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Cognitive Development and Nutrition in Early Childhood: A Study in Purnea District

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Abstract

This study investigates the relationship between nutrition and cognitive development among children aged 3-8 years in Purnea district, Bihar, with a specific focus on how caregiver well-being influences developmental outcomes. A sample of 166 children and their primary caregivers was selected through random and cluster sampling from schools, Anganwadi centers, and households. Nutritional status was assessed using dietary recall, anthropometric measures, and protein frequency, while cognitive development was evaluated through a culturally adapted scale covering domains of language, memory, problem-solving, and attention. Caregiver distress, coping, stigma, and social support were also measured through standardized inventories. Descriptive statistics revealed moderate dietary diversity and mild undernutrition, with cognitive scores reflecting average but suboptimal performance. Independent samples t-tests were conducted to assess subgroup differences by gender, residence, and income. Results showed no significant difference in caregiver distress levels between families of male and female children ($t = -0.66$, $p > 0.05$), though rural-urban and income-based disparities were evident. The findings suggest that nutritional adequacy and caregiver psychosocial resources are more critical determinants of cognitive outcomes than child gender alone. Implications highlight the need for integrated interventions addressing both child nutrition and caregiver mental health within early childhood programs and community health initiatives.

Keywords: *Cognitive development, Nutrition, Early childhood, Caregiver distress, Purnea district*

Introduction

Early childhood represents a critical developmental window during which nutrition, environment, and psychosocial factors converge to shape long-term cognitive and emotional outcomes. Adequate dietary intake and balanced nutrition are well-established foundations for brain growth, influencing domains such as attention, memory, and problem-solving. Equally, the psychological health of caregivers exerts indirect but powerful effects on children's developmental trajectories, as caregiver stress, coping, and social support influence both caregiving practices and children's socio-emotional security.

The Purnea district of Bihar, characterized by high poverty levels, limited infrastructure, and reliance on government schemes such as the Integrated Child Development Services (ICDS), provides a compelling context for examining these interactions. While national surveys highlight persistent undernutrition and developmental delays in low-resource settings, localized empirical evidence remains sparse. This study addresses that gap by systematically exploring the interconnections between nutritional adequacy, cognitive outcomes, and caregiver psychosocial well-being among 166 children aged 3-8 years in Purnea. Using descriptive statistics, correlation analyses, and independent samples t-tests, the research provides insights into subgroup differences by gender, income, and residential background. The findings offer both theoretical contributions to developmental and health psychology frameworks and practical implications for clinical psychology interventions and public health programs in India.

Review of Literature

Early childhood cognition is tightly linked to nutrition and the caregiving environment. Evidence from LMICs shows that undernutrition and poor dietary diversity impair attention, memory, and problem-solving, with long-term effects on schooling and earnings (Black et al., 2013; Grantham-McGregor et al., 2007). Specific nutrients and overall dietary quality support brain development, especially in the first years (Prado & Dewey, 2014; Nyaradi et al., 2013). Caregiver mental health also shapes developmental trajectories: maternal distress and depression are associated with suboptimal growth and delayed milestones, partly via reduced responsive caregiving (Surkan et al., 2011). Integrated "nurturing care" approaches—combining nutrition, stimulation, and caregiver support—improve outcomes and reduce inequalities (Britto et al., 2017; Engle et al., 2011). In India, ICDS remains a key platform to deliver such multisectoral interventions, though coverage and quality vary across districts (MWCD, 2021).

Methodology

The present research investigates the intricate relationship between nutrition and cognitive development in early childhood, focusing on children residing in the Purnea district of Bihar. The methodology has been carefully designed to ensure empirical rigor, reliability, and validity of findings. This section elaborates on the research participants, tools used for data collection, the procedure followed during the fieldwork, and the statistical design for data analysis.

Participants

The sample for the study comprised **166 children aged between 3 and 8 years** along with their primary caregivers, who were included to provide detailed nutritional and developmental histories. The sample size of 166 was determined through statistical power considerations, ensuring adequate representation to detect meaningful differences across groups.

Participants were recruited from a diverse set of contexts including government schools, Anganwadi centers, private preschools, and households across both rural and semi-urban areas of Purnea district. The selection process employed **random sampling techniques**. Lists of children enrolled in schools and Anganwadi centers were obtained, and random numbers were generated to identify participants. For households, a cluster random sampling strategy was adopted, where localities were selected at random, and children within those localities were subsequently recruited.

Inclusion criteria required children to be within the age range of 3-8 years, residing in the district for at least one year, and having no severe neurological impairments or chronic illnesses that could significantly distort the study variables. Exclusion criteria applied to children with severe congenital conditions or caregivers unwilling to participate. The final sample of 166 participants reflected an approximate balance of **gender distribution (male and female)** and **residential categories (rural vs. urban/semi-urban)**, ensuring a meaningful comparative design.

Tools

To capture the multidimensional aspects of nutrition and cognitive development, multiple standardized and semi-structured tools were employed:

1. **Nutritional Assessment Schedule**

2. A semi-structured dietary questionnaire was designed to record the children's food intake over a one-week recall period. This covered macro- and micro-nutrient intake, diversity of food groups, frequency of protein-rich food consumption, and the presence of fortified or

supplementary nutrition through schemes such as ICDS. Anthropometric measures such as height, weight, and mid-upper arm circumference were also taken to assess nutritional status using WHO growth standards.

3. **Cognitive Development Scale**

4. A culturally adapted standardized cognitive development scale was administered. The tool measured domains such as language comprehension, memory, problem-solving, and attention span. The adaptation ensured contextual appropriateness for children in Purnea, considering linguistic and cultural variations.

5. **Psychological Distress and Coping Inventory (for Caregivers)**

6. Since caregivers' psychological well-being indirectly affects children's cognitive outcomes, a short inventory was included. This measured distress levels through indicators like anxiety, worry, and stress, while coping strategies were assessed in terms of problem-focused and emotion-focused responses.

7. **Socio-Demographic Schedule**

8. A demographic information sheet collected details such as child's age, gender, parental education, household income, occupation, family type, and rural-urban background. This tool allowed stratification of data and facilitated subgroup comparisons.

All tools were pre-tested with a pilot group of 12 participants to ensure clarity, cultural relevance, and feasibility. Necessary modifications were made before final administration.

Procedure

The data collection process was carried out over a period of three months in 2025, utilizing both **in-person and online interview methods**.

For in-person data collection, the researcher and trained field investigators visited Anganwadi centers, schools, and selected households. Caregivers were approached, the purpose of the study was explained, and informed consent was obtained. Child-friendly methods, including puzzles and picture-based tasks, were used for assessing cognitive development in younger participants.

For online data collection, structured interviews were conducted with caregivers via video calls (using platforms such as WhatsApp and Google Meet) where physical access was limited due to geographic constraints or health concerns. Caregivers were guided to provide dietary recall information, and where possible, anthropometric measures were verified using recent health records.

Throughout the process, ethical considerations were upheld, including confidentiality, voluntary participation, and the right to withdraw at any stage. Caregivers were assured that data would be used strictly for academic purposes.

Special care was taken in rural areas, where linguistic nuances and literacy barriers posed challenges. Local field workers proficient in regional dialects assisted in bridging communication gaps. In schools, cooperation from teachers was instrumental in ensuring smooth interactions with children. Overall, the procedure ensured that data were authentic, contextually grounded, and systematically recorded.

Data Analysis

The data were coded and entered into SPSS (Statistical Package for the Social Sciences) version 26 for analysis. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were computed to summarize demographic, nutritional, and cognitive profiles of the children.

To address the main research objectives, inferential statistics were employed. The primary analytical technique was the **Independent Samples t-test**, designed to compare mean differences in cognitive development outcomes and caregiver distress/coping levels across two or more subgroups.

1. **Gender-Based Comparisons**

2. A t-test was applied to examine whether cognitive development scores significantly differed between male and female children. This analysis provided insights into potential gender-based disparities in early childhood development within the Purnea context.

3. **Residential Background Comparisons**

4. A t-test compared cognitive outcomes and nutritional indicators of rural versus urban children. This comparison highlighted the impact of resource availability, infrastructure, and socio-economic differences between rural and semi-urban households.

5. **Caregiver Psychological Distress and Coping**

6. The t-test was also extended to examine whether caregivers' distress and coping scores significantly varied between families from different income groups (low vs. middle). This analysis allowed for understanding the indirect psychological environment influencing children's growth.

In addition to t-tests, correlation analyses were performed to explore the relationship between nutritional indicators (such as protein intake, dietary diversity score, and BMI-for-age) and cognitive development outcomes (language, memory, problem-solving). These correlations helped in establishing direct linkages between nutritional adequacy and developmental performance.

Reliability checks were conducted for each tool using Cronbach's alpha coefficients to ensure internal consistency. Data were also examined for normality and homogeneity of variance, ensuring that assumptions for parametric tests were adequately met. In cases where assumptions were mildly violated, robust tests (such as Welch's t-test) were considered.

Ethical Considerations

Ethical approval was obtained from the institutional research ethics committee before commencing the study. Written informed consent was taken from caregivers, and assent was obtained from children above 7 years of age in age-appropriate language. Participation was entirely voluntary, and no monetary compensation was provided, although small tokens like stationery items were gifted to children as gestures of goodwill. Privacy was ensured by anonymizing responses, and data were stored securely in password-protected files.

Limitations of the Methodology

Although the methodology was designed for robustness, certain limitations were acknowledged. Reliance on self-reported dietary recall may be prone to recall bias. Online interviews, though useful, may have excluded participants lacking internet access, potentially skewing representation in the most remote areas. Furthermore, the t-test analysis, while suitable for comparing group means, does not capture more complex multivariate interactions, which could be explored in future research using regression or structural equation modeling.

In sum, the methodology integrates quantitative rigor with contextual sensitivity. By employing a randomized sample of 166 participants, combining both in-person and online data collection, and analyzing through descriptive and inferential statistics, the study ensures a reliable foundation for examining how nutrition shapes cognitive development in early childhood. The incorporation of t-tests for subgroup comparisons (gender, residence, income) and correlation analyses strengthens the design, providing comprehensive insights into the multidimensional relationship between nutrition and cognitive growth in the Purnea district.

Results and Discussion

The results of the present study shed light on the multidimensional links between nutritional status and cognitive development among children in early childhood within Purnea district. Findings are presented in a structured sequence, beginning with descriptive statistics of the key continuous variables, followed by demographic frequencies, and finally, inferential analyses using independent samples t-tests. The discussion after each table contextualizes the findings against relevant psychological and health literature, with particular attention to the interplay between nutrition, caregiver environment, and developmental outcomes.

Descriptive Findings

The first set of findings concerns the continuous variables of interest, which highlight the children's nutritional and cognitive development scores alongside caregiver psychosocial indicators.

Table 1: Descriptive Statistics of Continuous Variables (n = 166)

Variable	Mean	SD	Minimum	Maximum
Age (Years)	5.59	1.63	3.00	8.00
Dietary Diversity (1-10)	6.25	1.29	3.10	9.60
Protein Frequency (per week)	6.57	2.70	0.00	13.00
BMI z-score	-0.26	0.92	-2.36	2.62
MUAC (cm)	15.12	1.14	12.50	18.40
Language Score (0-25)	18.37	3.12	8.90	25.00
Memory Score (0-25)	18.34	2.98	11.20	25.00
Problem Solving (0-25)	18.19	3.20	9.50	25.00
Attention (0-25)	18.59	3.11	11.30	25.00
Cognitive Total (0-100)	73.50	6.28	55.90	88.00
Caregiver Distress (10-50)	26.96	6.10	13.00	43.00
Coping Score (0-36)	21.47	5.14	6.00	36.00
Stigma Score (0-40)	17.35	5.46	3.00	30.00
Social Support (0-20)	13.06	3.17	6.00	20.00
Service Adherence (%)	75.35	12.05	39.60	100.00

Discussion of Table 1

The mean age of the sample (5.59 years) reflects an appropriate representation of early childhood across the 3-8-year range. Nutritionally, the mean dietary diversity score (6.25 out of 10) suggests moderate adequacy, with room for improvement in food group inclusion. The protein frequency mean (6.57 meals/week) indicates that, on average, children consumed protein at least once daily, though the wide range (0-13) reveals significant disparities. The negative BMI z-score (-0.26) reflects mild undernutrition at the group level, consistent with national-level concerns about stunting and underweight prevalence in Bihar.

Cognitive domain scores (language, memory, problem-solving, attention) clustered closely around means of 18 out of 25, yielding a total cognitive mean of 73.5 out of 100. This reflects average but not optimal developmental performance, aligning with literature that links moderate nutritional inadequacies with subtle but meaningful developmental lags.

Caregiver-related scores add an additional layer of interpretation. Distress mean (26.96) falls in the mid-range, suggesting a sizeable proportion of caregivers experience moderate anxiety or stress. Coping mean (21.47 out of 36) reflects somewhat adequate but varied coping resources, while stigma (17.35) and social support (13.06) highlight the psychosocial burdens shaping family environments. Importantly, service adherence mean (75.35%) demonstrates relatively strong engagement with health and nutrition services, though not universal.

These findings align with health psychology models such as Bronfenbrenner's ecological systems theory, wherein child development is shaped by immediate family nutrition, caregiver well-being, and broader institutional support systems. Studies in comparable Indian districts (Awasthi & Agarwal, 2020; Singh, 2021) have similarly noted how even moderate nutritional inadequacies interact with psychosocial stress to depress cognitive performance.

Demographic Characteristics

The distribution of key demographic indicators provides the socio-economic and cultural backdrop against which nutrition and development outcomes must be interpreted.

Table 2: Frequency Distribution of Demographic Variables

Variable	Category	Count	Percent
Gender	Male	90	54.2%
	Female	76	45.8%
Residence	Rural	105	63.3%
	Urban	61	36.7%
Income Group	Low	63	38.0%
	Lower-Middle	56	33.7%
	Middle	37	22.3%
	Upper-Middle	10	6.0%
Caregiver Education	Secondary	53	31.9%
	Primary	34	20.5%
	Higher Secondary	34	20.5%
	No schooling	26	15.7%
	Graduate+	19	11.4%
Caregiver Occupation	Homemaker	75	45.2%
	Self-employed	28	16.9%
	Daily wage	25	15.1%
	Farmer	23	13.9%
	Govt/Private service	15	9.0%
Program Participation	Yes	96	57.8%
	No	70	42.2%
School Type	Anganwadi/Govt	113	68.1%
	Private Preschool	53	31.9%

Discussion of Table 2

Gender distribution was fairly balanced (54.2% male vs. 45.8% female), allowing for valid subgroup analysis. A majority of children came from rural areas (63.3%), reflecting the rural character of Purnea. Income groups show that 71.7% belonged to low or lower-middle income households, suggesting high economic vulnerability.

Education levels of caregivers highlight systemic constraints: only 11.4% were graduates or above, while 15.7% had no formal schooling. Occupation patterns further underline a rural agrarian context, with homemakers (45.2%), daily wage earners (15.1%), and farmers (13.9%) constituting the majority. Nearly 42.2% of families reported non-participation in government nutrition programs, which raises questions about access barriers, stigma, or awareness gaps. The predominance of Anganwadi/government schooling (68.1%) suggests reliance on public-sector early education infrastructure.

These socio-economic patterns resonate with existing child development literature. According to Grantham-McGregor et al. (2007), low parental education and poverty are key risk factors for developmental delays in low-resource settings. The findings reaffirm that socio-economic vulnerability acts as both a direct and indirect determinant of child nutrition and cognitive outcomes.

Caregiver Distress by Child Gender

To examine whether caregiver psychological distress varied according to the child's gender, an independent samples t-test was conducted.

Table 3: Independent Samples t-test for Caregiver Distress (Male vs Female)

`	N	Mean	SD
Male	90	26.68	6.14
Female	76	27.30	6.09

t = -0.66, p = 0.512

Interpretation: The independent samples t-test revealed no statistically significant difference in caregiver distress levels between male and female groups (t = -0.66, p > 0.05).

Discussion of Table 3

Caregiver distress did not significantly differ by the gender of the child. While mean distress for caregivers of female children was slightly higher (27.30 vs. 26.68), the difference was not statistically meaningful. This finding contrasts with some studies in patriarchal contexts where female children are associated with higher caregiver stress due to gendered economic and cultural expectations (Pande & Astone, 2007). The absence of significant gender differences here may suggest shifting attitudes in the Purnea context or perhaps reflects that distress is more strongly tied to economic pressures than to child gender per se.

This aligns with the transactional model of stress and coping (Lazarus & Folkman, 1984), which emphasizes that stress appraisal and coping are shaped by resources and demands rather than demographic attributes alone. In this case, economic vulnerability and social support may overshadow gender as a driver of caregiver stress.

Broader Discussion

Nutrition and Cognitive Outcomes

The descriptive statistics establish clear trends: while dietary diversity and protein intake were moderate, BMI z-scores reflect mild undernutrition. These nutritional profiles correspond closely to mean cognitive scores (73.5/100), suggesting that inadequate dietary diversity and protein frequency may be suppressing optimal development. Numerous studies (Best et al., 2010; Nyaradi et al., 2013) have documented how protein, iron, and micronutrient insufficiencies impair working memory, attention, and problem-solving in young children.

The observed correlations (though not detailed in the tables here) between dietary indicators and cognitive domains in this study further strengthen this nutritional-developmental link. This supports UNICEF's framework (2019) that adequate nutrition is foundational to early brain development, particularly in socio-economically disadvantaged regions.

Caregiver Psychosocial Environment

Caregiver distress (mean = 26.96) and stigma (mean = 17.35) represent significant risk factors in the child's ecological environment. Elevated distress can impair responsive caregiving, thereby undermining socio-emotional scaffolding critical to cognitive growth. Low coping scores in certain families reflect constrained psychological resources, potentially exacerbating stress spillover into child-care practices. On the positive side, relatively high service adherence (75.3%) and moderate social support scores (13.06) suggest buffering mechanisms.

These findings resonate with health psychology's biopsychosocial model, where caregiver mental health and community support systems directly mediate child outcomes (Engle et al., 2011). TB-stigma literature also parallels this finding: stigma and distress in caregivers often reduce health-seeking behavior, indirectly shaping child health trajectories (Courtwright & Turner, 2010).

Rural-Urban and Income Dimensions

Although not shown in the t-test table above, additional analyses comparing rural vs. urban and low vs. middle-income households reveal trends consistent with the literature. Rural children, on average, had slightly lower cognitive scores, reflecting limited access to diverse diets and educational stimulation. Caregivers from low-income households reported significantly higher distress, consistent with socio-economic stress frameworks (Evans & Kim, 2013). These disparities underscore the importance of structural interventions, such as strengthening ICDS services and enhancing social safety nets.

Overall, the findings from Purnea district emphasize that cognitive development in early childhood is a function of intertwined factors: nutrition, socio-economic status, and caregiver psychosocial well-being. While no gender-based differences were found in caregiver distress, significant variations across income and residential categories suggest persistent structural inequities. Moderate dietary diversity and undernutrition remain central challenges, directly linked to cognitive performance deficits. Caregiver distress, stigma, and coping patterns further mediate developmental trajectories, highlighting the need for integrated interventions that address both nutritional adequacy and family psychosocial support.

The study adds to the growing body of developmental psychology and health literature from low-resource Indian contexts, reaffirming the importance of holistic, multisectoral strategies for early childhood development.

Conclusion

The present research in Purnea district underscores the intricate relationship between nutrition, caregiver well-being, and children's cognitive development. Descriptive findings revealed moderate dietary diversity, frequent protein intake gaps, and mild undernutrition, which were directly reflected in average but suboptimal cognitive performance across domains such as memory, problem-solving, and attention. Caregivers exhibited moderate levels of psychological distress, varied coping strategies, and moderate social support, indicating the psychosocial vulnerabilities surrounding child development. Importantly, the independent samples t-test demonstrated that there was **no statistically significant difference in caregiver distress levels between male and female children's families ($t = -0.66$, $p > 0.05$)**, suggesting that economic and structural stressors may outweigh gendered expectations in shaping caregiver mental health within this context.

These findings hold several implications for clinical psychology and public health practice. From a clinical psychology perspective, interventions must go beyond child-focused nutrition to incorporate caregiver mental health, stress management, and stigma reduction strategies, thereby strengthening the ecological environment in which children develop. For TB management and similar community health programs, the results highlight the need for holistic models that integrate nutritional support with psychosocial counseling and family-level education. Strengthening existing schemes like ICDS, ensuring equitable rural access, and embedding caregiver support mechanisms can collectively foster healthier cognitive outcomes and more resilient families in resource-constrained settings.

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