



The impact of low birthweight in infant patterns of regulatory behavior, mother-infant quality of interaction, and attachment

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ABSTRACT

It remains unclear whether infants born preterm are more likely to develop an insecure attachment with their mothers. In this study, instead of using gestational age criteria, we observe attachment in infants born with very low birthweight. Although the collinearity between gestational age and birthweight is high, infants born with very low birthweight for their gestational age tend to stay more days in NICU and to have more comorbidities than other infants with the same gestational age. Thus, we wonder about the impact of low gestational birth (per se) in infants' regulatory behavior, the quality of mother-infant interactions, and attachment security. The participants are 71 infants' weight lower than 1599 g of gestational weight (varying between 23 and 34 weeks of gestational) and their mothers. Dyads were observed in free play and during Face to Face Still-Face paradigm with infants at 3 months of corrected age. At 12 months of corrected age, mother-infant attachment was observed during Strange Situation. Results indicate that infants with low/very low gestational birthweight have high levels of insecure attachment (70 %) and non-positive patterns of regulatory behavior (64 %). Maternal and infant interactive behavior is highly associated with infant attachment. In turn, maternal interactive behavior is associated with gestational age, birthweight, and number of days in NICU.

1. Introduction

Attachment is the emotional bond that evolves between an infant and their consistent caregivers [1]. Infant securely attached use their caregivers as a secure base to explore from and a source of comfort and reassurance in the presence of challenges or perceived threats. In contrast, insecurely attached infants fail in their attempt to obtain protection to explore or to be comforted after stressful events by caregivers [2]. To achieve attachment goals and deal with attachment figures, infants develop internal working models of their environment, relationships, and their own and others' behavior [3]. Recent neuroimaging research shows that these dynamic internal working models of multimodal experiences and interactions are not limited to attachment or social relationships but are also extended to intention attribution and action understanding [4].

In cross-cultural research with full-term infants at low biological or social risk, the incidence of secure attachment varies between 63 % and

77 % [5]. However, these values drop in samples with preterm (PT, infants born before completing 37 weeks of gestation), particularly in those with sequels, comorbidities or at social risk – varying between 33 % and 61 % (revision in [6]). Therefore, in healthy preterm infants with low social and family risk, the risk for attachment insecurity is minor (e.g., [7,8]). Yet, PT are more vulnerable to neurological abnormalities, physiological immaturities, and health comorbidities, and their families are more likely to face social and economic risks [9]. In sum, given the propensity of risks associated with premature birth, prematurity likely contributes to a higher prevalence of insecure attachment compared to samples of infants born at term.

Infants born with very low birthweight (<1500 g; VLBW) may be at higher risk to develop an insecure pattern of attachment with their mothers than other prematurely born infants, considering that this group (compared with others very preterm with higher birthweight) stays more days in NICU and have more neonatal risk factors (e.g., lack of oxygen). Such conditions lead to more comorbidities, developmental

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impairments and survival risk [10,11]. Thereby, mothers of VLBW experience more distress, trauma, and post-natal depression [12]. Also, resulting from their neurological immaturity, infants with very low birthweight present more reactivity, more negativity, and less self-control than other infants [13].

2. Attachment and their determinants: studies with infants born with very low birthweight

Only a few studies were performed with infants born with very low birthweight (see Table 1) regardless of their prematurity status (i.e., number of gestational weeks at birth). Two studies were performed exclusively with infants born under 1500 g of gestational weight. Brisch et al. [7] found 60 % of security at 14 months of age in VLBW at low

Table 1
Studies performed with infants born with very low birthweight.

Study	Sample characteristics	Attachment assessment	Attachment incidence
[7]	N = 79 Inclusion criteria: <1500 g of BW Mean of BW = 944 g (SD = 284, range = 320–1490) Mean weeks of GA = 27.6 (SD = 2.7, range = 23–35) 91 days of hospitalization Low social, educational and economical risk sample	Strange Situation Age of assessment: 14 months	B - 60.3 % A - 23.5 % C - 2.9 % D - 10.3 %
[14]	N = 34 Inclusion criteria: <1500 g of BW Mean of BW = 955 g (SD = 284) Mean weeks of GA = 27.9 (SD = 2.2). 86 days of hospitalization	Strange Situation Age of assessment: 14 and 19 months	14 months B - 55 % A - 21 % C - 15 % A/C - 8 % 19 months B - 47 % A - 26.5 % C - 26.5 %
[8]	N = 71 Inclusion criteria: <32 weeks GA or < 1500 g of BW Mean of BW = 1245 g (range = 521–2158) Mean weeks of GA = 30 (range = 24–33). 58 days of hospitalization Low social, educational and economical risk	Strange Situation Age of assessment: 18 months	B - 61 % A - 3 % C - 4 % D - 32 %
[15]	N = 50 (Inclusion criteria: <32 weeks GA) Mean of BW = 1270 g (SD = 374; range = 500–1930) Mean weeks of GA = 29.8 (SD = 2.10; range = 23.5–32.5). 51 days of hospitalization High social, educational and economical risk	Strange Situation Age of assessment: 12 months of corrected age	B - 30 % A - 40 % C - 30 %
[16]	N = 48 Two samples High Risk (sic or health sequels) - N = 30 Mean of BW = 1399 g (SD = 389) Mean weeks of GA = 30.6 (SD = 2.6). 58 days of hospitalization Low Risk (healthy infants N = 18) 10 days of hospitalization Mean of BW = 2134 g (SD = 245) Mean weeks of GA = 33.8 (SD = 1.9).	Strange Situation Age of assessment: 36 months	High-risk B - 53 % A - 10 % C - 37 % Low-risk B - 67 % A - 28 % C - 5 %

social risk. Another study found that attachment security drops from 55 % at 14 months to 47 % at 19 months of age [14]. Overall, these two studies indicate a lower incidence of secure attachment in VLBW than in infants born at full-term. It is also noteworthy that the incidence of avoidant attachment is above 20 % in these two studies. Other studies included VLBW (revision in Table 1), but not exclusively, and presented more dispersed results (e.g., attachment security varied between 75 % and 30 %).

Considering the characteristics of the samples (studies on Table 1), it seems that security prevalence varies according to mothers' years of education and family SES (Social Economical Status). Also, it appears that infants' health status aggravates insecurity.

When looking for causes to explain the lower prevalence of secure attachment in samples with VLBW, some studies found that mothers were more intrusive, controlling, and less sensitive while infants presented less cooperative behavior [12,17]. Research performed in the context of the experimental paradigm of Face to Face Still-Face (FFSF) found that VLBW tends to present less self-directed and self-comforting behaviors during these experiences [18]. Studying patterns of regulatory behavior in infants born with <32 weeks of gestational age (very/extreme preterm - VEP), Antunes et al. [15] showed that Social-Positive Oriented regulatory pattern was associated with secure attachment, the Distressed-Inconsolable pattern was associated with insecure-ambivalent attachment, and the Self-Comfort Oriented pattern was associated with avoidant attachment. Moreover, this study indicates a much lower incidence of a Social-Positive Oriented regulatory pattern in VEP compared to full term counterparts [19]. Nevertheless, infants with a Social-Positive regulatory behavior can maintain positive states during maternal unavailability or easily recover after. Also, they engage in positive and reciprocal interactions during non-stressful interactions. According to our best knowledge, no study about infant patterns of regulatory behavior included exclusively VLBW.

2.1. Present study

We add to this body of research a study about attachment security and their determinants in dyads with infants born exclusively with very/extremely low birthweight. To our best knowledge, this is the first study that investigates the attachment security, maternal and infant interactive behavior, and patterns of infant regulatory behavior at 12 months of corrected age in dyads with VLBW. Moreover, in this study, we are not excluding dyads at social and family risk, and we wonder how biological and social factors combined will affect our results.

3. Method

3.1. Sample characteristics and recruitment

Participants included 71 infants born (37 girls, 34 boys) with <1599 g of gestational weight ranging from 23 to 34 weeks of gestational age and their mothers. Dyads were followed longitudinally from infants' birth to 12 months postpartum (corrected for gestational age).

Recruitment of the sample took place over a two-year period before covid-19. Two research assistants contacted potential participants in the maternity wards and NICUs of Lisbon and Porto metropolitan hospitals and explained the study's purpose and procedures to them. To be eligible to participate in the present study, infants and mothers had to meet the following inclusion criteria. Infants had to have (a) birth weight <1.500 g. Mothers had to be (a) at least 18 years old at the time of the infant's birth; (b) their infant's primary caregiver; and (c) free of any record of severe mental health or drug/alcohol addiction problems, as determined by medical record review and maternal self-report. Although we meant to include only infants with birthweight <1500 g, we also included seven dyads with slightly heavier infants (but lighter than 1550 g) and one with 1595 g because infants tend to lose weight in the first days of life.

3.2. Perinatal and demographic characteristics

All information regarding infants' perinatal characteristics and demographic information were collected from hospital records (detailed information in Table 2). No infants had sensory or neuromotor disabilities, serious illnesses, or congenital anomalies. Forty-three infants had infectious diseases and consumed antibiotics (60.6 % of the sample) by medical prescription during the first year of their life.

About 57.7 % of the mothers (N = 41) were Portuguese-Caucasian from urban, employed, working-class, and middle-class socioeconomic backgrounds and had more than nine years of formal education. Also, 28.2 % Portuguese parents (mother or father, N = 20) were unemployed (Portuguese unemployment rate is 6 %). Around 15.5 % (N = 11) of the participants were from very low SES backgrounds, unemployed, less than nine years of education, and of African nationalities. Seven mothers were single mothers. Descriptive statistics for the perinatal and demographic characteristics of participants are provided in Table 2.

3.3. Procedures

All procedures in the present study were conducted according to the ethical guidelines presented in the Declaration of Helsinki, with written informed consent obtained from all individual participants or their legal guardians in the study before any assessment or data collection took place. All procedures were approved by the Ethics Committees of all Health Units and Hospitals involved, as well as by the Portuguese Data Protection Commission.

At 3 and 12 months postpartum (corrected age), mothers were contacted to schedule a follow-up visit to the laboratory. Mother-infant dyads were videotaped during one free-play situation and two laboratory paradigms: (1) the FFSF paradigm [20] when infants were 3 months old and (2) the Strange Situation procedure [21] when infants were 12 months old.

Face-to-Face Still-Face paradigm (FFSF, [20]). The FFSF paradigm includes three successive three-minute episodes: (a) a face-to-face baseline interaction during which mothers were instructed to play with their infants as they normally would at home without using toys or pacifiers; (b) a still-face perturbation, during which mothers were instructed to keep a "poker face" while looking at the infants, and to refrain from smiling, talking, or touching the infant; and (c) a reunion episode, during which mothers were instructed to resume their normal play interaction with the infant. To mark the beginning and end of each episode more clearly for scoring purposes, each episode was separated by a 15-s interval during which the mother was asked to turn away from the infant.

Mothers and infants were videotaped during the FFSF using two cameras, one focused on the mother's face and upper torso, and the other focused on the infant's face and body. Both cameras were connected to an image mixer software that generated a time-synchronized split-screen image of each partner on a single video record.

Mother-infant free play interactions were assessed with *Child-Adult Relationship Experimental Index* (CARE-Index). According to the Care-Index manual [22], maternal sensitivity is any pattern of behavior that

pleases the infant, increases the infant's comfort and attentiveness, and reduces his/her distress and disengagement. The CARE-Index was used to score qualitative dimensions of infant-adult interaction during free play at the 9-months lab visit. The CARE-Index system assesses seven aspects of mother-infant interactive behavior: facial expressions, verbal expressions, position and body contact, affection, turn-taking contingencies, control, and choice of activity. Each adult and infant are evaluated separately in each of these seven dimensions of interactive behavior.

The points for each dimension are added to yield seven scale scores, three adult independent scales, namely Sensitivity, Control, Unresponsiveness and four independent infant scales, namely, Cooperative, Compliant-compulsive, Difficult, and Passive, behaviors [22]. The videotaped free play interactions were scored by two trained and blind (against the study) coders on the CARE-Index. Inter-coder reliability was evaluated by comparing the two coders' ratings using ICC-intraclass correlation coefficients [23]. The obtained overall average ICCs was 0.86. According to manual instructions, each interaction lasted 5 min [22].

The *Strange Situation* [21] is a 21-minute laboratory-based observational paradigm involving a sequence of eight brief (3 min) episodes (or less if the infant is distressed) of increasing stress for the infant, including being introduced to an unfamiliar playroom, interacting with an unfamiliar adult stranger, and two mother-infant separations and reunions.

3.4. Measures

The *Coding System for Regulatory Patterns in the FFSF* [24] was used to score infants' regulatory patterns from videotapes of the FFSF at 3 months. This coding system describes three patterns of infants' regulatory behavior: *Social-Positive Oriented* pattern (i.e., infants exhibit predominantly positive social engagement and fully recover after maternal unavailability in the last episode of FFSF), *Distressed-Inconsolable* pattern (i.e., infants display conspicuous negative affect that persists or increases across FFSF episodes), and *Self-Comfort Oriented* pattern (i.e., infants primarily engage in self-comforting behaviors and are uncomfortable during all episodes of FFSF), that were derived from four dimensions of infants' behavior and affective facial expressions across the three episodes of the FFSF paradigm: (a) behavior organization (e.g., the infant exhibits predominantly positive social behavior, distressed behavior, or self-comforting behavior, or a mixed-pattern behavior); (b) intensity of exhibited behavior (e.g., the infant displays prolonged and intense crying); (c) quality of behavior (e.g., the infant reacts by displaying signals denoting pleasure such as smiles, laughter, and reciprocal neutral or positive vocalizations); and (d) infants' ability to recover from negative affect during the reunion episode of the FFSF.

The FFSF videotapes were scored for infant regulatory patterns by three trained, reliable coders. The inter-coder agreement was calculated by Cohen's kappa coefficient. Results indicated good agreement for all regulatory patterns ($M\kappa = 0.74$). Following the assessment of inter-coder reliability, discrepant classifications were discussed and resolved in conference.

3.4.1. Attachment classifications

Videotapes of infants' attachment behavior during the Strange Situation were scored by two trained, reliable coders following the procedures developed by Ainsworth et al. [21]. Infants were classified as either securely attached (B), insecure-avoidant (A), insecure-ambivalent (C), or insecure-disorganized (D). Cohen's kappa coefficients ($M\kappa = 0.89$) indicated excellent inter-coder reliability. Because only five cases (6.9 % of the sample) were scored as D, there are not enough cases to present reliable results with disorganized attachment.

Table 2
Sample characteristics.

	M	SD	Min.	Max.
Gestational weeks at birth	29.86	2.14	23.50	34.00
Birthweight (g)	1191.42	298.57	500	1595
Apgar at first minute	6.96	2.121	1	9
Apgar at fifth minute	8.65	1.110	2	10
Days in NICU	66.67	50.18	9	250
Parenteral nutrition	16.35	8.10	2	48
Maternal age	32.96	5.494	18	46
Maternal years of education	13.87	4.177	3	24
Number of siblings	0.65	0.85	0	4

4. Analytic plan

Three sets of statistical analyses were conducted to address the goals of the current study. First, the distribution of regulatory behavior patterns and attachment patterns were obtained using univariate frequency analysis. Second, cross-tabulations were performed to investigate the prevalence between the regulatory behavior patterns at 3 months and attachment patterns at 12 months. The chi-square test was used to determine group differences in prevalence. Additionally, the Bonferroni test correction was used as a measure of proportional reduction in error type I to predict patterns of attachment at 12 months based on patterns of regulatory behavior at 3 months. Third, bivariate statistics were used to evaluate the association between perinatal and demographic variables and (a) the three infant regulatory patterns at 3 months and (b) attachment classifications at 12 months. Fourth, correlational statistics were performed to study the association between perinatal and demographic variables and maternal and infant interactive behavior.

5. Results

5.1. Patterns of regulatory behavior of infants born with very low birthweight

In this sample, the most frequent pattern of regulatory behavior was Distressed-Inconsolable (39.4 %, $N = 28$), followed by Social Positive Oriented (35.2 %, $N = 25$) and less frequent is Self-Comfort Oriented (25.4 %, $N = 18$).

5.2. Patterns of attachment of infants born with very low birthweight

In this sample with infants with very low birth and risk accumulation, we found that only 29.2 % ($N = 21$) of the infants are securely attached. In the group of insecurely attached infants, 35.8 % ($N = 25$) are avoidant, and 36.1 % ($N = 26$) are ambivalent/resistant (results in Table 3).

5.3. Mother-infant quality of interaction in dyads with infants born with very low birthweight

According to Table 3, the means of maternal sensitivity and infant cooperativity in dyads with infants born with very low birthweight are of moderate to low quality (<6 out of 14 points of maternal security/infant security means that dyads are at risk for interactive problems), while maternal control and infant cooperativity are the second most prevalent maternal and infant behaviors.

5.4. Patterns of regulatory behavior and patterns of attachment

Our findings, described in Table 4, indicate a strong association between infants' regulatory behavior patterns and their attachment patterns (Fisher-Freeman-Halton = 42.146, $p < .001$, Cramer's $\phi = 0.579$). In fact, most infants with a secure attachment at 12 months presented a Social Positive Oriented pattern of behavioral regulation at 3 months of age (60 %), whereas infants classified as ambivalent attached presented

Table 3

Means, standard deviation, minimums and maximums of maternal and infant interactive behavior observed in free play at 9 months of corrected age.

	M	SD	Min.	Max.
Maternal sensitivity	7.44	2.322	4	13
Maternal control	3.93	3.654	0	10
Maternal unresponsivity	2.63	3.141	0	9
Infant cooperativity	7.00	2.217	4	13
Infant compulsivity	2.77	3.903	0	10
Infant difficult behavior	3.70	3.689	0	10
Infant passivity	0.53	1.442	0	6

Table 4

Association between regulatory behavior patterns at 3 months and attachment patterns at 12 months in VLBW.

		Attachment at 12 months			Total
		Avoidant	Secure	Ambivalent	
Patterns of regulatory behavior at 3 months	SPO	4 (16 % –2.3) ^a	15 (60 % 4.1) ^b	6 (24 % –1.6) ^a	25
	DI	4 (14.3 % 2.8) ^a	5 (17.9 % –1.7) ^a	19 (67.9 % 4.4) ^b	28
	SCO	16 (88.9 % 5.7) ^a	1 (5.6 % –2.6) ^b	1 (5.6 % –3.2) ^b	18
Total		24	21	26	71

Note. Each superscript letter denotes a subset of attachment at 12-months categories whose column proportions do not differ significantly from each other; $p < .01$ (column proportions test with Bonferroni adjustment). SPO = Social-Positive Oriented; DI = Distressed Inconsolable; SCO = Self-Comfort Oriented.

Distressed Inconsolable patterns three months before (67.9 %), and infants classified as avoidant at 12 months presented a Self-comfort Oriented pattern (88.9 %) at 3 months (Fig. 1).

5.5. Mother-infant interactive quality according to infant attachment

Our results indicate differences in maternal and infant interactive behaviors according to attachment patterns (Table 5). The values of maternal sensitivity and infant cooperativity are higher in dyads with infants securely attached, while maternal control and infant compulsivity are higher among avoidant attached infants, and maternal unresponsivity and infant difficulty are higher among infants ambivalent attached.

5.6. Demographics according to infant patterns of regulatory behavior, mother-infant quality of interaction, and attachment

No association was found for Gestational age, Birthweight, Apgar at the first minute, Apgar at the fifth minute, Maternal age, Maternal years of education, and Number of Siblings, according to infant patterns of behavioral regulation observed at 3 months or to infant attachment patterns observed at 12 months (corrected age) in Strange Situation.

However, maternal control was correlated with infant Gestational age ($r = -0.251$; $p = .035$) and maternal passivity was correlated with infant Gestational age ($r = -0.304$; $p = .01$) and Birthweight ($r = -0.254$; $p \leq 0.032$). Infants who stayed more days in NICU had mothers with high scores of passivity ($r = 0.309$; $p = .009$). We also found that 47.8 % (22/46) of the secure and avoidant attached infants consumed antibiotics in the first 12 months of life, against 76.0 % (19/25) of ambivalent attached infants [$\chi^2(1) = 3.850$; $p = .05$]. Therefore, the antibiotic prescription is three-fold more likely among ambivalent-attached infants (95 % confidence interval, 1.02–8.99) than among the other infants.

6. Discussion

VLBW infants are very immature in terms of motor, mental, behavioral, and emotional development and have a high risk for survival. This study adds to the body of research about attachment security of preterm, an investigation about mother-infant attachment and their possible determinants in dyads with infants born with very low birthweight. For that purpose, we studied 71 infant-mother dyads in free play, during the Face to Face Still-Face paradigm when infants were 3-months old of corrected age, and in Strange Situation at 12 months of corrected age.

Our findings indicate an impressive high prevalence of insecure attachment (70 %). Other Portuguese studies [15,40] with infants born very or extremely preterm have also found critical levels of insecurity (around 60 %). Research performed with VLBW in the USA and other European countries [7,14] also found a lower incidence of secure

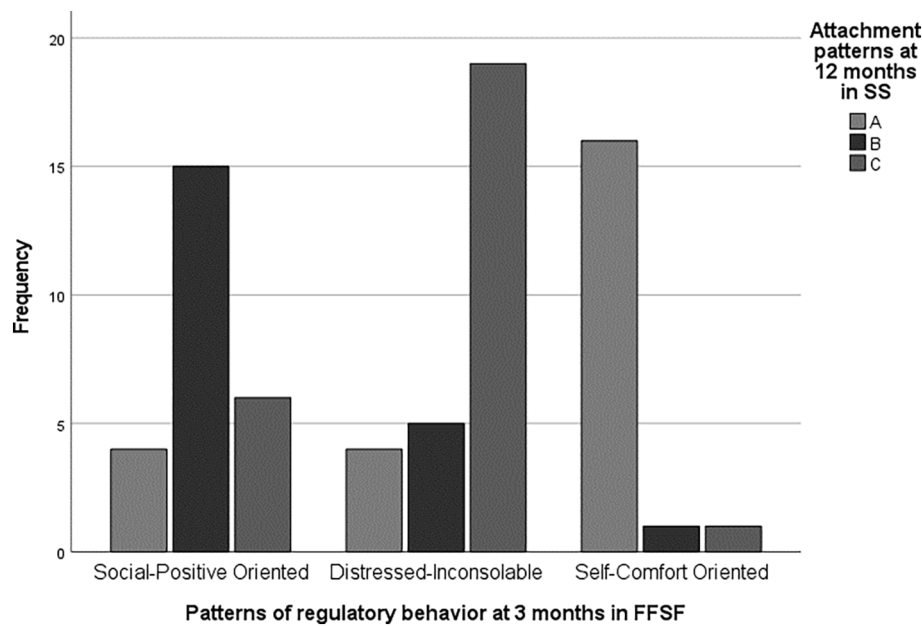


Fig. 1. Association between infants' regulatory behavior patterns and their attachment patterns.

Table 5

Means, standard deviations, and MANOVA results for perinatal factors and demographics, according to attachment patterns during the Strange Situation at 12 months (corrected age).

Interactional variables	Avoidant M (SD)	Secure M (SD)	Ambivalent-resistant M (SD)	F (3, 67)	p	Tukey HSD
Maternal sensitivity	6.50 (2.02) ^a	9.24 (2.21) ^b	6.85 (1.87) ^c	11.967*	0.001	b > a, c
Maternal control	6.08 (3.65) ^a	2.33 (3.01) ^b	3.23 (3.02) ^c	7.973*	0.001	a > b, c
Maternal unresponsivity	1.42 (2.58) ^a	2.43 (2.62) ^b	3.92 (3.38) ^c	4.434*	0.015	c > a
Infant cooperativity	6.42 (1.91) ^a	8.67 (2.15) ^b	6.09 (1.79) ^c	10.982*	0.001	b > a, c
Infant compulsivity	6.48 (3.93) ^a	0.67 (2.13) ^b	1.41 (2.87) ^c	24.079*	0.001	a > b, c
Infant difficulty	1.17 (2.37) ^a	3.57 (3.20) ^b	6.15 (3.51) ^c	16.470*	0.001	a < b, c
Infant passivity	0.21 (0.83)	1.14 (1.98)	0.32 (1.43)	2.912	0.061	

Note: Means with a different superscript are statistically different at $p < .05$ according to Tukey HSD procedure.

attachment than in infants born at full-term (47 %–60 %). Indeed, these values contrast with the findings obtained in Portuguese dyads with full-term infants from middle-class households, where attachment insecurity drops to 30 % or less [6,25,26].

In the case of this study, we can also explain the lower levels of attachment security with the presence of social risks (e.g., Low SES, Parents unemployment, Low maternal education). Indeed, the incidence of attachment security in PT tends to decrease in the presence of other social risks factors, such as low SES [27,40] or low parental education [28–30,40]. Such findings corroborate the premises of the Transactional Model of Sameroff & Fiese [31], which proposes that “the development of the child is a product of the continuous dynamic interactions of the child and the experience provided by his or her social settings” (p.1). The transactional model emphasizes the bidirectional and interdependent effects of the children's contribution, their social partners' feedback, and experiences in life contexts. Preterm, particularly those with very or extremely low birthweight, are prone to greater risks during their stay in the NICU (e.g., infections or cerebral hemorrhage), leaving the parents anxious and concerned with their survival. Furthermore, parents feel detached and separated from their infants, as they cannot interact as freely with their infants as they would at home [32]. At the same time, VLBW struggles to respond and react to their parents' stimulus resulting from their altered health and neurofunction status. Adding parents worries to infants' difficulties, the interaction evolves from transactional processes to disengagement or persistent negative states. Corroborating this perspective, we found lower maternal sensitivity and infant cooperative

behavior in this sample compared with FT [33].

As it has been documented (both with full-term and preterm infants), the secure attachment was positively associated with infant Social-Positive Oriented regulatory pattern during FFSF and with maternal sensitivity and infant cooperative behavior in free play interactions [6,25,33]. The insecure-ambivalent attachment was positively associated with infant Distressed-Inconsolable regulatory pattern, maternal unavailability/passivity in free play, and Antibiotic uptake during the first year of life. Finally, the avoidant attachment was positively associated with the infant Self-Comfort Oriented pattern regulatory pattern in FFSF, and with maternal control, infant compliance. Moreover, avoidant attachment was negatively associated with infant difficult behavior in free play interactions. Overall, we found that infants exhibit coherent behavior patterns both in stressful situations observed in experimental paradigms such as Strange Situation or FFSF and at regular free play interactions.

Supporting the significance of maternal behavior in this transactional process, we also found that maternal passivity was negatively correlated with infant gestational age and gestational weight, and positively correlated with the number of days that infant stayed in NICU. We speculate that VLBW responses are affected by their health condition and neuroprocessing while the pos-natal maternal experiences affect maternal behavior. It is important to stress that some infants stayed >200 days in the NICU – >6 months of their lives, these hospitalizations leave mother-infant relationships *on hold*. Both (infant and maternal behavior) mutually affecting and affected by infant regulatory behavior

and dyadic mutual regulation, may lead to the impressive amount of insecure attachment that we found.

Also, a tendency for higher prevalence avoidant attachment seems persistent in samples that included VLBW compared with samples of infants born at full-term [7,14]. It is possible that the very intrusive and painful healthcare provided in NICU to newborns (although necessary) may shape infants' ability to cope with these experiences by withdrawing and self-managing. Another explanation, drawn from our results, is that infant compliance and ability to self-comfort facing maternal controlling and intrusive behavior lead to avoidant attachment.

Interestingly, 76 % of the ambivalent-attached infants took antibiotics in the first year of their lives (against 47 % of secure and avoidant attached infants). Such contrasting proportions agree with past research, which shows that 90 % of the infants classified as ambivalent attached took antibiotics in the first nine months of life against 35 % of secure and avoidant [34,35]. The authors of this study (performed with infants born at least with 32 weeks of gestation and >1500 g of birthweight) argued that ambivalent attached infants exacerbate their emotions (e.g., over-emotional angry and fear responses expressed by heavy crying, inability to self-soothe or strong motor reactions), eventually raising concern to their parents and health professionals, which may lead to higher antibiotic prescription [35].

Although VLBW newborns' lives are in danger in the first days/months, it is also crucial to invest in parents' psychological support, reinforce parenting policies and practices during "families" stay in NICU, and support parents during the home transition and after the hospital discharge. In Portugal, the general practice is to provide early intervention services only after infants' discharge from NICU. We propose that these services be available to families during the newborn's hospitalization in partnership health teams. Past research found that these interventions can effectively support parents' behavior and parents-infant relationships [36] once provided in a continuous and individualized process during children's first years of life.

7. New directions and theoretical implications

Research suggests that infants securely and insecurely attached process attachment-relevant social information differently [37]. Securely attached infants tend to fully process the attachment-relevant information, whereas insecurely attached infants tend to block this information defensively, avoid it or exclude it from further processing [38,39]. According to Jin et al. [39] based on attachment experiences, infants create an expectation about caregivers' behavior (not only their caregivers but an abstract expectation of caregivers' protective and comforting behavior): "infants expect individuals to care about their ingroup members and to support their welfare via comforting, helping, and other prosocial actions" (p. 17). Consequently, this expectation not only is affected and affects each attachment relationship but may impact individual future prosocial behavior and social competence [4]. In the case of our study, this information is critical since we found that infants born with low birthweight are more likely to be insecurely attached and have less sensitive mothers. Such lower quality parental care and negative attachment experience, which repeatedly violates the comforting and protective expectation of caregivers' response, may impact social development and mental health.

8. Study limitations and strengths

When evaluating the results, it is important to consider the limitations and strengths of this study. First, the sample size is relatively small, reducing statistical power when we analyze the distribution of groups. For instance, the distribution of infant regulatory patterns by attachment patterns has less than five occurrences in some categories. Second, this sample has multiple associated risks, as expected for samples with infants born with very low birthweight. Nevertheless, our results cannot

be explained only in the light of one single factor (birthweight), but as the result of a complex array of risk factors that these infants face.

Strengths of this study include its longitudinal, prospective design, the use of direct observations of mother-infant interaction at 3 months and attachment at 12 months (corrected age), the inclusion of an understudied group of infants born with very low birthweight, and careful evaluation of biological and demographic factors as potential covariates. Thus, we believe the current findings contribute to a growing body of knowledge about attachment in infants born preterm.

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CRediT authorship contribution statement

Marina Fuertes: Conceptualization; Methodology; Validation; Formal analysis; Resources; Data Curation; Writing Original Draft; Writing - Review & Editing; Supervision; Project administration; Funding acquisition.

Sandra Antunes: Investigation; Resources; Data Scoring; Writing - Review & Editing.

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Declaration of competing interest

None of the authors have any conflicts of interest.

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