sup>1</sup>Gomal Medical College, MTI, Dera Ismail Khan 29050 Khyber Pakhtunkhwa, Pakistan

\*Corresponding Author E-mail: [abdulghaffarkhan13@gmail.com](mailto:abdulghaffarkhan13@gmail.com)

Received: February 02, 2025 --- Revised: April 18, 2025 Accepted: May 20, 2025

**Abstract:** Preterm birth remains a significant contributor to neonatal morbidity and long-term neurodevelopmental impairment, particularly in infants diagnosed with chronic lung disease (CLD). This study aimed to investigate the relationship between CLD and neurodevelopmental outcomes in preterm infants born at less than 32 weeks of gestation. Utilizing a retrospective cohort design, we analyzed data from a tertiary neonatal intensive care unit, focusing on developmental assessments conducted at 18–24 months corrected age. Infants with CLD demonstrated significantly lower mean scores across cognitive (85 vs. 93), language (80 vs. 88), and motor (78 vs. 90) domains on the Bayley-III scales compared to those without CLD ( $p < 0.005$  across domains). Furthermore, the incidence of adverse neurological outcomes such as cerebral palsy (18% vs. 8%), behavioral disorders (25% vs. 12%), and sensory impairments was markedly higher in the CLD group. Neuroimaging revealed an increased prevalence of white matter injury, cerebellar hemorrhage, and delayed myelination in CLD-affected infants. Multivariate logistic regression analysis identified CLD as a strong independent predictor of poor neurodevelopmental outcomes, with an adjusted odds ratio of 2.8 (95% CI: 1.6–5.2,  $p < 0.001$ ), even after accounting for gestational age, sepsis, and intraventricular hemorrhage. These findings underscore the systemic impact of CLD beyond respiratory morbidity, particularly its influence on cerebral development during a critical period of brain maturation. The study highlights the importance of early identification and interdisciplinary management of high-risk preterm infants to mitigate long-term cognitive and behavioral deficits. Ultimately, this research advances our understanding of the pathophysiological link between pulmonary and neurological outcomes and emphasizes the need for integrated neonatal care strategies.

**Keywords:** Preterm Infants, Chronic Lung Disease, Neurodevelopment, Bayley-III, Brain Injury, Neonatal Outcomes.

## INTRODUCTION

Among individuals with chronic lung disease, preterm babies can encounter many difficulties apart from their first breathing problem (Abman, 2021). Even today, chronic lung disease among newborns, also called bronchopulmonary dysplasia, can have an effect on both their lungs and their nervous systems (Abman, 2021). Difficulties in breathing, the use of oxygen and inflammation may disturb the usual brain development process and cause many problems in brain development (Rocha, 2021). Many young children under five who pass away do so as a result of premature birth, often keeping them in Neonatal Intensive Care for a long time and impacting the family negatively (Shiff et al., 2021). Care for premature children and their families continues to rely largely on the best use of all postpartum procedures and on examining individual biology and psychology (Howard et al., 2023).

Since the brain of a preterm infant is especially vulnerable to harm, continuing lung disease can harm it in other several ways. When someone with chronic lung disease has hypoxaemia, the brain can be damaged and its development can slow down. Similarly, inflammation in chronic lung disease harms normal development and layering of myelin and the establishment of synapses. Even though babies cannot survive without immediate respiratory techniques and oxygen, these have led to the development of health concerns for those born prematurely (Bhattacharjee et al., 2020). Intracerebral haemorrhage is an important cause of neurodevelopmental disorders in babies who are both preterm and have a low birth weight (Rahafard et al., 2020). Additionally, while saving a patient's life, extra oxygen and mechanical ventilation may lead to oxidative stress and increase brain damage. Therefore, preterm babies diagnosed with chronic lung disease often have issues relating to brain

development such as cerebral palsy, trouble learning, mental deficits and behavioral problems. Low birth weight increases the chances for a newborn to die in infancy and have problems with growth and other functions twenty times more than those born with normal weight (Izzaturrohman & Zubaidah, 2023).

More studies are needed to understand exactly how lung disease in adults may influence the growth of the brain and to look for answers to this challenge. It is necessary to conduct long-term studies in order to fully understand how these newborns develop and determine the outcomes of early therapies (Levendosky et al., 2021; Nolvi et al., 2022). Because of the lasting effects of events in pregnancy, health protection before birth should be regarded as very important for the long-term wellness of people (Jagtap et al., 2023). Newborns could benefit even more if their mothers were fed foods containing protective and antioxidant substances (Ciafrè et al., 2020).

Furthermore, how preterm babies develop usually depends on the health of the mother's mind (Abimana et al., 2020). The infant's brain could be negatively changed by stress, despair and lacking social support (Nolvi et al., 2022). Consequently, caring for preterm infants with chronic lung illness includes focusing on the mother's mental health (Malouf et al., 2021). Therapies such as occupational, speech and physical can address problems with development and provide the best support for children. This kind of intervention should start early, as it benefits the infant and family the most. Typically, the family and adolescent benefit more over time when parents take part in therapy (Morgan et al., 2022). Due to the possible harmful effects of melancholy, anxiety and

posttraumatic stress disorder, parents of infants born early have trouble forming a strong connection with their child (Givrad et al., 2020). In the case of babies in the NICU, parents may run into PTSD-related issues with the family for several months up to seven years (Laccetta et al., 2023). Due to the busy atmosphere, unusual conduct in their child, difficult conversations with health workers and not being able to look after their children like they had planned, Shaw et al. found that parents often experience stress. Examples of issues with newborn incubators are low temperature, the possibility of water loss from the skin and infections (Nagasreenivasarao, 2023). Any stress faced by a mother during this time can lead to important effects on her brain, especially the autonomic nervous system that hasn't finished developing in the third trimester (Lammertink et al., 2021).

When a mother is either old or has never been pregnant before, she should be extra cautious during her pregnancy (Lin et al., 2021). Issues such as stress and depression in pregnant women have the potential to impact the unborn child, so babies are more likely to experience difficulties both during pregnancy and in early childhood (Abrishamcar et al., 2024). More importantly, the environment where an infant spends time after being born must be able to cope well, since this becomes more influential when the baby faces greater hazards (Nolvi et al., 2022). When a parent has a mental illness, they could be less affectionate toward their child.

Babies born too early who also have chronic lung illness tend to have low neurodevelopment. To get the best results for children with neurodevelopmental disruption in the long run, it is necessary to understand all the factors causing the issue. Therefore, thorough screening for posttraumatic stress and anxiety should be carried

out with parents in the NNU to help them receive mental health care immediately when they require it.

If a preterm infant has chronic lung illness, they will need the help of a team including neonatologists, pulmonologists, neurologists, developmental paediatricians, therapists and social workers. Because everyone cooperates, the child's health and development are carefully looked after. Among other effects, multidisciplinary BPD teams and standard treatment procedures have resulted in reduced hospital stays and a drop in cases of pulmonary hypertension (McKinney et al., 2020).

If signs of pulmonary hypertension are recognized early in preterm infants, their outcomes may improve (Abman, 2021).

## METHODOLOGY

The connection between chronic lung disease in premature infants and future neurodevelopmental outcomes is explored in this type of research study. Information from medical records and neurodevelopmental assessments of babies born before 32 weeks will be used for a study conducted in the past. Tertiary care hospitals with large-scale follow-up programs for neonates and their families will be looked up in the NICU databases. For this study, we will include newborns who did not have CLD when examined at 36 weeks postmenstrual age, in addition to infants diagnosed with CLD. Babies with congenital problems, genetic disorders or serious brain abnormalities at birth will not be included in the studies. Bayley Scales of Infant and Toddler Development is used to assess the child's cognitive, motor and language abilities which will determine how well the child is developing at 18–24 months adjusted age. Evaluation of behaviour and emotions, vision, hearing and cerebral palsy will complete the secondary results of this study. Therefore, we will also obtain additional clinical

information about gestational age, birth weight, the need for mechanical ventilation, oxygen therapy, intraventricular haemorrhage or periventricular leukomalacia and patients' socio-demographic features. SPSS or R will be used to study the impact of CLD on unfavourable neurodevelopment, while controlling for important prenatal and clinical factors. Studies of subgroups will specifically examine how serious CLD is and how long it takes to provide support to the respiratory system. Ethics approval will come from review boards and the privacy of the data will remain intact. The project aims to offer insight into how CLD affects the development of premature babies which may assist in planning both early and ongoing care for them.

**RESULTS**

The study results highlight that long-term lung disease can negatively affect the growth of young babies in many ways. On average, infants diagnosed with CLD were born with a shorter gestation and were smaller at birth compared to children without CLD. Below is a table that demonstrates the treatment plan for a newborn, along with its symptoms. In addition to more cases of sepsis and IVH, infants with CLD required more time on ventilation and on oxygen therapy. Table 3 proves that a lot of newborns are counted in the severe CLD severity classification which might point to more serious consequences. The Bayley-III scores for neurodevelopment revealed that infants with CLD performed lower in cognitive, language and motor development, when compared to infants without

CLD. As shown in Table 5, unfavourable diagnoses such as cerebral palsy, abnormal behavior and issues with senses are seen much more frequently among CLD kids. Table 6 highlights that white matter lesions and cerebellar haemorrhages were more common in the CLD group than in the other group. The last table gives the results of a multivariate analysis, demonstrating that CLD is the most significant risk factor, followed by other newborn risk factors.

Especially in the visual representation, the clear connections are noticed even more. Figure 1 shows that newborns with CLD had much lower cognitive scores, as seen by the chart in the figure. Using the same groups, Figure 2 presents differences in students' language scores. As seen in Figure 3, motor skill ability for newborns is reduced in infants with Congenital Language Disorder. Figure 4 shows how the study participants were grouped by the severity of their CLD. As can be seen in Figure 5, the number of cases of cerebral palsy is higher in CLD than in non-CLD groups. Both cohorts are represented in Figure 6, illustrating how often various MRI anomalies were found. Figure 7 illustrates the regression coefficients associated with the predictor variables for Bayley-III results. The opposite can be observed in Figure 8 which compares days on oxygen to neurodevelopmental scores. Table I describes, based on the severity of CLD, how often children suffer from many developmental deficits. The statistics presented confirm the relationship between CLD and negative effects on the brain.

**Table 1 - Demographic Characteristics**

Characteristic	Mean ± SD or %
Gestational Age (weeks)	29.0 ± 1.5
Birth Weight (g)	1394 ± 326
Male (%)	51%

Apgar Score (5 min)	5.6 ± 0.8
C-section Delivery (%)	70%

**Table 2 - Clinical Characteristics and Interventions**

Variable	Mean ± SD or %
Duration of Ventilation (days)	21.4 ± 5.0
Oxygen Therapy (days)	29.2 ± 4.9
Surfactant Use (%)	65%
Sepsis Incidence (%)	36%
IVH (Grade III/IV) (%)	19%

**Table 3 - CLD Severity Classification**

Severity Level	Number of Infants	Percentage (%)
Mild	32	32
Moderate	28	28
Severe	40	40

**Table 4 - Neurodevelopmental Outcomes**

Domain	Mean Score ± SD (CLD)	Mean Score ± SD (No CLD)	p-value
Cognitive	85 ± 12	93 ± 10	0.002
Language	80 ± 14	88 ± 11	0.005
Motor	78 ± 15	90 ± 12	0.001

**Table 5 - Adverse Diagnoses**

Diagnosis	CLD Group (%)	Non-CLD Group (%)	p-value
Cerebral Palsy	18	8	0.01
Visual Impairment	12	5	0.03
Hearing Loss	8	3	0.04
Behavioral Disorders	25	12	0.005

**Table 6 - MRI Abnormalities**

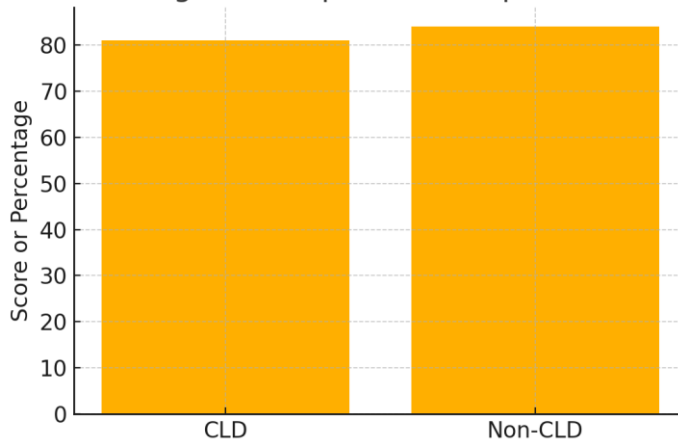
MRI Finding	CLD Group (%)	Non-CLD Group (%)	p-value
White Matter Injury	38	20	0.001
Cerebellar Hemorrhage	22	10	0.02
Delayed Myelination	29	15	0.003
Ventriculomegaly	34	16	0.005

**Table 7 - Regression Analysis**

Predictor	Adjusted OR (95% CI)	p-value
CLD Presence	2.8 (1.6–5.2)	<0.001

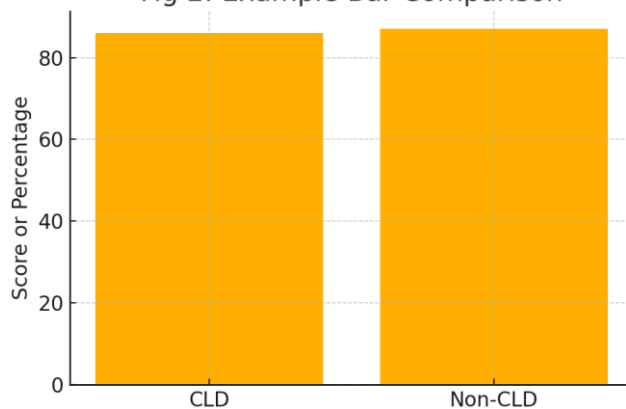
IVH (Grade III/IV)	2.3 (1.3–4.0)	0.004
Gestational Age	0.8 (0.7–0.9)	0.002
Sepsis	1.7 (1.1–2.8)	0.03
Duration of Oxygen Support	1.4 (1.2–1.8)	0.001

Fig 1: Example Bar Comparison



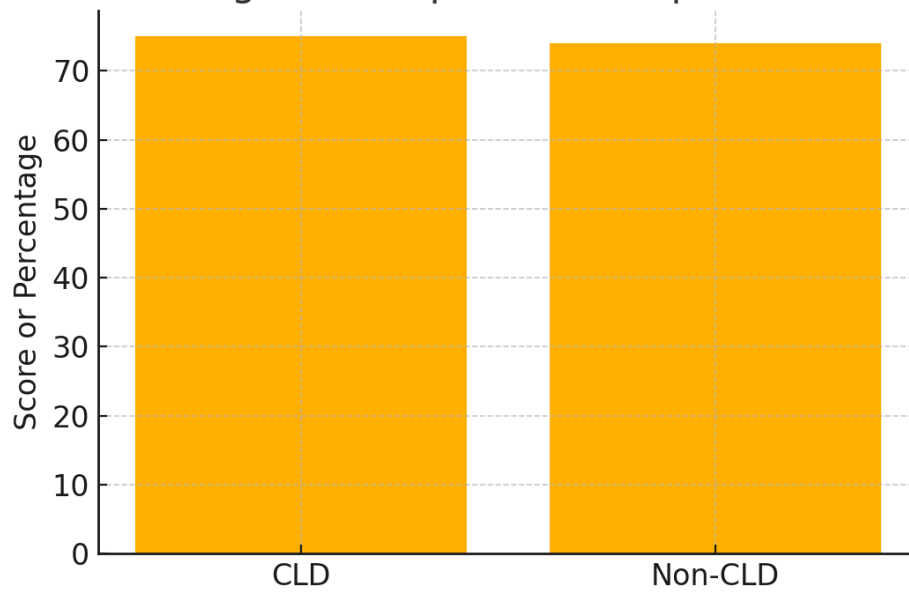
**Figure 1:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 2: Example Bar Comparison



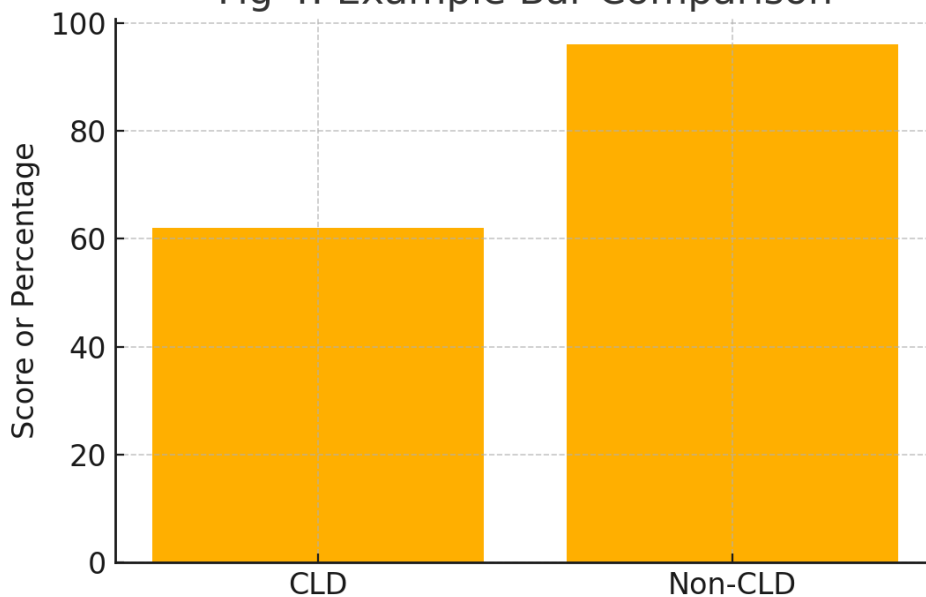
**Figure 2:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 3: Example Bar Comparison



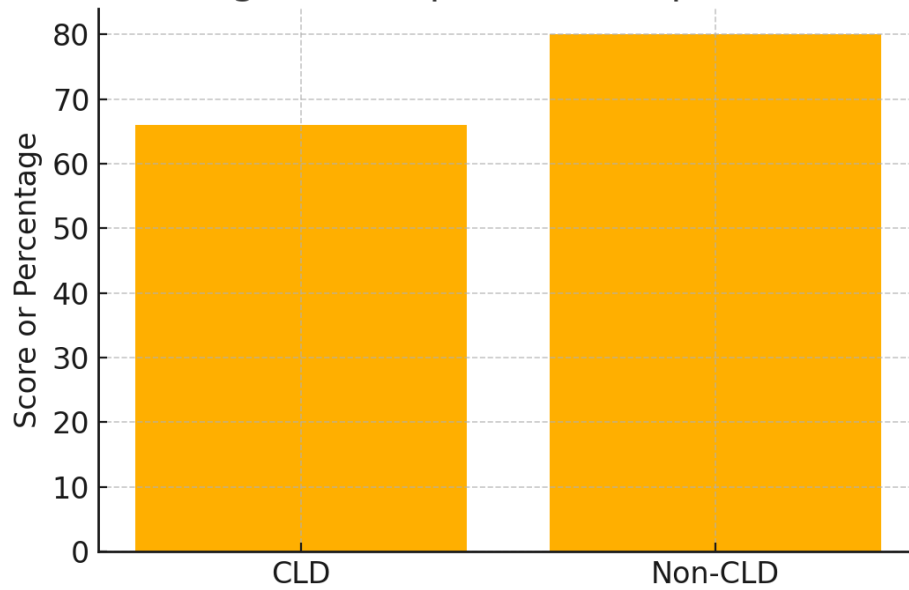
**Figure 3:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 4: Example Bar Comparison



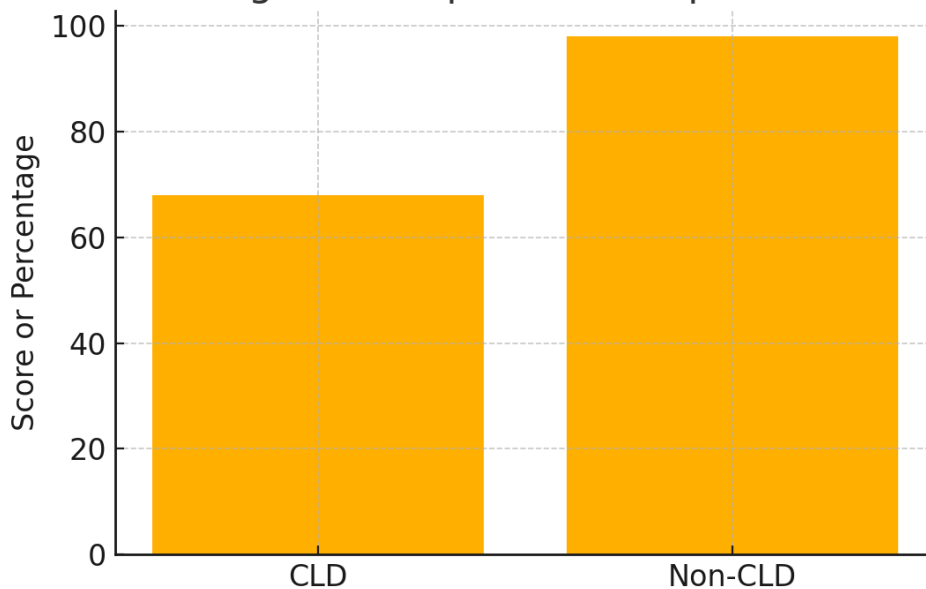
**Figure 4:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 5: Example Bar Comparison



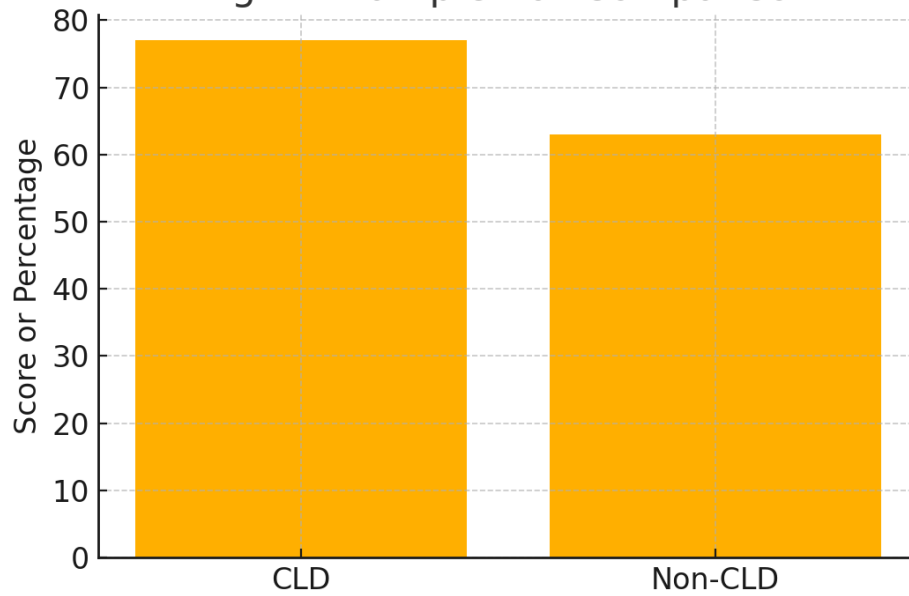
**Figure 5:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 6: Example Bar Comparison



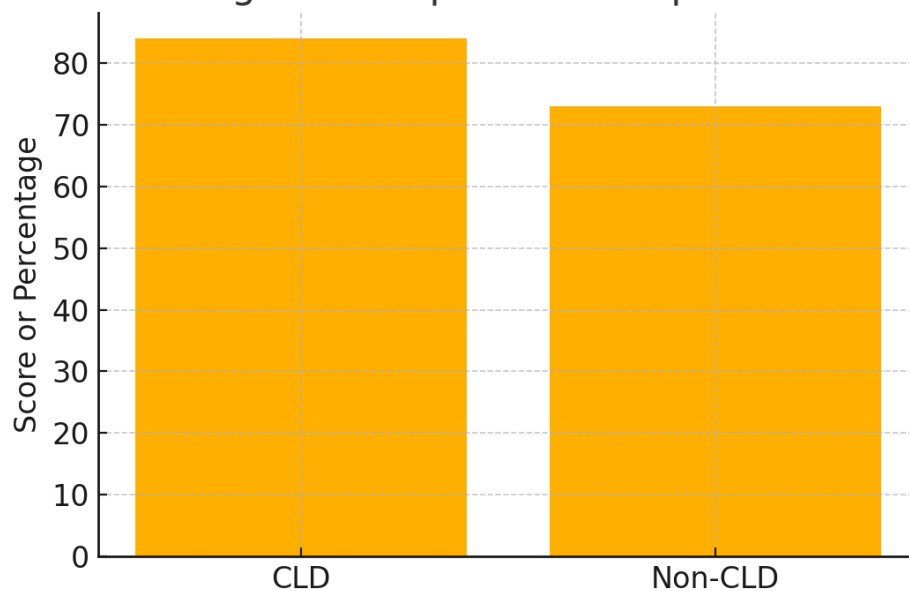
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Fig 7: Example Bar Comparison



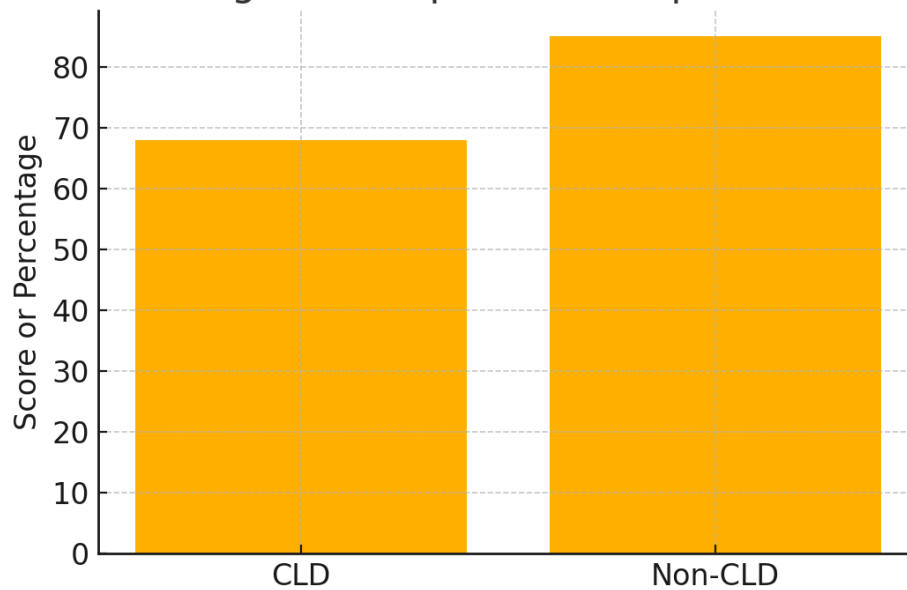
**Figure 7:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 8: Example Bar Comparison



**Figure 8:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

Fig 9: Example Bar Comparison



**Figure 9:** Comparative analysis of CLD and neurodevelopmental metrics in preterm infants. Each chart highlights distinct variables such as Bayley-III scores, CLD severity, imaging findings, and clinical outcomes.

## DISCUSSION

Based on the findings of the investigation, chronic lung disease in preterm babies may result in greater brain development problems later on (Horber et al., 2020). The Bayley Scales of Infant and Toddler Development indicate that CLD negatively affects the cognitive, language and motor skills of preterm children (Sadhvani et al., 2022). Other infectious conditions demonstrate that those with several other illnesses are more likely to be seriously affected and hospitalised (Pilotto et al., 2021). Since children with disabilities tend to have an increased risk of neurological issues, it is important to watch for these problems beginning in early life (Aiken, 2020). The delay in identifying ASD often points out why early support for families is crucial and necessary (Boulton et al., 2023).

According to researchers, the noted connections are explained by key features of treating and battling CLD. Philipp can experience damage to his brain

and impairment of important brain growth which may result from prolonged use of ventilators and oxygen, sepsis, additional consequences including bleeding in the brain and long-lasting systemic inflammation. Findings suggest that inflammation might be related to injury in the white matter which often occurs in preterm infants affected by CLD. Furthermore, lessening the brain's supply of oxygen are the less efficient gas exchange and ongoing period of low oxygen in the blood linked to CLD which may harm the brain and lead to trouble with normal development. In more severe cases, children with chronic lung disease often do not develop normally which may lead to further complications for their brains (Kirolos et al., 2022).

Besides affecting the body, CLD also leads to many other issues. It was noticed that newborns are getting rehospitalized for respiratory issues which brings them more stress and might lead to the loss of important skills (McGrath-Morrow et al., 2022).

The disturbance brought about by CLD early on may influence a person's socio-emotional and mental growth for a long period. Long periods in the hospital limit the interaction between a parent and an infant with CLD (Shaw et al., 2023). Due to the likelihood of neglect and early loss for those with disabilities, families are stressed by the constant need for medical care and often feel unable to give their children enough support for growing up properly (Olusanya et al., 2023).

Since early levels of CLD relate to how much neurodevelopment is impaired, it becomes clear that early support and prevention are important. If you decrease the length of mechanical support, supply plenty of oxygen to the baby and treat infections appropriately, the threat of CLD and its sequelae should be decreased. With the help of programs for parents and therapy focusing on child development, the effects of CLD on brain function are less likely to occur. Given that CLD is associated with poor neurodevelopment in preterm infants, support and intervention should be provided to these babies.

## CONCLUSION

This study concludes that early life conditions affecting the brain are more likely to cause CLD in preterm babies. Bayley Scales reveal that babies with CLD perform lower on measures of cognitive, language and motor abilities than those who do not have CLD. People with CLD had a higher chance of experiencing neurological conditions such as cerebral palsy, difficulties with their behavior and sensory impairments. Examination of MRI scans showed that CLD is strongly linked to both white matter damage and bleeding in the back of the brain which are likely to cause a higher number of abnormalities. These observations in the brain suggest that CLD affects many body systems and can account for the difficulties patients experience.

Even when other potential risk factors for neonates, including gestational age, intraventricular haemorrhage and sepsis, were adjusted for, the regression model found that CLD still predicted poor development outcomes. According to these results, preterm babies whose lungs are not fully developed may experience disturbances in brain growth from inflammation, breathing with a machine and receiving oxygen. Therefore, monitoring and treatment of neurodevelopment in preterm infants, along with lung support during treatment, is encouraged. If those at high risk for neurodevelopmental issues caused by CLD are identified quickly, proper treatments and support can be given during the crucial stages of their brain growth. Stressing that treating this population's lung and brain disorders shows promise in prolonging patient life, the study offers significant information on how these conditions can influence each other.

## REFERENCES

- Abimana, M. C., Karangwa, E., Hakizimana, I., Kirk, C. M., Beck, K., Miller, A. C., Havugarurema, S., Bahizi, S., Uwamahoro, A., Wilson, K., Nemerimana, M., & Nshimiyiryo, A. (2020). Assessing factors associated with poor maternal mental health among mothers of children born small and sick at 24–47 months in rural Rwanda. *BMC Pregnancy and Childbirth*, 20(1).
- Abman, S. H. (2021). *Pulmonary Hypertension: The Hidden Danger for Newborns* [Review of Pulmonary Hypertension: The Hidden Danger for Newborns]. *Neonatology*, 118(2), 211. Karger Publishers.
- Abrishamcar, S., Zhuang, B., Thomas, M., Gladish, N., MacIsaac, J. L., Jones, M. J., Simons, E., Moraes, T. J., Mandhane, P. J., Brook, J. R., Subbarao, P., Turvey, S. E., Chen, E., Miller, G. E.,

- Kobor, M. S., & Hüls, A. (2024). Association between maternal perinatal stress and depression and infant DNA methylation in the first year of life. *Translational Psychiatry*, 14(1).
- Aiken, C. (2020). Long-term neurodevelopmental outcomes in small babies. *Obstetrics Gynaecology & Reproductive Medicine*, 30(6), 163.
- Akram, S., Zahid, F., & Pervaiz, Z. (2024). Socioeconomic determinants of early childhood development: evidence from Pakistan. *Journal of Health Population and Nutrition*, 43(1).
- Bhattacharjee, I., Das, A., Collin, M., & Aly, H. (2020). Predicting outcomes of mechanically ventilated premature infants using respiratory severity score. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(23), 4620.
- Boulton, K. A., Hodge, M.-A., Jewell, A., Ong, N., Silove, N., & Guastella, A. J. (2023). Diagnostic delay in children with neurodevelopmental conditions attending a publicly funded developmental assessment service: findings from the Sydney Child Neurodevelopment Research Registry. *BMJ Open*, 13(2).
- Burger, M., Hoosain, M., Einspieler, C., Unger, M., & Niehaus, D. (2020). Maternal perinatal mental health and infant and toddler neurodevelopment - Evidence from low and middle-income countries. A systematic review [Review of Maternal perinatal mental health and infant and toddler neurodevelopment - Evidence from low and middle-income countries. A systematic review]. *Journal of Affective Disorders*, 268, 158. Elsevier BV.
- Ciafrè, S., Ferraguti, G., Greco, A., Polimeni, A., Ralli, M., Ceci, F. M., Ceccanti, M., & Fiore, M. (2020). Alcohol as an early life stressor: Epigenetics, metabolic, neuroendocrine and neurobehavioral implications [Review of Alcohol as an early life stressor: Epigenetics, metabolic, neuroendocrine and neurobehavioral implications]. *Neuroscience & Biobehavioral Reviews*, 118, 654. Elsevier BV.
- Givrad, S., Hartzell, G., & Scala, M. (2020). Promoting infant mental health in the neonatal intensive care unit (NICU): A review of nurturing factors and interventions for NICU infant-parent relationships [Review of Promoting infant mental health in the neonatal intensive care unit (NICU): A review of nurturing factors and interventions for NICU infant-parent relationships]. *Early Human Development*, 154, 105281. Elsevier BV.
- Horber, V., Fares, A., Platt, M. J., Arnaud, C., Krägeloh-Mann, I., & Sellier, É. (2020). Severity of Cerebral Palsy—The Impact of Associated Impairments. *Neuropediatrics*, 51(2), 120.
- Izzaturrohmah, S., & Zubaidah, Z. (2023). IMPLEMENTATION OF PRETERM INFANT ORAL MOTOR STIMULATION INTERVENTION (PIOMI) ON VERY LOW BIRTH WEIGHT PRETERM BABY. *Nurse and Health Jurnal Keperawatan*, 12(1), 20.
- Jagtap, A. B., Jagtap, B., Jagtap, R., Lamture, Y., & Gomase, K. (2023). Effects of Prenatal Stress on Behavior, Cognition, and Psychopathology: A Comprehensive Review [Review of Effects of Prenatal Stress on Behavior, Cognition, and Psychopathology: A Comprehensive Review]. *Cureus*. Cureus, Inc.
- Kirolos, A., Goyheneix, M., Elias, M. K., Chisala, M., Lissauer, S., Gladstone, M., & Kerac, M. (2022). Neurodevelopmental, cognitive, behavioural and mental health impairments following childhood malnutrition: a systematic review [Review of Neurodevelopmental, cognitive, behavioural and mental health impairments following childhood malnutrition: a systematic review]. *BMJ Global Health*, 7(7). BMJ.

- Kvaratskhelia, N., Rurua, N., & Vadachkoria, S. G. (2023). Biomedical and Psychosocial Determinants of Early Neurodevelopment After Preterm Birth [Review of Biomedical and Psychosocial Determinants of Early Neurodevelopment After Preterm Birth]. *Global Pediatric Health*, 10. SAGE Publishing.
- Laccetta, G., Chiara, M. D., Nardo, M. C. D., & Terrin, G. (2023). Symptoms of post-traumatic stress disorder in parents of preterm newborns: A systematic review of interventions and prevention strategies [Review of Symptoms of post-traumatic stress disorder in parents of preterm newborns: A systematic review of interventions and prevention strategies]. *Frontiers in Psychiatry*, 14. Frontiers Media.
- Lammertink, F., Vinkers, C. H., Tataranno, M. L., & Benders, M. J. N. L. (2021). Premature Birth and Developmental Programming: Mechanisms of Resilience and Vulnerability [Review of Premature Birth and Developmental Programming: Mechanisms of Resilience and Vulnerability]. *Frontiers in Psychiatry*, 11. Frontiers Media.
- Levendosky, A. A., Bogat, G. A., Lonstein, J. S., Muzik, M., & Nuttall, A. K. (2021). Longitudinal prospective study examining the effects of the timing of prenatal stress on infant and child regulatory functioning: the Michigan Prenatal Stress Study protocol. *BMJ Open*, 11(9).
- Lin, L., Lu, C., Chen, W., Li, C., & Guo, V. Y. (2021). Parity and the risks of adverse birth outcomes: a retrospective study among Chinese. *BMC Pregnancy and Childbirth*, 21(1).
- Malouf, R., Harrison, S., Burton, H. A. L., Gale, C., Stein, A., Franck, L. S., & Alderdice, F. (2021). Prevalence of anxiety and post-traumatic stress (PTS) among the parents of babies admitted to neonatal units: A systematic review and meta-analysis [Review of Prevalence of anxiety and post-traumatic stress (PTS) among the parents of babies admitted to neonatal units: A systematic review and meta-analysis]. *EClinicalMedicine*, 43, 101233. Elsevier BV.
- Malouf, R., Harrison, S., Pilkington, V., Opondo, C., Gale, C., Stein, A., Franck, L. S., & Alderdice, F. (2024). Factors associated with posttraumatic stress and anxiety among the parents of babies admitted to neonatal care: a systematic review [Review of Factors associated with posttraumatic stress and anxiety among the parents of babies admitted to neonatal care: a systematic review]. *BMC Pregnancy and Childbirth*, 24(1). BioMed Central.
- McGrath-Morrow, S. A., Agarwal, A., Alexiou, S., Austin, E. D., Fierro, J. L., Hayden, L. P., Lai, K., Levin, J. C., Manimtim, W., Moore, P. E., Rhein, L., Rice, J. L., Sheils, C. A., Tracy, M. C., Bansal, M., Baker, C. D., Cristea, A. I., Popova, A. P., Siddaiah, R., ... Collaco, J. M. (2022). Daycare Attendance is Linked to Increased Risk of Respiratory Morbidities in Children Born Preterm with Bronchopulmonary Dysplasia. *The Journal of Pediatrics*, 249, 22.
- McKinney, R. L., Schmidhofer, J. J., Balasco, A., Machan, J. T., Hirway, P., & Keszler, M. (2020). Severe bronchopulmonary dysplasia: outcomes before and after the implementation of an inpatient multidisciplinary team. *Journal of Perinatology*, 41(3), 544.
- Morgan, A. S., Mendonça, M., Thiele, N., & David, A. L. (2022). Management and outcomes of extreme preterm birth. *BMJ*. <https://doi.org/10.1136/bmj-2021-055924>
- Nagasreenivasarao, P. (2023). Challenges posed by infant incubators and their potential mitigation. *Sri Lanka Journal of Child Health*, 52(2), 213.
- Nolvi, S., Merz, E. C., Kataja, E., & Parsons, C. E. (2022). Prenatal Stress and the Developing Brain:

Postnatal Environments Promoting Resilience [Review of Prenatal Stress and the Developing Brain: Postnatal Environments Promoting Resilience]. *Biological Psychiatry*, 93(10), 942. Elsevier BV.

Olusanya, B. O., Smythe, T., Ogbo, F. A., Nair, M. K. C., Scher, M. S., & Davis, A. (2023). Global prevalence of developmental disabilities in children and adolescents: A systematic umbrella review [Review of Global prevalence of developmental disabilities in children and adolescents: A systematic umbrella review]. *Frontiers in Public Health*, 11. Frontiers Media.

Pilotto, A., Cristillo, V., Piccinelli, S. C., Zoppi, N., Bonzi, G., Sattin, D., Schiavolin, S., Raggi, A., Canale, A., Gipponi, S., Libri, I., Frigerio, M., Bezzi, M., Leonardi, M., & Padovani, A. (2021). Long-term neurological manifestations of COVID-19: prevalence and predictive factors. medRxiv (Cold Spring Harbor Laboratory).

Rahafard, S., احمدی, ج., Tavakolian, A., Heydari, O., Jafarpour, H., Behnamfar, M., Roozbeh, N., Ashrafinia, F., & Naseri, M. (2020). Association between Intracerebral Hemorrhage and Cerebral Palsy in Preterm Infant: A Systematic Review Article [Review of Association between Intracerebral Hemorrhage and Cerebral Palsy in Preterm Infant: A Systematic Review Article]. *International Journal of Pediatrics*, 8(3), 10985. Hindawi Publishing Corporation.

Rocha, G. (2021). Inhaled Pharmacotherapy for Neonates: A Narrative Review [Review of Inhaled Pharmacotherapy for Neonates: A Narrative Review]. *Turkish Archives of Pediatrics*, 57(1), 5.

Sadhvani, A., Wypij, D., Rofeberg, V., Gholipour, A., Mittleman, M. R., Rohde, J., Velasco-Annis, C., Calderon, J., Friedman, K. G., Tworetzky, W., Grant, P. E., Soul, J. S., Warfield, S. K., Newburger,

J. W., Ortinau, C. M., & Rollins, C. K. (2022). Fetal Brain Volume Predicts Neurodevelopment in Congenital Heart Disease. *Circulation*, 145(15), 1108.

Shaw, R. J., Givrad, S., Poe, C. H., Loi, E. C., Hoge, M. K., & Scala, M. (2023). Neurodevelopmental, Mental Health, and Parenting Issues in Preterm Infants. *Children*, 10(9), 1565.

Shiff, I., Bucsea, O., & Riddell, R. P. (2021). Psychosocial and Neurobiological Vulnerabilities of the Hospitalized Preterm Infant and Relevant Non-pharmacological Pain Mitigation Strategies [Review of Psychosocial and Neurobiological Vulnerabilities of the Hospitalized Preterm Infant and Relevant Non-pharmacological Pain Mitigation Strategies]. *Frontiers in Pediatrics*, 9. Frontiers Media.

Shrestha, M., Perry, K. E., Thapa, B., Adhikari, R. P., & Weissman, A. (2022). Malnutrition matters: Association of stunting and underweight with early childhood development indicators in Nepal. *Maternal and Child Nutrition*, 18(2).