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From Survival to Thriving: Impact of Preterm Birth on Socio-Emotional Development at 18 Months in the Kinshasa Mother-Child Cohort (KMCC), DR Congo

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Abstract

Introduction

Prematurity is a leading cause of under-five mortality and long-term neurodevelopmental morbidity worldwide. While our parent study in the Kinshasa Mother-Child Cohort (KMCC) established that preterm birth nearly doubles early postnatal mortality (aHR 1.97), the developmental trajectory of surviving preterm infants in resource-limited settings remains understudied. This study evaluates socio-emotional outcomes at 15–18 months among KMCC survivors.

Method

This prospective nested cohort study evaluated 398 infants aged 15–18 months from the KMCC (Kinshasa, DR Congo). Socio-emotional development was assessed using the French/Lingala-adapted ASQ:SE-2, categorized as Low Risk (0–50), Monitor (51–64), and Refer (≥ 65). The developmental database was linked to the parent-cohort registry on the shared unique identifier (82.4% match). Generalized ordered logistic regression was used; complementary representativeness, survival-bias (IPW), cumulative-risk, interaction, threshold-sensitivity, and bootstrap analyses were performed.

Results

Among 398 children (26.1% preterm), ASQ:SE-2 categorized 43.0% as Low Risk, 17.8% as Monitor, and 39.2% as Refer. Preterm birth independently increased odds of Monitor/Refer (aOR 1.67; 95% CI 1.08–2.73). Single motherhood (aOR 2.41; 95% CI 1.45–5.08) and male sex (aOR 1.58; 95% CI 1.04–2.41) were independent predictors. Survival-bias analysis confirmed evaluated survivors were enriched in vulnerable characteristics; the preterm effect was stronger in boys (aOR 2.35) than girls (aOR 0.91). Cumulative risk showed a steep dose-response (OR 1.68 per factor).

Conclusion

Preterm birth, single motherhood, and male sex are associated with socio-emotional vulnerability at 15–18 months in Kinshasa. The burden is concentrated in boys. These findings support integrated developmental monitoring and family-centered nurturing care within post-neonatal follow-up in the DRC.

INTRODUCTION

Prematurity, defined as any birth occurring before 37 completed weeks of gestation, remains one of the major public health challenges worldwide [1]. Over the past few decades, the number of preterm births has increased [1]. In 2020, the number of preterm births worldwide was estimated at 13.4 million,

representing nearly one in ten births, with the heaviest burden concentrated in low- and middle-income countries (LMICs), particularly in sub-Saharan Africa and South Asia [2, 3].

Complications related to prematurity are the leading cause of death in children under five years of age and are also responsible for significant long-term morbidity, particularly affecting neurological, cognitive, behavioral, and socio-emotional development [1, 2, 4]. Advances in neonatal care have increased the survival rate of premature newborns. However, survivors remain vulnerable to long-term neurodevelopmental disorders [1, 5].

Socio-emotional development encompasses a child's ability to recognize and express their emotions, develop positive social relationships with others, control their behavior, and adapt to their social environment [6]. These skills are a major determinant of academic success, mental health, and social integration throughout life. Data from several international cohorts show that children born prematurely experience more emotional difficulties, anxiety disorders, attention problems, and an increased risk of psychiatric disorders in adolescence and adulthood [7–11].

The mechanisms explaining this association are complex and multifactorial. Perinatal brain injuries, brain immaturity, inflammation, neonatal stress, prolonged hospitalizations in intensive care units (ICUs), as well as psychosocial factors including the quality of parent-child interactions jointly contribute to the developmental trajectories of children born prematurely [7, 12, 13].

In LMICs, these risks are often amplified by limited access to specialized neonatal care, insufficient resources for developmental monitoring, malnutrition, infectious diseases, and adverse socioeconomic contexts [12, 14]. WHO and UNICEF emphasize that early interventions based on nurturing care, psychosocial support for parents, breastfeeding, kangaroo care, and early stimulation improve the overall development of children, particularly premature infants [14, 15].

In the Democratic Republic of Congo (DRC), prematurity remains a significant cause of neonatal morbidity and mortality. Despite efforts to improve neonatal care, particularly through the implementation of Kangaroo Care in several health facilities, data on long-term neurodevelopmental consequences, especially the socio-emotional development of premature infants, remain very limited. The few available studies have primarily focused on survival, growth, or psychomotor development [16–17], while socio-emotional dimensions remain insufficiently documented.

To address this knowledge gap, our research group initiated the prospective Kinshasa Mother-Child Cohort (KMCC). Preterm birth was significantly associated with six-week mortality, with low Apgar and low birth weight [18]. This study follows surviving infants from the same KMCC cohort to 15–18 months to evaluate socio-emotional development.

The aim is to: (1) describe socio-emotional development using ASQ:SE-2; (2) estimate the association between preterm birth and socio-emotional risk; and (3) examine how social vulnerability interacts with biological prematurity in Kinshasa.

METHODS

Study Design

This is a prospective nested cohort study within the KMCC. The parent cohort followed 2,383 dyads from birth to six weeks (March-July 2024) [18]. Children aged 15–18 months between 26 Sept-11 Nov 2025 were eligible and re-contacted via the cohort registry and community tracing using the unique identifier (key). The developmental database (n = 398) was linked to the parent cohort on the shared identifier; 326/398 (82.4%) matched.

Sample Size

The sample size for this study was calculated independently of that of the initial cohort using OpenEpi software. Since the expected prevalence of developmental delay or socio-emotional difficulties was unknown, we estimated it at 50%, with an absolute precision of α = 0.05, a 95% confidence level, and an anticipated non-response rate of 5%. The minimum required sample size was 404 children.

Data Collection, Measurement Instrument, and Variable

To ensure data quality and effective follow-up, data collection was carried out by physicians and nurses trained over three days. These interviewers completed the Age and Stages Questionnaire: Social-Emotional, Second Edition (ASQ:SE-2) between September 26, 2025, and November 11, 2025.

The ASQ:SE-2 is a standardized tool for assessing the socio-emotional development of children aged 1 to 72 months, enabling the early detection of socio-emotional difficulties in this area. It explores seven dimensions: self-regulation, compliance, communication, adaptive behaviors, autonomy, affect, and interaction. For this study, we used the 18-month ASQ:SE-2 edition, which is designed for infants aged 15 to 20 months and 30 days, corresponding to the study's target population. The questionnaire comprises 33 items, each offering four response options ("Often or always," "Sometimes," "Rarely," or "Never") [19]. Following each item, a follow-up question asked parents to indicate whether the observed behavior was a source of concern for them.

The responses allowed for the calculation of an overall score divided into three categories: (1) low risk for an ASQ:SE-2 score between 0 and 50, (2) Monitor for an ASQ:SE-2 score between 51 and 64, and (3) Refer for an ASQ:SE-2 score ≥ 65. The ASQ:SE-2 items were translated from English into French and Lingala, the vernacular language spoken in Kinshasa. The translation process involved collaborative work between a translator and the researchers, who then reviewed and compared the versions to arrive at an optimal translation. Identified inconsistencies were corrected, and a consensus was reached on the final version. Parents answered the investigators' questions on behalf of their child in the language of their choice.

The internal consistency of the questionnaires was assessed using Cronbach's alpha coefficient. For the ASQ:SE-2, the value obtained (α = 0.713) indicates acceptable reliability, consistent with the threshold of 0.70 generally considered the minimum criterion in the literature [20].

The primary exposure was prematurity (< 37 weeks). Covariates: maternal age, education, marital status, wealth quintile, parity, ANC (< 4 vs > = 4), delivery mode (vaginal vs Cesarean), birth weight (< 2500 g vs > = 2500), 5-min Apgar (< 7 vs > = 7), and child sex.

Statistics

Descriptive analyses of sociodemographic and obstetric variables, as well as infant characteristics, were performed. Participants were described using counts and percentages, and their sociodemographic characteristics were compared using chi-square or Fisher's exact tests where appropriate.

Given the characteristic of the dependent variable, socio-emotional development, we initially considered using an ordered logistic regression (ologit) model. This model relies on the assumption of proportionality of odds, according to which the effect of the explanatory variables is assumed to be constant across the different categories of the dependent variable. Failure to adhere to this assumption can lead to biased estimates. To verify this condition, we used Brant's test, which consists of a series of separate logistic regressions and whose Wald statistic, based on the χ^2 distribution, allows us to assess proportionality [21]. When the test is non-significant, the proportionality assumption is considered to be met; conversely, a significant result indicates a violation and suggests that the classical ordered logit model is not appropriate. In these situations, the model can be estimated using the generalized ordered logit (Gologit), as developed by Fu [22].

The variables in the multinomial model were selected according to the Directed Acyclic graph (DAG) and theoretical considerations, independently of their significance in bivariate analyses, in order to ensure proper adjustment of confounding factors and to avoid the introduction of biases related to purely significant selection [23–25].

In addition to the main model, complementary analyses were performed: (a) Linkage with the parent cohort and representativeness: the children evaluated at 15–18 months represent only the surviving and re-contacted part of the KMCC birth cohort and may therefore differ from it. The developmental database (n = 326) was linked to the parent-cohort registry using the shared unique identifier, which provided the perinatal data recorder at birth and vital status at six weeks. Linked children (n = 326) were compared to non-matched parent-cohort dyads who were not evaluated at 15–18 months (n = 2,116) for the exposure and all covariates, using χ^2 or Fisher’s exact tests. (b) Survival bias and inverse-probability weighting (IPW): children who died before 15–18 months could not be assessed. Because preterm birth, low birth weight and low Apgar score were associated with six-week mortality in the parent cohort [18], surviving preterm children may be a selected, healthier subgroup (“healthy-survivor” effect), which would bias the association towards the null. Six-week mortality was first described in the parent cohort

according to gestational age, birth weight and 5-minute Apgar score. A logistic regression model fitted on the whole parent cohort then estimated, for each child, the probability of surviving (p_surv) from maternal characteristics. Each linked child was weighted by 1/p_surv, and the weighted adjusted OR of preterm birth for the at-risk outcome was compared with the unweighted adjusted OR obtained in the same 326 liked children. Similar estimates were interpreted as an absence of material survival bias. (c) Cumulative risk ("risk-stacking): to examine whether biological and social vulnerabilities accumulate, a cumulative risk score was computed as the number of risk factors present among preterm birth, single motherhood and male sex (range 0–3). The proportion of at-risk children was described for each score level, and the score was entered as a continuous term in a logistic regression to estimate the OR per additional factor. (d) Interactions: preterm × sex and preterm × marital status interactions were tested by adding product terms to the adjusted logistic model. When an interaction was suggestive, the OR of preterm birth was estimated separately in each stratum. (e) Outcome definition and threshold sensitivity: because the ASQ:SE-2 cut-offs have not been validated in the Congolese population, we checked that the results did not depend on the categorization of the score. The total ASQ:SE-2 score was analyzed as a continuous variable using linear regression with heteroscedasticity-robust (HC1) standard errors and Poisson regression (incidence rate ratio, IRR). The binary outcome was also re-defined using alternative cut-offs of 45, 50, 55 and 60 points, and the aOR of preterm birth was re-estimated for each cut-off. (f) Bootstrap: to assess the stability of the preterm estimate given the moderate sample size, the adjusted model was re-estimated on 1,000 non-parametric replications (seed 1234), and the median aOR with its bootstrap 95% CI is reported.

Ethical Considerations

This study was approved by the Ethics Committee of the School of Public Health at the University of Kinshasa (ESP/CE/152/2023). The confidentiality of the information collected was guaranteed to the parents, who were informed of the objectives and methodology of the research. Written consent was obtained before their participation in the study at the initial enrollment and was also reiterated at the 15-month follow-up. Any child identified as having a developmental delay or disorder was referred to specialized care and rehabilitation facilities. Furthermore, the parents' choice not to participate in the research was fully respected.

RESULTS

Characteristics of the Study Population

Of the 404 participants required, a total of 398 were included in the study, corresponding to a response rate of 98.5%. The proportion of preterm births among the included infants was 26.1% (95% CI: 22.0–30.7%), corresponding to 104 out of 398 infants. Overall, approximately 74% of mothers were between 20 and 34 years old, with a mean age of 27.69 ± 6.18. Nearly nine out of ten mothers were living with a partner (87.4%). 94.2% of infants were between 17 and 18 months old, 6.3% were born with a low birth

weight, and 91.2% of infants were delivered vaginally. 44% of the mothers had attended fewer than four antenatal care visits during their pregnancy. The other characteristics are detailed in Table 1.

Table 1
Characteristics of participants according to gestational age from September to November 2025, Kinshasa.

	Total		Preterm		Term		p_value
	No.	%	No.	%	No.	%	
Maternal and Household characteristics							
Mother's age (years) (mean ± SD	27.69 ± 6.18		27.45 ± 6.28		27.77 ± 6.15		0.650
Maternal age (years)							0.559
15–19	39	9.8	13	33.3	26	66.7	
20–34	296	74.4	75	25.3	221	74.7	
≥ 35	63	15.8	16	25.4	47	74.6	
Maternal education							0.115
None / Primary	143	35.9	44	30.8	99	69.2	
Secondary / University	255	64.1	60	23.5	195	76.5	
Marital status							0.748
In union	348	87.4	90	25.9	258	74.1	
Alone	50	12.6	14	28.0	36	72.0	
Household wealth index							0.096
Poorest / Poor	12	3.2	1	8.3	11	91.7	
Middle	70	18.6	21	30.0	49	70.0	
Richer	149	39.6	47	31.5	102	68.5	
Richest	145	38.6	31	21.4	114	78.6	
Obstetrical characteristics							
Parity							0.839
Primiparous	137	34.4	38	27.7	99	72.3	
Pauciparous	154	38.7	38	24.7	116	75.3	
Multiparous	107	26.9	28	26.2	79	73.8	
ANC attendance							0.120
Less than 4 ANC	174	43.9	52	29.9	122	70.1	
4 ANC or more	222	56.1	51	23.0	171	77.0	

	Total		Preterm		Term		p_value
	No.	%	No.	%	No.	%	
Mode of delivery							0.644
Vaginal	363	91.2	96	26.4	267	73.6	
Cesarean	35	8.8	8	22.9	27	77.1	
Children's characteristics							
Childs's age (months)							0.996
15–16	23	5.8	6	26.1	17	73.9	
17–18	375	94.2	98	26.1	277	73.9	
Apgar score at 5 minutes							0.199
< 7	16	4.1	2	12.5	14	87.5	
≥ 7	375	95.9	101	26.9	274	73.1	
Birth weight (gram)							0.103
< 2500	25	6.3	10	40.0	15	60.0	
≥ 2500	373	93.7	94	25.2	279	74.8	
Sex							0.835
Girl	191	48.0	49	25.7	142	74.3	
Boy	207	52.0	55	26.6	152	73.4	

Socio-emotional development screening

In total, 43% (95% CI: 38.17–47.89%) infants were categorized as being at no risk or low risk; 17.8% (95% CI: 14.37–21.93%) were identified as infants to be monitored, and 39.2% (95% CI: 34.50–44.10%) were classified as infants to be referred, according to the ASQ:SE-2 questionnaire.

The median total score on the ASQ:SE-2 was slightly higher in preterm infants compared to term infants, suggesting greater socio-emotional difficulties in preterm births. However, the significant overlap in score distributions indicate that this difference should be interpreted with caution (Fig. 2).

In the bivariate analysis, the mother's marital status was associated with positive socio-emotional screening ($p < 0.05$). Children of single mothers were more frequently classified as "Refer" (50.0%) than those of mothers living with a partner (37.6%). Conversely, the proportion of children classified as "no risk or low risk" was higher among mothers living with a partner (45.4%) than among single mothers

(26.0%). The proportion monitor was also slightly higher among children of single mothers (24.0% vs. 17.0%).

Furthermore, the child's sex also showed a trend, with a higher proportion of boys requiring referral. The remaining characteristics were similar (Table 2).

Table 2
Characteristics of participants according to the socio-emotional development screening from September to November 2025, Kinshasa.

	No or low risk		Monitor		Refer		p_value
	No.	%	No.	%	No.	%	
Maternal and Household characteristics							
Gestational age (WA)							0.299
< 37	38	36.5	20	19.2	46	44.2	
37–42	133	45.2	51	17.3	110	37.4	
Maternal age (years)							0.275
15–19	12	30.8	11	28.2	16	41.0	
20–34	131	44.3	47	15.9	118	39.9	
≥ 35	28	44.4	13	20.6	22	34.9	
Maternal education							0.188
None / Primary	60	42.0	32	22.4	51	35.7	
Secondary / University	111	43.5	39	15.3	105	41.2	
Marital status							0.034
In union	158	45.4	59	17.0	131	37.6	
Alone	13	26.0	12	24.0	25	50.0	
Household wealth index							0.433
Poorest / Poor	2	16.7	3	25.0	7	58.3	
Middle	31	44.3	11	15.7	28	40.0	
Richer	59	39.6	27	18.1	63	42.3	
Richest	69	47.6	26	17.9	50	34.5	
Obstetrical characteristics							
Parity							0.567
Primiparous	53	38.7	26	19.0	58	42.3	
Pauciparous	68	44.2	24	15.6	62	40.3	
Multiparous	50	46.7	21	19.6	36	33.6	
WA = Week of Amenorrhea							

	No or low risk		Monitor		Refer		p_value
	No.	%	No.	%	No.	%	
ANC attendance							0.158
Less than 4 ANC	84	48.3	27	15.5	63	36.2	
4 ANC or more	86	38.7	43	19.4	93	41.9	
Mode of delivery							0.694
Vaginal	158	43.5	65	17.9	140	38.6	
Cesarean	13	37.1	6	17.1	16	45.7	
Children's characteristics							
Childs's age (months)							0.655
15–16	8	34.8	4	17.4	11	47.8	
17–18	163	43.5	67	17.9	145	38.7	
Apgar score at 5 minutes							0.903
< 7	6	37.5	3	18.8	7	43.8	
≥ 7	162	43.2	64	17.1	149	39.7	
Birth weight (gram)							0.715
< 2500	12	48.0	3	12.0	10	40.0	
≥ 2500	159	42.6	68	18.2	146	39.1	
Sex							0.053
Girl	94	49.2	30	15.7	67	35.1	
Boy	77	37.2	41	19.8	89	43.0	
WA = Week of Amenorrhea							

Empirical results of Gologit estimation

Brant result

We initially analyzed the data using an ordered logit regression (ologit). Based on the proportionality test, this regression proved inadequate for our analyses. Brant's test revealed a violation of the proportionality hypothesis ($\chi^2 = 28.88$; $p < 0.001$, $df = 11$).

Factors Associated with Infant Socio-Emotional Development

In the adjusted multinomial model, the factors associated with an ASQ:SE-2 Monitor or Refer, compared to a normal or low-risk outcome (Model 1), were preterm (aOR: 1.67; 95% CI: 1.08–2.73), maternal living alone (aOR: 2.41; 95% CI: 1.45–5.08), and male sex (aOR: 1.58; 95% CI: 1.04–2.41). In contrast, no factor studied was significantly associated with categorizing the infant as "Refer" compared to the categories "Normal/Low Risk" and "Monitor" (Model 2) (Table 3).

Table 3
Factors associated to socio-emotional development

	Model 1*			Model 2**		
	ORa	**p_value**	**95% CI**	**ORa**	**p_value**	**95% CI**
Gestational age (WA)						
< 37	1.67	0.042	1.08–2.73	1.45	0.127	0.89–2.34
37–42	Ref			Ref		
Maternal age (years)						
15–19	Ref			Ref		
20–34	0.90	0.807	0.37–2.17	1.14	0.764	0.49–2.65
≥ 35	0.86	0.778	0.30–2.49	1.05	0.924	0.37–2.95
Parity						
Primiparous	1.09	0.798	0.57–2.06	1.22	0.549	0.64–2.30
Pauciparous	1.10	0.728	0.63–1.96	1.21	0.521	0.68–2.14
Multiparous	Ref			Ref		
Marital status						
In union	Ref					
Alone	2.41	0.021	1.45–5.08	1.60	0.159	0.83–3.10
Maternal education						
None / Primary	Ref			Ref		
Secondaire/ University	0.95	0.841	0.59–1.53	1.39	0.183	0.86–2.28
Household wealth index						
Poorest / Poor	Ref			Ref		
Middle	0.22	0.062	0.04–1.08	0.47	0.241	0.13–1.67
Richer	0.31	0.140	0.06–1.47	0.51	0.280	0.15–1.74
Richest	0.22	0.058	0.05–1.05	0.35	0.101	0.11–1.22
Child's sex						
Girl	Ref			Ref		
* Model 1 = Normal vs Monitor + Refer; ** Model 2 = Normal + Monitor vs Refer						
WA = Week of Amenorrhea						

	Model 1*			Model 2**		
	ORa	**p_value**	**95% CI**	**ORa**	**p_value**	**95% CI**
Boy	1.58	0.034	1.04–2.41	1.46	0.087	0.95–2.24
* Model 1 = Normal vs Monitor + Refer; ** Model 2 = Normal + Monitor vs Refer						
WA = Week of Amenorrhea						

Representativeness and survival bias

Matching succeeded for 326/398 (82.4%). Survivors were enriched in low birth weight (16.3% vs 6.8%; p < 0.001) and low Apgar at 5 minutes (7.2% vs 2.5%; p < 0.001); other factors comparable. Six-week mortality: preterm 3.98 vs 1.79%, LBW 8.63%, low-Apgar 20%. None of the 326 evaluated children died; associations are conservative. IPW aOR 1.19 (95% CI: 0.67–2.09) vs 1.20 unweighted.

Cumulative risk ('risk-stacking'): 49.2% (0), 54.3% (1), 73.4% (2), 100% (3); linear OR 1.68 per factor (95% CI 1.27–2.22; p = 0.0003).

Interaction preterm×sex (key): OR 2.59 (95% CI; 1.00-6.73; p = 0.051). In boys aOR 2.35 (1.17–4.73; p = 0.017); in girls aOR 0.91 (p = 0.77). The effect is concentrated in boys.

Continuous score: Poisson IRR 1.10 (95% CI: 1.07–1.13; p < 0.001); preterm aOR stable 1.42–1.50 across thresholds.

Domain and bootstrap: no ASQ:SE 2 domain significant; bootstrap median aOR 1.43 (95% CI: 0.91–2.26).

DISCUSSION

This nested cohort study provides novel evidence on socio-emotional development at 15–18 months in Kinshasa, bridging with our published survival findings [18]. Preterm birth independently increased the odds of socio-emotional vulnerability by 67%; single motherhood and male sex compounded this risk.

Our results align with data demonstrating that preterm infants have increased vulnerability to neurodevelopmental disorders, particularly emotional, behavioral, and sociocognitive difficulties. A systematic review and meta-analysis, including over 64,000 children, highlighted adverse behavioral and cognitive outcomes in preterm infants, with effects persisting into school age [26]. Similarly, a systematic review of social cognition reported differences in social attention during early childhood and reduced performance on sociocognitive tests during the preschool period in preterm infants [27]. These disorders could be attributed to the combined effects of brain immaturity, neonatal complications, inflammation, disrupted sensory experiences, and psychosocial stress within the family. It is important to emphasize that prematurity is not the sole cause of socio-emotional disorders. Development results from the interaction between biological vulnerability, postnatal care, and the social context. These difficulties may partly reflect the diffuse, non-focal nature of brain injury associated with prematurity the

'encephalopathy of prematurity' which combines white matter injury with disrupted maturation of cortical and subcortical circuits implicated in neurodevelopmental disorders [28]. Repeated neonatal stress and pain exposure during neonatal intensive care unit stay have also been linked to altered hypothalamic-pituitary-adrenal axis reactivity, with elevated cortisol still detectable at 18 months in children born very preterm, which may further compound socio-emotional vulnerability in preterm survivors [29].

A central contribution is the 'healthy-survivor' (survival-bias) framing. With a nearly two-fold higher six-week mortality among preterm infants, the 18-month evaluated preterms are a resilient subset; the observed 67% risk increase is a conservative estimate, underscoring that survival gains require dedicated long-term developmental support. The most original result is the preterm-by-sex interaction: strong in boys (aOR 2.35) and absent in girls (aOR 0.91). Male susceptibility to neurodevelopmental vulnerability is established, and the socio-emotional sequelae of prematurity appear concentrated in male infants, with implications for targeted surveillance. This male-specific vulnerability is consistent with a recent systematic review and meta-analysis showing that boys born preterm or with low birthweight face a heightened risk of adverse neurodevelopmental outcomes compared to girls, a disparity not fully explained by biological or social confounders [30]. Given the borderline statistical significance of our interaction term ($p = 0.051$), however, this finding should be considered hypothesis-generating and warrants confirmation in larger, adequately powered cohorts. Risk-stacking shows a dose-response (OR 1.68/factor), indicating social vulnerabilities act additively with biological prematurity; a practical triage tool for family-centered care, especially for boys of single mothers.

The association observed in the first generalized ordered logit equation but absent from the second, requires careful interpretation. Prematurity was correlated with moving from the low-risk category to the categories including monitoring and referral but was not an independent factor for isolated referral compared to the two lower categories. This result suggests that prematurity may be linked to early or less severe socio-emotional difficulties detectable through screening, without, however, clearly distinguishing children requiring closer monitoring.

Children whose mothers were single parents were more than twice as likely to be placed in the monitoring/referral categories. This finding underscores the crucial role of parental support, the mental health of caregivers, time constraints, and material resources in the early socio-emotional development of young children. Nevertheless, marital status should be considered an indicator of social and family circumstances, rather than a causal factor. Research with families of premature infants has demonstrated that parental psychological well-being, attachment, and social support are correlated with child development [31–32]. Recent data also reveal that increased maternal sensitivity is correlated with a decrease in emotional and behavioral problems in premature infants [33–34]. These findings support family-centered approaches, which simultaneously integrate the developmental needs of the child with the psychosocial needs of caregivers.

Male sex was also correlated with a higher probability of obtaining an outcome requiring follow-up or referral. This finding is broadly consistent with data indicating that boys born moderately or late preterm

may exhibit a higher frequency of externalizing behavior problems, although sex disparities vary depending on developmental outcomes and the populations studied [35]. The observed association should therefore not be considered evidence of an intrinsic disadvantage associated with male sex; rather, it suggests the need for sex-differentiated developmental monitoring and further investigation of the behavioral domains contributing to ASQ:SE-2 scores. Longitudinal follow-up focusing specifically on self-regulation and affect domains would be particularly informative, as an international research agenda on early pathways to attention-deficit/hyperactivity disorder has identified infant self-regulation as a key early marker warranting closer developmental surveillance [36].

The high proportion of children classified as requiring referral (39.2%) calls for cautious interpretation. The ASQ:SE-2 is a screening tool and does not establish a clinical diagnosis. A screening result exceeding the referral threshold requires further developmental or clinical assessment, but does not necessarily confirm a socio-emotional disorder. This high frequency could reflect a genuine unmet need for developmental support, but it may also be affected by contextual differences in item interpretation, by the versions translated into French or Lingala, or by the use of thresholds that have not yet been formally validated with the Congolese population. The cross-cultural adaptation of developmental screening tools requires rigorous evaluation of content validity, construct validity, and the local context-adjusted follow-up and referral thresholds; internal consistency alone does not guarantee diagnostic validity. This concern is consistent with a recent multi-country evaluation showing variable diagnostic accuracy of ASQ-based screening tools in low-resource settings, underscoring the need for locally validated cut-offs before broader implementation in the DRC [37].

Our findings have practical implications for pediatric health services in Kinshasa. Developmental monitoring should be incorporated into the follow-up care of preterm infants, particularly boys and children from socially vulnerable households. The WHO recommends family engagement, caregiver support, discharge preparation, and ongoing post-hospital support for families of preterm or low birth weight infants [38]. Interventions that promote parent-child interaction are likely to optimize development; for example, early intervention targeting parents of preterm infants has been shown to improve their subsequent psychosocial and personal development [39]. In resource-limited settings, integrating caregiver support, personalized parental guidance, and targeted developmental monitoring into existing maternal, newborn, and child health services can be both feasible and beneficial. A critical next step will be to document the actual care pathway available to children screened as 'Refer' in Kinshasa, including access to pediatric neurodevelopmental and mental health services, since the clinical benefit of screening ultimately depends on the existence of a functional referral system downstream.

Strengths and Limitations

This study has several limitations. The ASQ:SE-2 was translated but not formally validated for the Congolese context. Results rely on caregiver self-report (reporting/social-desirability bias). Residual confounding possible (neonatal morbidity, maternal depression, parenting practices not all measured). In

particular, maternal postpartum depression was not systematically screened in this study, despite consistent evidence from low- and middle-income countries that postnatal depression is independently associated with adverse infant health and developmental outcomes, and may partly mediate the association observed here between single motherhood and socio-emotional risk [40]. Future waves of the KMCC should incorporate a validated maternal mental health screening tool, such as the Edinburgh Postnatal Depression Scale, to disentangle this pathway.

Survival bias is inherent: evaluated preterm children are a resilient survivor subset, so associations are lower-bound estimates. Prematurity was binary (gestational-stratum analyses would help). Single-time-point assessment prevents trajectories and causal inference.

Strengths: prospective nested KMCC design, Gologit2 after formal proportional-odds testing, DAG-guided confounding, explicit survival-cohort linkage (representativeness check and IPW survival-bias sensitivity), cumulative-risk and sex-interaction analyses, bootstrap stability, and ASQ:SE-2 administered by trained professionals [37].

Conclusion

In conclusion, this study bridges early neonatal survival and long-term thriving within KMCC. Preterm birth, single motherhood, and male sex significantly increase socio-emotional vulnerability at 15–18 months. To operationalize the WHO/UNICEF Nurturing Care Framework in the DRC, we recommend: (1) integrating routine ASQ:SE-2 screening; (2) psychosocial and home-visit support for single mothers of preterm infants; and (3) longitudinal validation of Congolese developmental norms and early-intervention programs. Recent efforts such as the WHO's Global Scales for Early Development (GSED), validated in a rural East African setting, illustrate a feasible approach for developing and validating context-specific developmental norms in sub-Saharan Africa, and could guide similar work for socio-emotional screening tools in the DRC [41].

Abbreviations

ANC
Antenatal care
aOR
adjusted odd ratio
ASQ
SE-2:Age and stages questionnaire:social-emotional, second edition
CI
confidence interval
DRC
Democratic Republic of Congo
ICU

intensive care unit
IRR
incidence rate ratio
KMCC
Kinshasa mother-child cohort
LMIC
Low- and middle-income countries
WHO
World Health Organization

Declarations

Authors' contributions

FKK and PAZ: conception and design of the study, analysis of data. FKK: writing original draft and critical revision of the manuscript. DDG: critical revision. HB, JM, PAZ: supervision and critical revision of the manuscript. All the authors read and approved the final manuscript.

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Clinical trial number: not applicable

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Figures

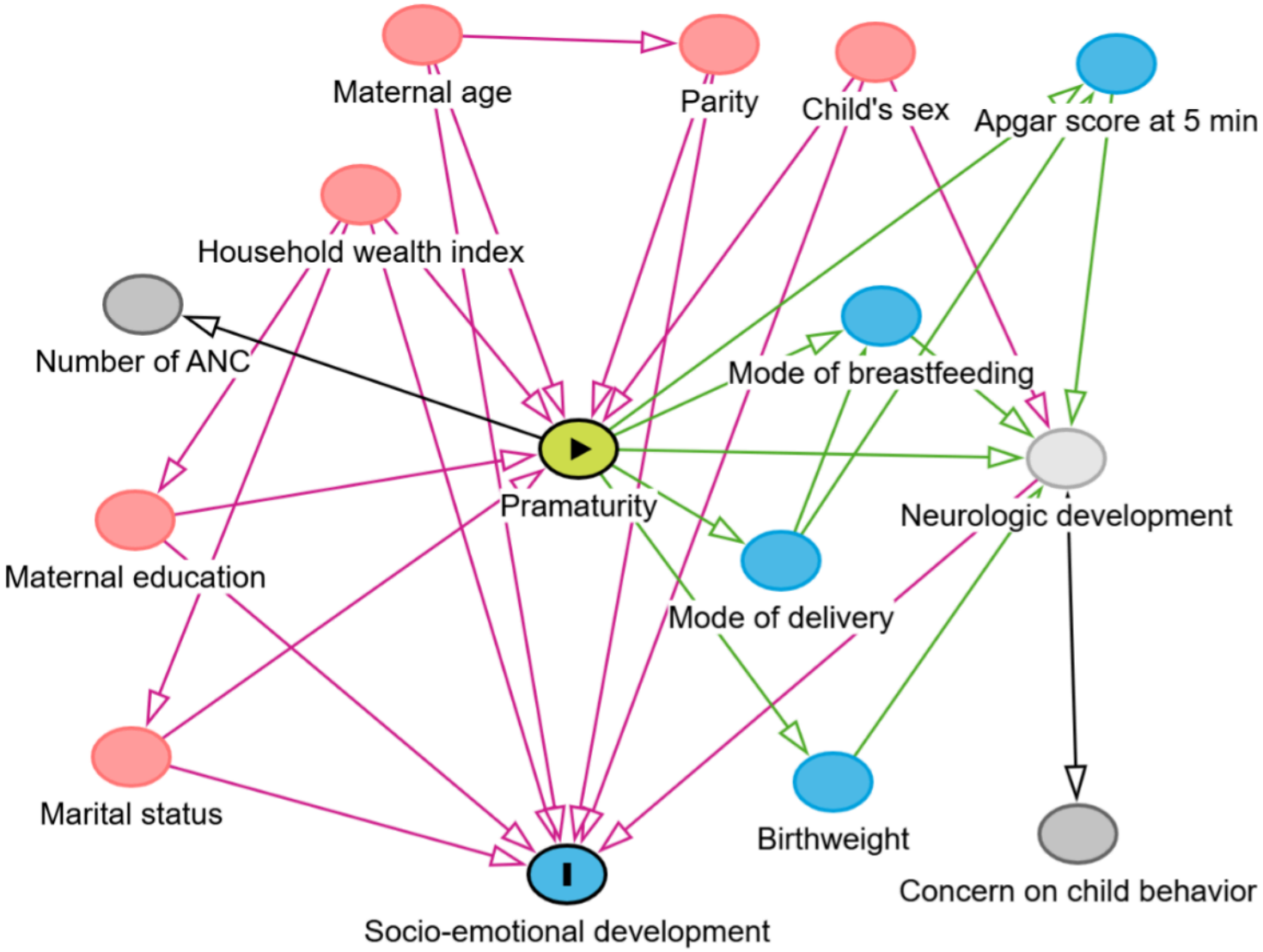


Figure 1

Direct Acyclic Graph for socio-emotional development

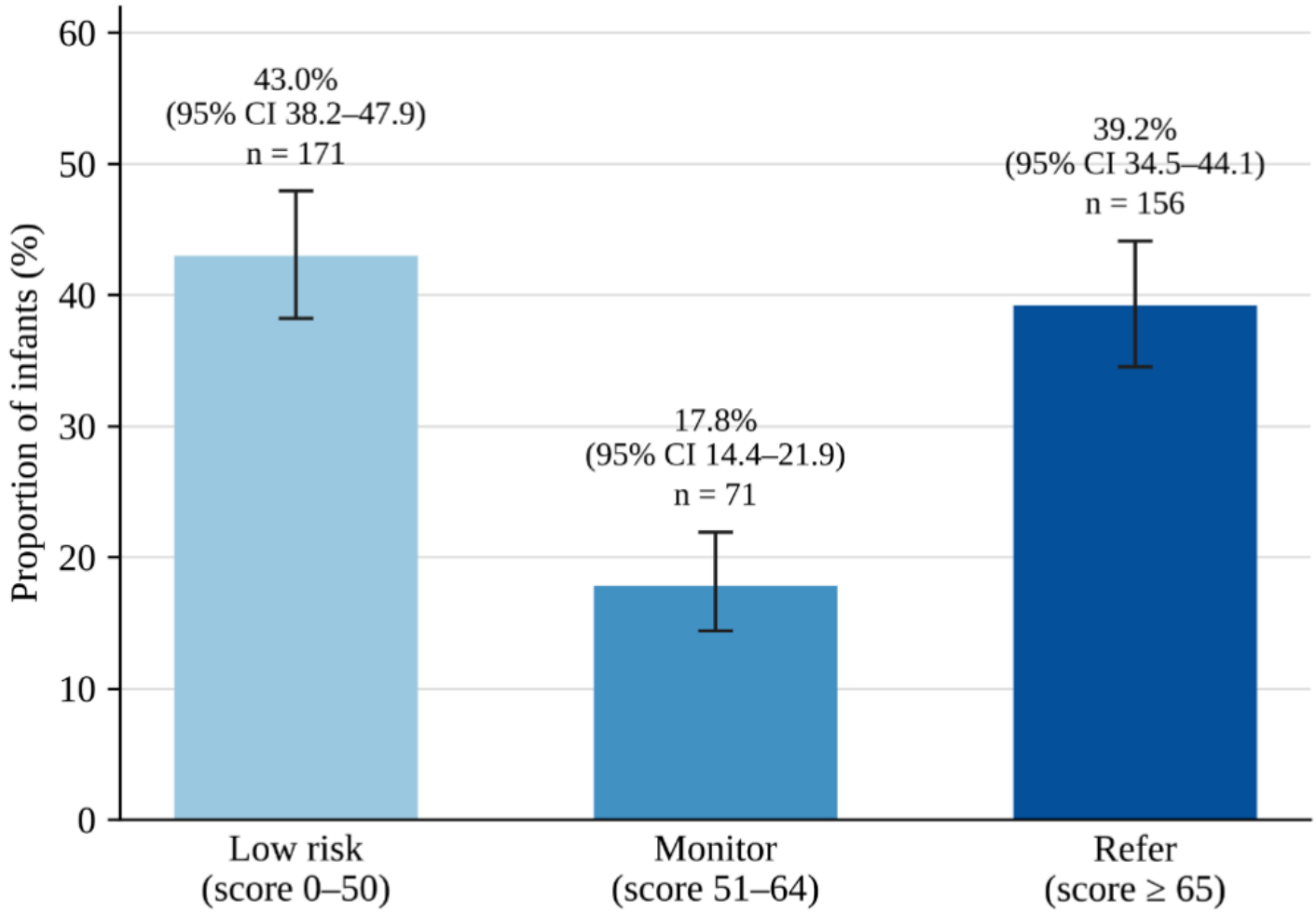


Figure 2

Distribution of infants according to the ASQ:SE-2

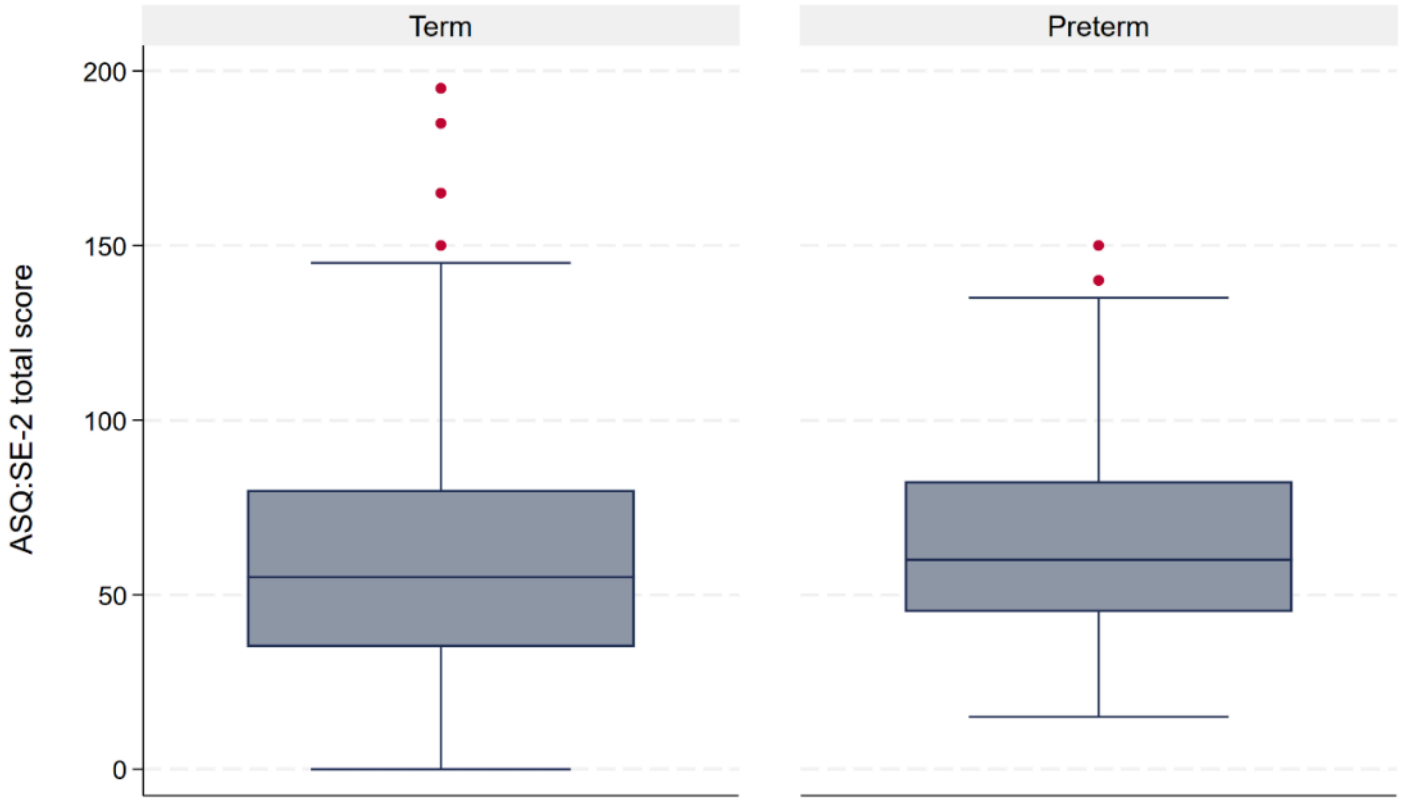


Figure 3

ASQ: SE-2 total score for Nourrisson preterm and term