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RESEARCH ARTICLE

Predictors of Cognitive Function in School Children: Screen Time, Nutritional Status and Pneumonia

Prediktor Fungsi Kognitif pada Anak Sekolah: Screentime, Status Gizi dan Pneumonia

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Abstract

Cognitive development and intelligence of children are shaped by multifactorial influences, including genetic predisposition, environmental conditions, nutritional status, cognitive stimulation, educational exposure, and overall health status. The average Intelligence Quotient (IQ) of the Indonesian population is 89.96, which is categorized within the average range at the global level. A cross-sectional analytical study was conducted involving 80 school-aged children selected through simple random sampling. IQ was measured using the CFIT administered by child psychologists, while nutritional status was assessed using the WHO BMI-for-age reference. Logistic regression modeling was used to identify significant determinants, followed by ROC curve analysis, Youden Index calculation, and risk score estimation, which was derived from the ratio of each significant predictor to the smallest significant coefficient. Significant associations were observed for screen time (PR = 5.23; 95% CI: 1.49–18.29), history of pneumonia (PR = 3.92; 95% CI: 1.13–13.68), and poor nutritional status (PR = 4.03; 95% CI: 1.34–12.11). The predictive model showed an area under the curve (AUC) of 0.794, with a youden index-derived cut-off of ≥ 2 (95% CI: 0.630–0.882), indicating a threshold for increased risk of low cognitive function among children. Screen time, a history of pneumonia, and poor nutritional status were identified as key predictors of lower cognitive function, with a risk score of ≥ 2 as the threshold. Parental control over digital exposure and the reinforcement of preventive health behaviors are essential components in improving children's cognitive outcomes.

Keywords: history of pneumonia, intelligence quotient, nutritional status, screen time

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Abstrak

Perkembangan kognitif dan kecerdasan anak-anak dibentuk oleh pengaruh multifaktorial, termasuk kecenderungan genetik, kondisi lingkungan, status gizi, stimulasi kognitif, paparan pendidikan, dan status kesehatan secara keseluruhan. rata-rata kecerdasan (IQ) penduduk Indonesia adalah 89.96, yang dikategorikan rata-rata di tingkat global. Penelitian ini bertujuan untuk mengidentifikasi faktor risiko signifikan yang terkait dengan fungsi kognitif yang lebih rendah pada anak-anak dan untuk menentukan ambang batas skor risiko yang optimal. Studi analitis cross-sectional dilakukan melibatkan 80 anak usia sekolah yang dipilih melalui teknik pengambilan sampel acak sederhana. Pengukuran IQ menggunakan kuesioner CFIT oleh psikolog anak, serta pengukuran status gizi berdasarkan IMT/U WHO. Analisis statistik termasuk pemodelan regresi logistik untuk mengidentifikasi determinan yang signifikan, diikuti oleh analisis kurva Karakteristik Operasi Penerima (ROC), perhitungan Indeks Youden, dan estimasi skor risiko (berasal dari rasio setiap prediktor signifikan dengan koefisien signifikan terkecil). Terdapat tiga faktor menunjukkan hubungan yang signifikan: screen time (PR = 5,23; IC 95%: 1,49–18,29), riwayat pneumonia (PR = 3,92; IC 95%: 1,13–13,68), dan status gizi buruk (PR = 4,03; IC 95%: 1,34–12,11). Model prediktif menunjukkan AUC 0,794, dengan batas Indeks Youden 2 (0,630 – 0,882) menunjukkan ambang batas untuk peningkatan risiko kecerdasan rendah pada anak-anak. Screen time, riwayat pneumonia, dan status gizi yang buruk adalah faktor prediktor kognitif yang lebih rendah dengan skor ≥2. Kontrol orang tua terhadap paparan digital dan penguatan perilaku kesehatan preventif adalah komponen penting dalam meningkatkan hasil kognitif anak.

Kata Kunci: *riwayat pneumonia, kecerdasan anak, status gizi, screen time*

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Highlight:

- Excessive screen time, malnutrition, and a history of pneumonia are the primary determinants increasing the risk of cognitive decline in school-aged children.
- The development of an individual factor-based predictive model has been proven fit and demonstrates good accuracy in detecting children's intellectual decline.
- Establishing risk factor accumulation cutoff points serves as a crucial benchmark for early detection and provides strategic direction for prevention policies at both family and school levels.

INTRODUCTION

According to World Population Review (2026), Indonesia's average intelligence quotient (IQ) in 2025 was 93.2, which falls within the average IQ category. This is consistent with an earlier study in Depok City in 2025, in which the proportion of children aged 9–12 years with an average intelligence level was 52.3%, below average 18.2%, borderline 9.1%, and intellectually deficient 9.1% (Kristanti et al., 2025). According to the 2023 Indonesian Health Survey (SKI), the stunting prevalence among school-aged children (5–12 years) was 14.1%, and stunting among children aged 5–12 years in Depok City was found to be 13.5%. This prevalence is fairly high and close to the national figure (Ministry of Health of the Republic of Indonesia, 2023).

Adequate nutrient intake is important for children's growth and development (Ahmad et al., 2023) Undernourished children are more susceptible to infectious diseases that can hinder their growth and development, reflecting their high caloric needs. Children also require substantial energy for the demanding physical activity of school (Papotot et al., 2021). Many risk factors affect a child's intelligence, both external and internal. Internal factors—individual characteristics such as a history of low birth weight, sleep quality, a history of infectious disease, nutritional status, and screen time duration—influence a child's cognitive function. Previous findings also suggest that a child's nutritional status has a much greater effect than parenting style (Kristanti et al., 2025; Nieto et al., 2022; Peinkhofer et al., 2023).

A study by Mun et al. (2023) showed that children with a history of pneumonia had significantly lower cognitive function than those without such a history. Previous studies found that enteropathogen infection and a greater number of sick days were associated with lower cognitive scores at 24 months, especially in children with low birth weight (MAL-ED Network Investigators, 2018)

A history of pneumonia has a lasting effect on cognitive function: children aged 3–8 years who had been hospitalized with respiratory failure had lower average IQ scores. This suggests that serious respiratory disorders in childhood can have long-term effects on cognitive function (Girard et al., 2018; Watson et al., 2022). Comparing pneumonia with other health conditions, pneumonia (including that caused by SARS-CoV-2) has been linked to long-term cognitive decline (Peinkhofer et al., 2023).

Sleep quality is also related to children's cognitive function. Children with longer sleep duration show a positive correlation with cognitive function. Among girls, good sleep quality was associated with better cognitive function (Short et al., 2018). Previous studies indicates that 7–9 hours of nighttime sleep can support the development of cognitive function, particularly inhibition and working memory at preschool age. This shows that sleep quality also warrants study as a risk factor for children's intelligence, not only nutritional or health status (Nieto et al., 2022).

Few studies on children's cognitive function have addressed risk-factor scoring. Some use machine-learning-based scoring, but from a technological angle, identifying socioeconomic status, maternal BMI during pregnancy, and first-trimester alcohol consumption (Bowe et al., 2022). Several studies has found that genetics is the strongest predictor of cognitive function (de la Fuente et al., 2021). Several studies that the strongest predictor of cognitive function is genetics (de la Fuente et al., 2021). Previous findings takes a clinical-practice approach, while the epidemiological angle—especially at the community level—remains unexplored, and such studies are still rare in Indonesia.

Given the above, no study has yet addressed risk-factor scoring for children's intelligence based on individual determinant factors. This study therefore examined individual risk factors and factor scoring for cognitive function among primary school children aged 9–12 years in Depok City in 2025.

METHODS

This was an observational analytical study with a cross-sectional design, conducted at SDN 04 Bojong Sari in September 2025. Primary data were collected using structured questionnaires. Sleep quality was measured with the Sleep Timing Questionnaire (STQ), and screen time with the Canadian Society for Exercise

Physiology (CSEP) questionnaire, for which the instrument demonstrated acceptable validity (calculated r = 0.666 > critical r = 0.497) and reliability (Cronbach's α = 0.846). Other questionnaires covered history of pneumonia and history of acute respiratory infection (ARI); nutritional status was assessed using the WHO BMI-for-age standard; and intelligence was measured with the CFIT administered by a child psychologist to assess IQ. IQ was scored using standardized IQ values categorized by the Wechsler classification, with high IQ (score ≥ 90) and low IQ (score < 90), based on the Wechsler system in which 90 is the lower threshold of the average intelligence range. Data collection took two days: the first was dedicated to IQ measurement by the psychologist, and the second to completing questionnaires, attended by parents and children at the school. Inclusion criteria were children aged 9–12 years, parents willing to take part in data collection, children able to read and write independently, and children who were healthy and without other conditions such as ADHD and autism. The study included 80 subjects selected by simple random sampling, in which the names of children aged 9–12 years were drawn at random and enrolled as subjects.

Data were analyzed using the Prevalence Ratio (PR) and the chi-square test for the bivariate analysis; logistic regression modeling to control for a confounding variable (sleep quality) and to produce the adjusted PR for the multivariate analysis; and ROC analysis to derive the risk-factor score for intelligence level. The Hosmer–Lemeshow test was used to assess model goodness of fit for the risk-factor scoring, with a p-value above 0,05 taken as acceptable. The Youden Index was used to determine the cut-off point in the risk-factor scoring, based on the sensitivity and specificity of the data. The study obtained ethical approval from the ethics committee of Universitas Pembangunan Nasional Veteran Jakarta (No. 165/VIII/2025/KEP) and was funded by the Institute for Research and Community Service (LPPM) of Universitas Pembangunan Nasional Veteran Jakarta under contract No. 141/UN61.4/LIT.RISTA/2025, 15 May 2025.

RESULTS AND DISCUSSION

Subject characteristics

State Elementary School (SDN) 04 Bojongsari is located on Jalan Pelita Bojongsari Baru, Bojongsari Village, Bojongsari Subdistrict, Depok City, West Java Province. The school is under the Depok City Education Office and has operated since 1976. Based on data for the odd semester of the 2025/2026 academic year, SDN 04 Bojongsari holds a B accreditation and applies the Merdeka Curriculum. Learning is delivered on a full-day system (5 school days).

The school has 17 teachers, with 231 male and 214 female students, across 14 study groups (classes). In terms of facilities, SDN 04 Bojongsari has 14 classrooms, 1 library, and 2 student sanitation units. The school stands on 860 m² of land, draws electricity from the state utility (PLN) at 5,500 watts, and does not yet have internet access for classroom learning. The subjects characteristics are presented in Table 1.

Tabel 1. Karakteristik subjek

Variabel	n	%
Screen time		
High	26	32.5
Low	54	67.5
History of pneumonia		
Yes	38	47.5

Variabel	n	%
No	42	52.5
Sleep quality		
Poor	36	45.0
Good	33	55.0
History of ARI		
Yes	33	55.0
No	36	45.0
Sex		
Male	41	51.2
Female	39	48.8
Age		
9 years	9	11.3
10 years	32	40.0
11 years	21	26.3
12 years	18	22.5
Nutritional status		
Undernourished–overweight	37	46.3
Normal	43	53.8
Intelligence level (IQ)		
Low	46	57.5
High	34	42.5

Source: Primary data, 2025

Based on Table 1, 57.5% of children had a low IQ. Children with a history of ARI were also more numerous (55%) than those without. Most participants were 10 years old (40.0%), and 51.2% were male. Most primary school children in this study had normal nutritional status (53.8%).

Bivariate analysis of factors associated with children's intelligence level

As shown in Table 2, Children with high screen time had a 1.75-fold higher prevalence of low intelligence than those with low screen time. This is supported by a p-value of 0.003, indicating a significant association between screen time and children's intelligence. Nutritional status was also significantly associated with intelligence (p = 0.002; PR = 1.81), meaning that children with poor nutritional status were at 1.8 times higher risk than those with good nutritional status. A history of pneumonia likewise carried a 1.89 times higher risk of low intelligence than no such history.

Table 2. Bivariate analysis of factors associated with children's intelligence level

Variable	Child's intelligence level		p-value	PR (95%CI)
	Low, n(%)	High, n(%)		
Screen time				
High	21 (80.8)	5 (19.2)	0.003*	1.75 (1.24-2.46)
Low	25 (46.3)	29 (53.7)		
Sex				
Male	22 (53.7)	19 (46.3)	0.475	1.21 (0.71-2.02)
Female	24 (61.5)	15 (38.5)		
Nutritional status				

Variable	Child's intelligence level		p-value	PR (95%CI)
	Low, n(%)	High, n(%)		
Poor	28 (75.7)	9 (24.3)	0.002*	1.81 (1.22-2.69)
Good	18 (41.9)	25 (58.1)		
History of pneumonia				
Yes	29 (76.3)	9 (16.2)	0.001*	1.89 (1.25-2.83)
No	17 (40.5)	25 (59.5)		
Sleep quality				
Poor	24 (66.7)	12 (33.3)	0.134	1.33 (0.92-1.94)
Good	22 (50)	22 (50)		
History of ARI				
Yes	26 (59.1)	18 (40.9)	0.750	1.07 (0.73-1.56)
No	20 (55.6)	16 (44.4)		

Note: *Chi-square test, significant if p-value < 0.05; PR = Prevalence Ratio

Multivariable analysis of risk factors for children's intelligence

As shown in Table 3, the determinants of intelligence were screen time duration, a history of pneumonia, and nutritional status. Children with high screen time duration had a PR 5.23 (95% CI: 1.49–18.29; p = 0.010) for lower intelligence compared with those with low screen time, after controlling for history of pneumonia, nutritional status, and sleep quality. Children with a history of pneumonia had a PR of 3.92 (95% CI: 1.13–13.68) compared with those without a history of pneumonia in the last three months, after controlling for other variables. Poor nutritional status carried a PR of 4.03 (95% CI 1.34–12.11) compared with good nutritional status, after controlling for other variables. The risk-factor scoring for intelligence level identified three variables: screen time, history of pneumonia, and nutritional status. Based on these results, the researchers scored each risk variable.

Table 3. Multivariate analysis of risk factors for children's intelligence level

Variable	B	p-value	PR (95% CI)
Screen time	1.64	0.010*	5.23 (1.49–18.29)
History of pneumonia	1.37	0.032*	3.92 (1.13–13.68)
Nutritional status	1.39	0.013*	4.03 (1.34–12.11)
Sleep quality	0.39	0.535	1.49 (0.42–5.24)

Note: *Multivariate logistic regression; significant if p-value < 0.05; PR (adjusted Prevalence Ratio)

The Hosmer–Lemeshow test gave a p-value of 0.848, indicating that the model fits and can be used (Table 4). The ROC analysis for predicting the risk-factor score for intelligence level was 0.794, indicating fairly good predictive ability. The Youden Index gave a cut-off score of ≥ 2 points for the at-risk category and < 2 points for the not-at-risk category.

Table 4. Risk-factor scoring for intelligence level in school children aged 6–1 years in Depok City

Variable	B (regression coefficient)	Hosmer & Lemeshow Test	AUC	Score	Youden Index
Screen time	1,64	0.848*	0,794 (Cukup Baik)	1	2 (0,630 – 0,882)
Pneumonia status	1,37			1	

Nutritional status	1,39	1
Total		**3**

Note: *Score assignment: score weights were computed from the ratio of each predicted variable's regression coefficient (B) to the smallest coefficient (B = 1.37), so each risk factor is worth 1 point (maximum total score = 3); the model goodness-of-fit (Hosmer-Lemeshow test) gave p = 0.848 (p > 0.05), indicating a fitting model. AUC = 0.794 (95% CI: 0.630–0.882), indicating fairly good model discrimination. Threshold (Youden Index cut-off): cut-off point ≥ 2 points.

Figure 1 shows the cognitive-function risk-factor scoring based on three individual variables (screen time, history of pneumonia, and nutritional status). Each variable is worth 1 point; children with two or more risk variables tend to have low cognitive function. It is therefore important to set a reasonable screen time limit for children under 9 years and older, while poor nutritional status can also raise the risk of infectious disease such as pneumonia.

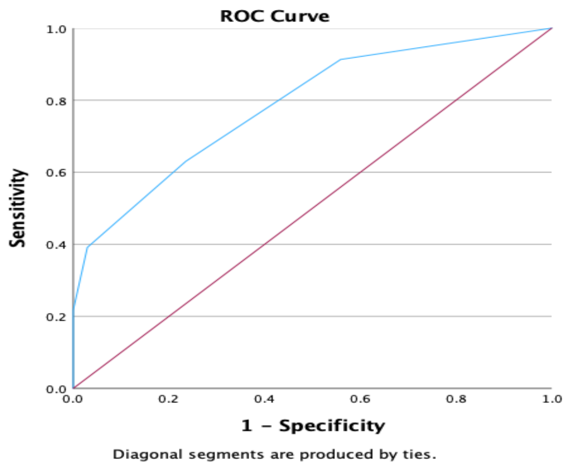

Figure 1. ROC Curve Scoring Risk Factor on Intelligent Level

Previous finding has addressed the bidirectional relationship between a history of pneumonia and cognitive function in adults and older people, while direct data on primary school children remain limited (Mun et al., 2023). This study found a significant association between a history of pneumonia and children's cognitive function. The effect of pneumonia on cognition is likely related to systemic inflammation and impaired oxygenation during infection, which can affect brain development. Longitudinal studies in older adults show that small cognitive changes before pneumonia can also increase infection risk, indicating a reciprocal relationship between health status and cognitive function. Preventing pneumonia is important to reduce long-term risk, since older adults with a childhood history of pneumonia are at risk of cognitive decline—an effect that also applies to children in a critical period of cognitive development (Hendel et al., 2023).

Recurrent infections early in life, including pneumonia, can contribute to poorer cognitive development through systemic inflammation and nutritional disturbance that affect brain growth and cognitive function (MAL-ED Network Investigators, 2018). Consistent with this, the present study found that nutritional status also affects children's cognitive function. Environmental factors, nutritional status, and repeated infection exposure therefore play important parts in cognitive development, making pneumonia one infectious disease that can be a risk factor affecting learning ability and cognitive function in primary school children (MAL-ED Network Investigators, 2018).

As noted, one risk factor for children's cognitive function is nutritional status. Good nutritional status means well-met nutrient needs, and nutrition plays an important part in children's development and cognitive function, especially during critical growth periods such as preschool and primary school age. Iron, macronutrient, and micronutrient supplementation has been shown to improve cognitive function in undernourished children (Roberts et al., 2022). Several studies show that nutritional status (fat, total calorie, and protein intake), eating habits, physical activity, and socioeconomic status are closely related to cognitive function and affect children's reaction speed and cognitive flexibility (Samigullin et al., 2025). Early nutrition through exclusive breastfeeding affects brain myelination, which supports verbal and non-verbal cognitive development. Previous studies shows that nutritional interventions such as foods rich in polyphenols, omega-3, and micronutrients can improve working memory and cerebral blood flow in children at risk of malnutrition, indicating potential gains in executive function and brain health. Adequate nutrition from early life through school age is essential to support optimal cognitive development and prevent cognitive dysfunction in children (DiGirolamo et al., 2020; Kadosh et al., 2021).

Malnutrition such as stunting and underweight negatively affects neurocognitive development, but improving nutritional status can restore cognitive function, especially before age 8. Besides malnutrition, overweight or obesity also reduces children's cognitive function, though less markedly than malnutrition. Overweight children still show signs in certain domains such as executive function, attention, and motor skills, so children at either nutritional extreme—below or above normal—need attention. Many modifiable factors warrant attention, such as socioeconomic status, environment, and stimulation, and multidimensional interventions are needed—not only nutrition but also environment, sanitation, parental education, and cognitive stimulation (Suryawan et al., 2022).

Good nutritional status is very important for children's cognitive development, especially at preschool age. Nutrient deficiencies such as iron and other micronutrient deficiencies can impede cognitive function, while iron and micronutrient supplementation plays a dual role in improving cognitive function in undernourished children (Ansuya et al., 2023). Adequate nutrition from pregnancy through age two also plays an important part in continued motor and cognitive development into adolescence, with stronger effects in boys and in families of low socioeconomic status (Arija and Canals, 2021).

Beyond nutritional status, this study also found that children with excessive screen time duration were at risk regarding cognitive function. Excessive screen use in children, especially under age 6, is generally linked to reduced cognitive function, including executive skills such as cognitive flexibility, verbal working memory, and inhibition. A study of children aged 9–10 years showed that longer screen time—especially watching TV, videos, and social media—was associated with lower cognitive scores (Costa et al., 2025). The type of content also matters: children who usually watch educational and interactive content can improve executive function and delayed gratification in early childhood, unlike passive entertainment content, which tends to have negative effects (Anderson and Subrahmanyam, 2017). Among children with ADHD, shorter screen time and higher maternal education were associated with better cognitive function, underscoring the importance of managing screen time in vulnerable groups. Previous finding also indicates that screen exposure during family mealtimes and duration of more than 2 hours per day can lower cognitive development in toddlers

(Gastaud et al., 2023). Limiting screen time to less than 2 hours per day with high-quality educational content is recommended to support optimal cognitive development in children (Lakicevic et al., 2025).

This finding may reflect the increasing integration of digital devices into children's daily lives. Screen time is also a source of parental concern because of its potential effect on children's cognitive development (Gastaud et al., 2023). Previous studies have shown that excessive screen time, especially in early childhood, has negative effects on cognitive domains such as executive function, working memory, attention, and language development. However, the effects depend on content type (educational vs. entertainment), context of use (co-viewing with parents vs. solo use), and age at first exposure (Lakicevic et al., 2025). While previous findings indicate small effects that depend on the content children receive, educational and interactive content—especially with parental involvement—can reduce adverse cognitive effects and may even provide cognitive benefits (Mallawaarachchi et al., 2024).

A history of illness and environmental factors also affect children's cognitive function, and optimal stimulation can offset the negative effects of poor nutritional status. Normal nutritional status supports the best cognitive development, but other factors—environment, socioeconomic status, and learning experience—also strongly shape cognitive outcomes. The interaction between nutritional status and illness history, together with social and environmental factors, contributes in complex ways to children's cognitive development (Sharma et al., 2023). This study also found that children with a history of pneumonia were at 3.9 times higher risk than those without, after controlling for nutritional status and screen time, although the largest risk was for screen time over 2 hours, at 5.23 times higher than for children with less than 2 hours, after controlling for nutritional status and history of pneumonia. These findings provide new evidence that an infectious-disease factor (pneumonia) is closely related to cognitive development, reinforcing the theory that health during the growth period is the foundation of intelligence. Screen time and poor nutritional status were also shown to predict low IQ, so parents should monitor and limit children's screen time and ensure good nutrient intake to protect their children's intelligence.

CONCLUSION

These findings add to the limited evidence on the association between pneumonia history and cognitive function among school-aged children. In the risk-factor scoring, screen time, history of pneumonia, and nutritional status each scored 1, giving a total of 3 when all individual risk factors are present, with a Youden Index of 2. Children with more than one risk factor—screen time over 2 hours, a history of pneumonia, or poor nutritional status—are therefore at risk of low cognitive function. Parents are encouraged to keep their children's screen time under 2 hours and to ensure the content watched is educational and interactive. Attention to clean and healthy living behavior (PHBS) and to children's nutritional status is also important to maintain immunity and prevent infectious disease, especially pneumonia. Screen time over 2 hours can potentially reduce children's cognitive function and lead to low IQ, an effect that can be mitigated by maintaining health, hygiene, and nutritional status. Children with low IQ accounted for 75% of those with poor nutritional status, which can be avoided by improving nutrition through nutritious, balanced meals.

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