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The challenges of stillness: a longitudinal study about the associations between mothers' violations of the still-face, infant patterns of regulatory behavior, mother-infant interactive behavior, and infant attachment

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Abstract

Background During the still-face (SF) episode of the Face-to-Face Still-Face paradigm (FFSF), mothers are instructed to remain still, unresponsive, and silent. However, some participants do not comply with these instructions, and researchers typically exclude them from their analyses. These mothers report feelings of anxiety and discomfort during SF. However, little is known about maternal SF violations and whether they are associated with other aspects of the mother-infant relationship.

Aims In this experimental and longitudinal study, we compared mothers who violated the SF instructions to mothers who complied with them. We then focused on the group of mothers who violated the SF instructions, to investigate whether the type (i.e., those meant to soothe the infant vs. other violations), intensity (severe vs. mild), and form (verbal and non-verbal) of mothers' SF violations in the FFSF at 3 months postpartum were associated with infant regulatory behavior in FFSF, mother-infant free-play behavior at the same age, infant attachment at 12 months, or other infant or maternal/familial characteristics.

Methods The participants included 54 mothers identified as violating the SF instructions at 3 months and their infants, and 296 mothers who did not violate the SF instructions. At 3 months, mother-infant dyads were videotaped during two successive interaction tasks: an unstructured free-play task followed by the FFSF paradigm. At 12 months, infant attachment was assessed in the Strange Situation.

Results Mothers who violated the SF were less sensitive during mother-infant free play than mothers who complied with the SF instructions, and their infants were more cooperative and less likely to exhibit a disorganized/disoriented attachment. Among mothers who violated the SF instructions, those who did so to soothe their infant exhibited higher sensitivity during free play, and their infants were more likely to exhibit a Social Oriented pattern of regulatory behavior during the FFSF, than mothers who violated the SF for other reasons. Furthermore, their infants were more

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cooperative during free play, and at 12 months, more likely to have a secure attachment, and less likely to have a disorganized/disoriented attachment.

Conclusion Possibly, mothers who violate the SF to soothe their infants are more empathic and more likely to be a "safe haven" in stressful situations, contributing to secure relationships. However, mothers who violated SF for other reasons need further investigation and are linked with disorganized/disoriented infant attachment.

Keywords Face-to-Face Still-Face paradigm, Maternal violation of the still-face, Maternal sensitivity, Strange situation paradigm, Infant attachment

The Face to Face Still Face paradigm (FFSF) [1] has been extensively used to investigate how infants respond to the stress of parental withdrawal and early parent-infant behavioral and physiological co-regulatory processes [2]. The FFSF consists of three successive two-minute episodes: an initial face-to-face play interaction (baseline), followed by a disruption in social interaction during which the parent is instructed to maintain eye contact with the infant while holding a neutral expression and refraining from talking or touching the infant (still-face, SF), followed by a return to playful interaction (reunion) [see 3 for a review].

An understudied topic in the FFSF literature is parents who violate the SF instructions, and the possible correlates of those violations. Typically, parents who violate the SF are removed from the study before analyses begin and not evaluated further. Experienced researchers try to prevent this problem by carefully explaining the SF instructions to the parent and providing written, visual, or verbal reminders before the SF episode begins. Nevertheless, despite their efforts, a small group of parents violates the SF instructions in most samples. Although small in size, this parental group warrants further consideration. In early FFSF research, Tronick et al. [1] observed that many mothers reported difficulty in staying unresponsive to their infant's distress and bids for reengagement with the mother during the two-minute SF episode, even if mothers complied with the SF instructions. A smaller number additionally "broke" their still-faced demeanor. Violations of the SF instructions include interacting with the infant during the SF episode, such as touching or speaking to the infant, using gestures such as hand-clapping or nodding, or exhibiting emotional facial expressions (e.g., smiling, sadness). Other SF violations are more mother-centered and include looking away from the infant (e.g., looking at objects in the room), engaging in self-focused behaviors (e.g., checking phone, self-grooming), or exhibiting general agitation. It is important to emphasize that mothers are aware that the SF episode is shortened if their infants become distressed (no infant is left upset for more than 15 s).

Mayes and colleagues [4] conducted open-ended interviews with mothers following the FFSF to better understand their feelings about participating in the SF episode. They also evaluated whether mothers' feelings were linked to their infant's discomfort. Their results showed that over half of the mothers in their sample reported experiencing discomfort or anxiety during the SF episode, and the level of their reported discomfort rose with increasing infant distress, corroborating Tronick et al.'s observations [1]. Interestingly, mothers varied in their reported coping strategies. Some tried to minimize their discomfort, while others expressed that they felt helpless for not being able to respond to their infant's needs. Still other mothers, especially those with distressed infants, violated the SF instructions by taking their infants out of the seat and holding them physically close. Moreover, when reestablishing normal interaction with their infants, these mothers were more likely to verbally express their feelings by acknowledging their discomfort or relief during the reunion episode. These findings suggest that the FFSF is an experimental paradigm that elicits distress in both infants and mothers.

Similar findings are reported for mothers interacting with older children in other stressful contexts. For example, in a study of mother-toddler interaction observed in unstructured and challenging contexts [5], about half of the mothers reported negative feelings during a challenging (waiting) task. In contrast, nearly all mothers reported positive feelings during the free-play task. Moreover, mothers' level of discomfort was correlated with the degree of their toddler's distress and negativity. Taken together, the results of these studies suggest that mothers' reactions to interacting with their children in challenging contexts vary. Approximately half of the mothers reported feeling distressed when interacting with their children in challenging contexts, especially when their children displayed negative affect.

We speculate that some mothers' distress during the SF may stem from a desire to soothe or comfort their children ("safe haven" behavior), which in turn may reflect a sense of maternal empathy. However, in the FFSF literature, including research in our lab, only a small number of mothers violate the SF instructions by trying to comfort their infants despite feeling distressed. Rather, most mothers cope with their distress and complete the task without violating the SF instructions.

Very little is known about the demographic and behavioral characteristics of mothers who violate the SF and how they may differ from mothers who comply with the SF instructions. It is also unclear whether mothers who violate the SF vary in the type of maternal violations they exhibit during the SF. Are mothers who violate the SF to comfort their infants more empathic and concerned with their infants' needs than those who violate the SF for other reasons? That is, do these mothers prioritize providing comfort, security, and support to their infants over complying with the researcher's instructions? Do other mothers break the SF because they have difficulty regulating their attention, behavior, or emotions during the SF, perhaps provoked by their own and their infant's distress, or by the novelty of the experience?

Moreover, does the specific reason that mothers violate the SF instructions matter? That is, are mothers who violate the SF to soothe their infants more likely to behave sensitively with their infants in other contexts, compared to mothers who violate the SF instructions for other reasons? In either scenario, one might expect that the type of maternal SF violation displayed by mothers in the FFSF would be correlated with the quality of the mother-infant relationship in other contexts, but the direction of effects might vary.

Although understudied, this notion is consistent with the perspective that parents and infants regulate their interactions jointly through sharing affective and behavioral states, parents provide the context and support that enables their infants to regulate their behavior. In turn, infants' responses to their parent's affect and behavioral displays alter parents' subsequent responses and their emerging mental representations of the infant [6]. Thus, in the presence of a distressed infant or a dysregulated infant displaying incoherent behavioral displays [7], mothers' level of discomfort rises [4, 5]. Some argue that how parents communicate their discomfort during parent-infant interactions can influence infants' emerging working models of attachment and other aspects of their socioemotional development [4, 6].

The present study

The goal of the present study was to shed more light on mothers who violate the SF instructions. This was accomplished first by comparing them to mothers who did not violate the SF instructions. Next, among mothers who violated the SF instructions, we also evaluated the type of SF violations mothers displayed during the FFSF at 3 months postpartum and whether these violations were associated with other aspects of the mother-infant relationship assessed in other contexts. To accomplish this goal, we evaluated the following specific aims.

Aims and hypotheses

The first aim was to compare mothers who violated the SF instructions to mothers who did not, regarding: (i) ratings of maternal and infant interactive behavior during free play at 3 months, (ii) infant patterns of regulatory behavior during the FFSF at 3 months, (iii) infant attachment classifications during the Strange Situation at 12 months, and (iv) infant perinatal variables or maternal/familial demographics.

The second aim was to learn more about the dyads in which mothers violated the SF instructions. To address this aim, we first identified mothers who failed to comply with the SF instructions, utilizing a large sample of mother-infant dyads who participated in the FFSF in our lab at 3 months postpartum and were followed to 12 months. Using a detailed coding system, we classified the violating mothers into two groups based on the type of SF violation they exhibited during the SF episode: (1) mothers who violated the SF to soothe their infant (thus prioritizing their infant's needs over adhering to the researcher's instructions) and (2) mothers who violated the SF for other reasons. Although our primary aim was to evaluate the type of SF violations mothers exhibited, we also examined the intensity (severe versus mild violations) and form (verbal, non-verbal, or both) of those violations.

The third aim was to examine whether the type, intensity, and form of maternal SF violations were associated with qualitative ratings of maternal and infant interactive behavior made during an independent free-play context at 3 months postpartum. We expected that mothers who violated the SF instructions to soothe their infants, perhaps out of empathy or concern for their distress, would exhibit higher levels of maternal sensitivity during mother-infant free-play interactions at the same age. Conversely, we expected that mothers who violated the SF instructions for other reasons (e.g., by becoming distracted or bored or engaging in self-oriented behaviors such as checking their phone or because they struggled to modulate their anxiety) would have fewer sensitive interactions with their infants during free play, and possibly more controlling or unresponsive behaviors.

The fourth aim was to evaluate whether the two types of maternal SF violations were associated with infants' attachment classifications during the Strange Situation [8], when infants were 12 months old. We expected that mothers who violated the SF instructions to soothe their infant would be more likely to have an infant with secure attachment and less likely to have an infant with disorganized attachment at 12 months, compared to mothers who violated the SF instructions for other reasons. This hypothesis was based on research suggesting that maternal safe haven behavior during early mother-infant interactions is linked to secure attachment formation [9],

and on other research suggesting that when mothers fail to regulate their attention or emotions during the FFSF, their infant's interpretation of their behavior and mother-infant coregulatory processes may be negatively altered, possibly leading to insecure and disorganized/disoriented attachment [10].

In a fifth aim, we investigated whether infants' regulatory behavior during the FFSF was associated with the way mothers violated the SF instructions, specifically in terms of type, form, and intensity. We hypothesized that mothers of infants with a Distressed-Inconsolable Pattern of regulatory behavior would be more likely to interpret these behaviors as an increased need for reassurance and soothing, which may lead them to respond accordingly.

The sixth aim was to contextualize our understanding of maternal SF violations by evaluating whether the two types of SF violations were associated with infant perinatal variables or maternal/familial demographics. We expected that the type of SF violation mothers exhibited would be associated with infant perinatal and maternal/familial characteristics. Still, given the paucity of research in this area, no specific hypotheses were made.

In the seventh aim, we explored potential covariates among the independent variables to understand why some mothers violated the Still-Face instructions. Given that our sample includes participants from different groups, we used mixed-model analyses to identify covariates of the types of still-face violations, accounting for variability within groups and appropriately modeling random effects.

Methods

Participants

From a larger pool of 350 Portuguese mother-infant dyads who participated in the FFSF at 3 months and were followed to 12 months postpartum, 54 mothers did not comply with the SF instructions (15.4%). Dyads in the larger sample were participants in four independent longitudinal studies using identical methods and procedures that were carried out in our lab during the past 10 years [17, 22, 29–31].

Descriptive statistics for mothers who violated the SF instructions in the current sample ($N = 54$) and mothers who did not violate the SF instructions from the original sample ($N = 296$) are presented in Table 1. The 54 dyads whose mothers violated the SF instructions did not differ from the 296 mothers who complied with the SF instructions regarding infant perinatal or maternal/familial variables.

Although the number of mothers who violated the SF instructions ($N = 54$) is unpredictable, the sample size is adequate to attain the study aims. With a size of 54, the study is well-powered to identify moderate effect sizes (0.5) with a high degree of confidence (95% power) at a standard significance level (0.05).

Based on hospital records, no infants had any known sensory or motor impairments, severe illnesses, or congenital anomalies at delivery, and none exhibited developmental delays at either the 3- or the 12-month follow-up visits. Moreover, no parents had any history of mental health problems and/or substance abuse, based on hospital clinical records. Of the 54 infants in the sample of mothers who did violate the SF instructions, 24 (44.4%) were moderate-to-late preterm (born between 32 and 36 weeks of gestation) with appropriate weight for their gestational age and good health indicators. Additionally, 5 infants (9.3%) were born very preterm with less than 31 weeks of gestation. Further details on neonatal indicators for these groups can be found in Table S1 in the Appendix. These infants were recruited in longitudinal studies evaluating the consequences of preterm birth, which originally included 191 infants born preterm (45.9%).

At the time of recruitment, families varied in sociodemographic characteristics, including the number of siblings living in the home, maternal age, and maternal education (see Table 1). Most were from working- to middle-class backgrounds: Only four mothers had completed less than 10 years of formal education and were from low-income households. The current sample included 26 female and 28 male infants. Twenty-five infants were born full-term, and 29 were born preterm below 37 weeks of gestation.

Table 1 Characteristics of both groups (Mother that follow SF instructions and mothers that violated the SF instructions) Still-Face violation

Demographics	Non-violation M (SD)	Violation M (SD)	t(349)	*p*
Gestational Age (weeks)	8.22 (2.81)	36.0 (3.71)	0.922	0.36
Birthweight (g)	3.77 (3.08)	2499 (0.824)	−0.160	0.87
Apgar at first minute	2.02 (2.75)	8.30 (1.55)	0.459	0.64
Apgar at fifth minute	8.12 (2.89)	9.65 (0.76)	1.763	0.08
Number of siblings	2.17 (3.17)	14.42 (4.15)	−0.893	0.37
Maternal age (years)	2.16 (2.92)	30.81 (5.06)	−0.361	0.72
Maternal Education (years)	13.84 (3.67)	14.32 (4.15)	0.948	0.35

Procedures

Mother-infant dyads in the current longitudinal study were recruited from three metropolitan hospitals in Lisbon and Porto at the time of the infant's birth. Recruited dyads were invited to participate in two laboratory visits. At 3 months, mother-infant dyads were videotaped during two successive interaction tasks: an unstructured free-play task followed by the *Face to Face Still-Face Paradigm (FFSF, Tronick et al., 1978)*. At 12 months, mother-infant dyads were videotaped during the Strange Situation to assess infant attachment.

Measures

Type, intensity, and form of maternal SF violations during the Still-Face episode of the FFSF

As stated earlier, 54 mothers violated the experimenter's instructions to hold a still face and be unresponsive and non-interactive with the infant during the SF episode of the FFSF at the 3-month lab visit. Using videotapes of the FFSF, coders then used a detailed scoring system (see Table S2 in the Appendix) to record and score all behaviors these mothers exhibited during the SF episode that violated the SF instructions. Mothers violated the SF in diverse ways, such as interacting with the infant (e.g., by talking to, touching, gesturing at, using emotional facial expressions with the infant, giving the infant a pacifier or taking the infant out of its seat) or by becoming distracted or bored or engaging in self-related behaviors (e.g., checking their phones or self-grooming).

Type of SF violation Coders then categorized maternal violations into one of two broad types. The first type included violations intended to soothe the infant (e.g., whispering gently with comforting words or soothing sounds, caressing the baby's body, smiling, or making facial expressions to distract the baby when they became physically agitated or verbally protested). Based on prior literature [e.g., 4], for a maternal violation to be coded as soothing the infant, the infant had to show signals of discomfort, distress, agitation, or protest.

The second type included violations occurring for other, non-infant-centered reasons (e.g., attending to objects in the room, checking the phone, engaging in self-grooming, adjusting maternal clothing or hands, exhibiting general agitation, or misunderstanding the instructions).

Intensity of SF violation The intensity of mothers' SF violations was further coded into categories ranging from light/mild (i.e., behaviors that temporarily or minimally impact the mothers' stillness) to severe (i.e., behaviors that are strong or prolonged enough to significantly disrupt the still-face effect). Examples of mild violations include behaviors such as altered facial expressions, whispering or gently talking to the infant, or gently touching the infant. Examples of severe violations include behaviors such as giving infants a pacifier, removing infants from their seats, or mothers leaving their seats.

Form of SF violation Maternal SF violations were further coded as being non-verbal, verbal, or both non-verbal and verbal.

All cases were double-coded independently. Intercoder reliability was good for both the type and form of SF violation, and moderate for the intensity of SF violation. The Cohen's kappa coefficient was 0.72 for the type of SF violation, 0.84 for the form of SF violation, and 0.64 for the intensity of SF violation.

Mother-infant interactive behavior

At the 3-month visit, prior to the FFSF, mother-infant dyads were videotaped during a 5-minute free-play interaction, administered following the guidelines in Crittenden`s Child-Adult Relationship Experimental Index [CARE-Index, 11].

Qualitative dimensions of infant and maternal behavior during free play were scored from the videotapes using the CARE-Index. All cases were double-coded by two trained, reliable coders masked to the study's hypotheses and background variables. The CARE-Index includes three adult scales (Sensitivity, Control, and Unresponsiveness) and four infant scales (Cooperativity, Compliant-Compulsive, Difficulty, and Passivity). Each maternal and infant scale was scored in 7 dimensions: facial expressions, verbal expressions, position and body contact, affection, turn-taking, control contingencies, and choice of activity (from 0 to 14 points). Each child and adult scale (e.g., maternal sensitivity) includes descriptors for each dimension (e.g., facial expression). Intercoder reliability was assessed using ICC (average overall ICC was 0.79, indicating good reliability).

Infant regulatory behavior patterns during FFSF

The Coding System for Regulatory Patterns in the FFSF [22] was employed to evaluate infants' regulatory patterns based on videotapes of the FFSF at 3 months [1]. This system categorizes three patterns of infants' regulatory behavior: Social-Positive Oriented, Distressed-Inconsolable, and Self-Comfort Oriented. These patterns are derived from four dimensions of infants' behavior and affective facial expressions observed across the three episodes of the FFSF paradigm: (a) behavior organization (e.g., the infant primarily displays positive social behavior, distressed behavior, self-comforting behavior, or mixed-pattern behavior); (b) intensity of exhibited behavior (e.g., the infant shows prolonged and intense crying); (c) quality of behavior (e.g., the infant responds with signals of pleasure such as smiles, laughter, and

neutral or positive vocalizations); and (d) the infant's ability to recover from negative emotions during the reunion episode of the FFSF.

Three trained, reliable coders scored the FFSF videotapes for infant regulatory patterns. All cases were double-coded. The intercoder agreement was assessed using Cohen's kappa coefficient, indicating good consistency across all regulatory patterns (M $\kappa = 0.81$). Discrepancies in classifications were discussed and resolved through a coders conference. Although there were FFSF violations, this coding system considers all episodes (not only the SF episode), allowing to force the classification. However, it is important to note that, in some cases, infants may not have experienced high stress (since they were comforted), potentially resulting in a higher prevalence of the Social-Positive Oriented Pattern. Therefore, these analyses should be considered as exploratory.

Infant attachment classifications

At the 12-month visit, mother-infant dyads were videotaped during the Strange Situation paradigm [SSP, 8] The SSP is a 21-minute laboratory paradigm consisting of a sequence of eight episodes designed to place mild but increasing levels of stress on the infant and parent-infant dyad (i.e., being introduced to an unfamiliar playroom, interacting with an unfamiliar adult stranger, and brief separations from and reunions with the mother).

Videotapes of infants' attachment behavior during the SSP were scored by an independent team of trained, reliable coders following the procedures developed by Ainsworth et al. [8] and Main and Solomon [12]. Infants were classified as either securely attached (B), insecure-avoidant (A), insecure-ambivalent/resistant (C), or disorganized/disoriented (D). All cases were double-coded. Intercoder reliability was good for the ABC classification ($M\ \kappa = 0.81$) and moderate for the D vs. no-D classification ($M\ \kappa = 0.72$).

Analytic plan

Descriptive statistics for the sample's characteristics and other study variables were obtained using univariate statistics. The distributional properties of the study variables were also tested. In Aim 1, student t-tests were used to compare mothers who violated the SF instructions in the current sample to mothers who complied with the SF instructions in the original sample on ratings of infant and maternal interactive behavior during free play at 3 months, and Chi-square tests were used to compare the two groups on infant patterns of regulatory behavior during the FFSF at 3 months and attachment classifications in the Strange Situation at 12 months.

Aims 2–7 were based on data collected from mothers who violated the SF instructions and their infants. For Aim 2, univariate analyses were used to describe the number and percent of the type, intensity, and form of maternal SF violations. For Aim 3, analyses utilized descriptive statistics and student t-tests to evaluate the association between the type of maternal SF violation and rated dimensions of mother-infant free play behavior. Analyses for Aims 4, 5, and 6 included chi-square analyses and post hoc Cramér's V tests to evaluate the association between the type, intensity, or form of maternal SF violation and both infant regulatory and attachment patterns (A, B, C, D). Chi-square analyses and post hoc Cramer's V tests were also used to evaluate the association between infant attachment patterns and infant perinatal variables. Analyses for Aim 5 utilized student's t-tests, ANOVA, and Chi-square tests to evaluate the association between maternal SF variables (type, intensity, and form) and various infant perinatal, maternal, and familial variables. For Aim 7, mixed models were applied to test the association between potential covariates (fixed effects) and maternal types of SF violations, which account for variability within groups and appropriately model random effects. Alpha was set at < 0.05 for all statistical tests.

Results

Aim 1: Do the 54 mothers who violated the SF instructions differ from the 296 non-violating mothers on ratings of infant and maternal interactive behavior in free play at 3 months, infant regulatory patterns during the FFSF at 3 months, or infant attachment classifications during the Strange Situation at 12 months?

As seen in Table 2, mothers who complied with the SF instructions had higher ratings on maternal sensitivity and lower ratings on maternal controlling behavior during free play at 3 months, compared to mothers who violated the SF instructions in the current sample. The effect size for maternal sensitivity (Hedges' $g = 2.83$) and maternal controlling behavior (Hedges' $g = 3.11$) were strong, suggesting a robust effect. In turn, infants of mothers who complied with the SF instructions were rated as being more cooperative during free play and the magnitude of the effect analyses suggest a robust effect (Hedges' $g = 2.88$).

In contrast, no significant associations were found for infants' regulatory behavior patterns during the FFSF at 3 months (see results in Table S3 in the Appendix) or for infants' organized attachment patterns (A, B, or C) during the Strange Situation at 12 months (Table 3). However, the prevalence of disorganized attachment was higher among infants of mothers who violated the SF instructions (see Table 3).

Results for Aims 2–7 focus on the group of mothers who violated the SF instructions and their infants.

Table 2 Differences in the qualitative ratings of maternal and infant interactive behaviour during free play at 3 months according to violation or Non-Violation of the instructions of Still-Face episode during the Face-to-Face Still-Face paradigm: means, standard deviations, t-tests, and Cohen´s d values. Still-Face violation

Interactive Behavior during Free Play at 3 Months	Non-violation M (SD)	Violation M (SD)	t(315)	*p*	Hedges' g	$IC_{95\%}$ of g Lower-upper
Maternal sensitivity	8.22 (2.81)	6.65 (2.93)	3.62	< 0.001	2.83	−0.85 _ −0.26
Maternal controlling	3.77 (3.08)	4.93 (3.27)	-2.38	0.014	3.11	−0.07 _ −0.66
Maternal unresponsiveness	2.02 (2.75)	2.35 (2.88)	−0.79	0.433	2.74	-1.71 _ 0.42
Infant cooperation	8.12 (2.89)	6.72 (2.81)	3.30	0.001	2.88	−0.78 _-. 19
Infant compulsiveness	2.17 (3.17)	2.87 (3.81)	-1.27	0.209	3.30	−0.80 _ 0.51
Infant difficultness	2.16 (2.92)	2.72 (3.73)	-1.05	0.297	3.07	−0.11 _.48
Infant passivity	1.62 (2.21)	1.69 (2.53)	0.177	0.860	2.27	-2.64 _ 0.32

Table 3 Associations between Non-violation or violation of Still-Face violation during the Face-to-Face Still-Face paradigm at 3 months and distribution of attachment patterns

Maternal Still-Face Violation		Infant Attachment Classification				Total
		A	B	C	D	
Non	Violation	97_a (32.8%, 3.2)	103_a (34.8%, 0.7)	82_a (27.7%, 1.1)	14_b (4.7%, -7.7)	18 (100%)
	Violation	6_a (11.1%, -3.2)	16_a (29.6%, −0.7)	11_a (20.4%, -1.1)	21_b (38.9%, 7.7)	54 (100%)
	Total	103 (29.4%)	119 (34.0%)	93 (26.6%)	35 (10%)	350 (100%)

Pearson Chi-Square = 61.851, DF = 3, $p < .001$. A different superscript letter denotes that the frequencies differ significantly from each other; $p < .05$ (column proportions test with Bonferroni adjustment). Cramer's = 0.420; $p < .001$

Table 4 Differences in the qualitative ratings of maternal and infant interactive behaviour during free play at 3 months according to the type of type of maternal Still-Face violation (to sooth their infants or for other reason) the instructions of Still-Face episode during the Face-to-Face Still-Face paradigm. type of maternal Still-Face violation

Interactive Behavior during Free Play at 3 Months	Soothing behaviors M (SD)	Other M (SD)	t(52)	*p*	Hedges' g	$IC_{95\%}$ of g Lower-upper
Maternal sensitivity	9.44 (2.36)	5.25 (2.06)	6.42	< 0.001	2.19	1.24–2.57
Maternal controlling	3.39 (2.33)	5.69 (3.42)	-2.91	0.005	3.15	-1.30- −0.16
Maternal unresponsiveness	1.17 (1.54)	2.94 (3.22)	-2.75	0.008	2.82	-1.19 −0.06
Infant cooperation	9.17 (2.57)	5.50 (2.05)	5.27	< 0.001	1.61	0.97–2.25
Infant compulsiveness	1.67 (2.47)	3.47 (4.23)	-1.97	0.054	3.80	-1.04 −0.09
Infant difficultness	1.33 (2.72)	3.42 (4.00)	-2.25	0.029	3.69	-1.13 −0.01
Infant passivity	1.83 (2.01)	1.61 (2.78)	0.336	0.739	2.59	−0.49 −0.65

Aim 2: Type, intensity, and form of maternal SF violations.

Consistent with our expectations, mothers' SF violations varied by type, intensity, and form. Of the 54 mothers who exhibited violations of the SF instructions during the FFSF at 3 months, 18 (33.33%) did so to soothe their infant, and 36 (66.67%) did so for other reasons. In terms of intensity, 31 mothers (57.41%) had violations classified as severe, whereas 23 mothers (42.59%) had violations classified as mild. Violations also varied in form: 18 mothers (33.33%) engaged in non-verbal violations, 11 (20.37%) in verbal violations, and 25 (46.30%) exhibited violations that were both non-verbal and verbal.

Aim 3: Is the type, intensity, and form of maternal SF violation associated with maternal or infant interactive behavior during free play at 3 months?

As seen in Table 4, mothers who violated the SF instructions to soothe their infant were rated as being more sensitive, less controlling, and less unresponsive with their infant during free play than mothers who violated the SF for other reasons. In turn, infants whose mothers violated the SF instructions to soothe them were rated as being more cooperative and less difficult with their mothers during free play. However, after applying the Bonferroni correction, only maternal sensitivity, maternal controlling behavior, and infant cooperative behavior remained significantly associated with types of maternal violation in the FSFF, while maternal unresponsivity was marginally significant ($p = .056$). The effect size for the significant interactive measures was very large, indicating that these differences are meaningful and not merely statistically significant. Therefore, mothers who engaged in soothing behaviors to calm their infants were significantly more sensitive and less controlling with their infants during

Table 5 Associations between types of maternal Still-Face violation during the Face-to-Face Still-Face paradigm at 3 months according to infant pattern of regulatory behavior

Types of Maternal Still-Face Violation	Patterns of Regulatory Behavior			Total
	Social-Positive Oriented	Distressed-Inconsolable	Self-Comfort Oriented	
Soothing behavior	15_a (83.3%, 5.0)	2_a (11.1%, -3.0)	1_a (5.6%, -2.3)	18 (100%)
Other	5_b (13.9%, -5.0)	19_b (52.8%, 3.0)	12_b (33.3%, 2.3)	36 (100%)
Total	20 (37.0%)	21 (38.9%)	13 (24.1%)	54

Fisher Exact Test = 24.004, DF = 2, $p < .001$. A different superscript letter denotes that the frequencies differ significantly from each other; $p < .05$ (column proportions test with Bonferroni adjustment). Cramer's = 0.678; $p < .001$

Table 6 Associations between type of maternal Still-Face violation during the Face-to-Face Still-Face paradigm at 3 months and distribution of infant attachment patterns at 12 months

Type of Maternal Still-Face Violation	Infant Attachment Classification				Total
	A	B	C	D	
Soothing behavior	$1_{a, b}$ (5.6%, −0.9)	11_b (61.1%, 3.6)	$2_{a, b}$ (11.1%, -1.2)	4_b (22.2%, -1.8)	18 (100%)
Other	$5_{a_r b}$(13.9%, 0.9)	$5_{a_r b}$ (13.9%, -3.6)	$9_{a, b}$ (25%,-1.2)	17_a (47.2%, 1.8)	36 (100%)
Total	6 (11.1%)	16 (29.6%)	11 (20.4%)	21 (38.9%)	54

Note. Infant attachment was assessed during Ainsworth's Strange Situation at 12 months (corrected age). A = insecure-avoidant attachment; B = secure attachment; C = insecure-ambivalent/resistant attachment; D = Disorganized/Disoriented. Fisher Exact Test = 11.634, DF = 3, $p = .006$. A different superscript letter denotes that the frequencies differ significantly from each other; $p < .05$ (column proportions test with Bonferroni adjustment). Cramer's = 0.498; $p < .005$

free play than mothers who violated Sf instructions for other reasons, and their infants exhibited higher levels of cooperative behavior. In contrast, measures of the intensity and form of maternal SF violations were not significantly associated with either the type of maternal SF violation during the FFSF or ratings of mother-infant interactive behavior during free play (see Tables S4 and S5 in the Appendix).

Aim 4: Is the type, intensity, and form of maternal SF violation associated with infants' regulatory patterns during the FFSF at 3 months?

To address this question, we first analyzed the distribution of infant regulatory behaviors observed during the FFSF. Subsequently, we examined whether the type, intensity, or form of maternal SF violations observed in the sample were linked to infants' regulatory patterns during the FFSF. The most common regulatory behavior pattern displayed by infants in this sample was the Distressed-Inconsolable pattern (38.9%, $n = 21$), followed closely by Social-Positive Oriented pattern (38.9%, $n = 20$), and the Self-Comfort Oriented pattern (24.1%, $n = 13$).

However, as seen in Table 5, infants with a Social-Positive Oriented pattern were more likely to have mothers who violated SF instructions to soothe them. In contrast, infants with a Distressed-Inconsolable or a Self-Comfort Oriented pattern tended to have mothers that violated the SF instructions for other reasons. The Fisher's Exact Test result ($p < .001$) indicates a statistically significant relationship, with a strong effect size (Cramer's V = 0.678, $p < .001$). No significant differences were observed between infant regulatory patterns and the form and intensity of maternal SF violations (see Tables S6 &S7 in the Appendix).

Aim 5: Is the type, intensity, or form of maternal SF violation associated with infant attachment patterns at 12 months?

To answer this question, we first assessed the distribution of infant attachment classifications (ABCD), and then evaluated whether the type, intensity, or form of maternal SF violations observed in this sample was associated with infants' attachment patterns.

The most prevalent attachment pattern exhibited by infants in this sample was disorganized/disoriented (D) attachment (38.9%, $n = 21$), followed by secure (B) attachment (29.6%, $n = 16$), insecure-avoidant (A) attachment (20.4%, $n = 11$), and insecure-ambivalent-resistant (C) attachment (11.1%, $n = 6$). Notably, infants' prematurity status (infants born full-term (GA < 37 weeks of gestation), moderate-to-late preterm (GA between 32 and 36 weeks of gestation), and very preterm (GA > 32 weeks of gestation) was not significantly associated with infant attachment classifications at 12 months (A, B, C, D) $\chi^2 = 10.631$, $DF = 6$, $p = .10$.

As seen in Table 6, mothers who violated the SF instructions to soothe their infants were more likely to have an infant with a secure attachment at 12 months and less likely to have an infant with a disorganized/disoriented attachment, compared to mothers who violated the SF instructions for other reasons. In turn, mothers who violated SF instructions for other reasons were more likely to have an infant with a disorganized/disoriented attachment. Neither the intensity nor the form of mothers' SF violations was significantly associated with

Table 7 Estimates of fixed effects for types of maternal SF violations

Parameter	Estimate	Std. Error	t	*p*	95% CI
Intercept	2.461	0.287	8.585	< 0.001	[1.884, 3.039]
Social-Positive Oriented Pattern	0.49	0.213	2.299	0.026	[-0.920, – 0.060]
Distressed-Inconsolable	0.06	0.208	0.291	0.772	[-0.480, 0.359]
Maternal Sensitivity	0.128	0.055	2.302	0.026	[-0.240, – 0.016]
Maternal Controlling	0.026	0.023	1.133	0.263	[-0.073, 0.020]
Infant Cooperative Behavior	– 0.043	0.05	– 0.857	0.396	[-0.058, 0.143]
Secure Attachment	– 0.063	0.221	– 0.285	0.777	[-0.382, 0.508]
Resistant Attachment	– 0.14	0.207	– 0.674	0.504	[-0.278, 0.557]
No D signals	– 0.094	0.196	– 0.479	0.635	[-0.301, 0.488]
D signals	0.001	0.149	0.005	0.996	[-0.301, 0.299]

infants' attachment patterns (see Tables S8 & S9 in the Appendix). The results indicate a significant association between these variables (*Fisher's Exact Test* = 11.634, $p = .006$; *Cramer's V* = 0.498, $p < .005$), suggesting a moderate to strong effect size.

Aim 6: Is the type, intensity, or form of maternal SF violation associated with infant perinatal or with maternal/familial demographic variables?

Contrary to expectations, neither the type of mothers' SF violations (soothing or other), intensity of violation (severe or mild), or form of violation (verbal, nonverbal or both) was significantly associated with infant perinatal variables (i.e., gestational weeks at delivery or Apgar scores at 1–5 min) or maternal/familial demographic variables (i.e., number of siblings, maternal age, or maternal education). Similar non-significant associations were found for a categorical classification of infants' prematurity status (infants born full-term (GA < 37 weeks of gestation), moderate-to-late preterm (GA between 32 and 36 weeks of gestation), and very preterm (GA > 32 weeks of gestation). See results in Tables S10, S11 & S12 in the Appendix).

Aim 7: What are the main predictors of maternal SF violation when the effects of all significant independent variables are considered?

The results of the mixed-model analysis showed that higher levels of maternal sensitivity during free play at 3 months and the Social-Positive Oriented pattern of infant regulatory behavior during the FFSF were each significantly associated with mothers' type of SF violation in the category of soothing behaviors. In contrast, other predictors (covariates) that were significant predictors in the bivariate analyses, including maternal controlling behavior, child cooperation, and additional group categories, were not significantly associated with type of maternal SF violations. It is important to stress that the Social-Positive Oriented Pattern has a significant and strong association with the violation in the category of soothing behaviors ($\beta = -0.49$, $p = .026$), with a 95% confidence interval of [-0.920, – 0.060]. Also, as maternal sensitivity increases, violation in the category of soothing behaviors increases. The confidence interval for this variable [-0.240, – 0.016] suggests that this effect is small but statistically reliable.

For the covariance parameters, the estimated residual variance was 121.06 (SE = 0.026), and the restricted log-likelihood (-2LL) value was 61.859, suggesting a good model fit. The small standard error around the residual variance estimate and the restricted log-likelihood value indicate that the model captures the variability in the data effectively, with substantial residual variance (results in Table 7).

Discussion

The goal of the current exploratory study was to shed further light on mothers who violated the SF instructions during the still-face episode of the FFSF at 3 months. We addressed this goal first by comparing mothers who violated the SF to other mothers who complied with the SF instructions on a variety of behavioral and demographic characteristics. We then focused on variations among mothers who violated the SF instructions. Specifically, we ascertained whether different types of SF violations are associated with variations in infants' regulatory behavior patterns during the FFSF, or the quality of the mother-infant relationship assessed in other contexts, including mother-infant interactive behavior during free play at 3 months and infants' attachment patterns during the Strange Situation at 12 months. Mothers who violate the SF are typically excluded from further analysis in the FFSF literature, yet our findings suggest that further consideration of this understudied group is warranted.

Analyses in this study were based on longitudinal data collected for 350 mother-infant dyads who participated in four longitudinal studies in our lab utilizing identical procedures and measures. Of the 350 mothers, 54 (15.43%) violated the SF instructions during the FFSF at 3 months.

When compared to mothers who complied with the SF instructions, mothers who violated the SF instructions were rated lower on maternal sensitivity and higher on maternal controlling behavior during free play at 3 months, and their infants were rated as being less cooperative. Notably, the magnitude of these effects was strong, indicating that these differences are meaningful. In contrast, no significant group differences were found for infants' regulatory behavior patterns during the FFSF at 3 months or for infants' organized attachment patterns (A, B, or C) during the Strange Situation at 12 months. However, the prevalence of disorganized attachment was higher among infants of mothers who violated the SF instructions, as corroborated by the robust size effect. These results reinforce the idea that, by excluding mothers who violate the SF, we miss an opportunity to learn that mothers vary in the reasons they violate the SF instructions, and these reasons are associated with other aspects of the mother-infant relationship in other contexts.

Our remaining analyses focused on variations in the type, intensity, and form of maternal SF violations within the group of mothers who violated the SF instructions. Of the 54, nearly half violated the SF to soothe their infant, and slightly more than half violated it for other reasons. Moreover, mothers varied in the intensity and form of their SF violations. These findings confirm that mothers vary in their reactions to the SF episode.

We evaluated two broad hypotheses regarding the implications of the two types of maternal SF behavior for the mother-infant relationship in other contexts. The first hypothesis was that mothers who violate the SF instructions to soothe their infants might be exceptionally sensitive and responsive to their infants' needs, prioritizing them over adhering strictly to the researcher's instructions. Thus, these mothers might be more likely to behave sensitively with the infants in other contexts, promoting secure attachment formation.

The second hypothesis concerned mothers who violate the SF for reasons unrelated to soothing the infant, such as becoming distracted, focusing on self or objects in the room, feeling generally agitated, or misunderstanding the instructions. These behaviors may reflect difficulties in maternal attention or emotion regulation or a lack of empathy or concern for the infant's experience. We expected that maternal SF violations of this type would be associated with less maternal sensitivity during mother-infant interactions in other contexts, promoting the formation of an insecure attachment relationship.

Our hypotheses were inspired by Bowlby's [13] attachment theory, which highlights two primary aspects of caregiver behavior that promote attachment formation: *safe haven behavior* (providing comfort and protection when children feel distressed, threatened, or anxious) and *secure base behavior* (providing confidence to children when exploring or engaging with the world). A secure attachment figure should be able to provide both. However, mothers' and infants' perceptions of a stressful situation may differ. For example, infants may be distressed when mothers become non-responsive and unavailable during the SF episode of the FFSF, but their mothers may assess that their infants are safe and not intervene. For other mothers, infants' distress may augment their own distress, leading to efforts to soothe or comfort the infant.

Our findings support both hypotheses. Mothers who violated the SF instructions to comfort their agitated or distressed infant were rated as more sensitive and less controlling with their infants during an independent free play context at 3 months, compared to mothers who violated the SF for other reasons. Moreover, infants whose mothers violated the SF instructions to soothe them, rather than for other reasons, were more cooperative and less difficult during free play. In contrast, infants whose mothers violated the SF instructions for other reasons were rated as being as less cooperative and more difficult with their mothers during free play interactions.

We also found that mothers who violated SF instructions to comfort their infants were more likely to have infants who exhibited a Social-Positive Oriented pattern of regulatory behavior during the FFSF. Although this finding should be considered exploratory (as mothers' SF violations might influence infants' behavior during other episodes of the FFSF), it suggests that other factors not evaluated here, such as maternal representations of their infant's behavior, may also play an important role in shaping maternal behavior during FFSF paradigm. For instance, Rosenblum, et al. [14] reported that differences in mothers' emotion regulation strategies with their infant during the FFSF were related to differences in the way mothers described their infant's behavior in other contexts (i.e., their mental representations of the infant). Mothers with balanced mental representations (even if they felt guilty or anxious about being unresponsive to the infant during the SF episode) were more likely to view the reunion episode as an opportunity to "repair" the interactive rupture caused by the SF perturbation, making it less likely that they would violate the SF instructions. In contrast, mothers with non-balanced mental representations of the infant found it more challenging to modulate their anxiety during the SF and were more likely to violate the SF instructions.

Across different cultures, mothers' attachment representations, mental health, and caregiving experiences also shape their interactions with infants [e.g., 15, 16]. Moreover, research suggests that maternal behavior affects and is affected by infants' regulatory behavior in a bidirectional manner, to shape subsequent interactive

behavior and the mother-infant relationship [e.g., 17, 18]. In this process, maternal characteristics such as stress, depression, or unresolved trauma could also contribute to further dyadic challenges in the mother-infant relationship, which, over time, may transact with infant and maternal behavior to promote insecure or disorganized/disoriented attachment relationships.

Consistent with this hypothesis, we found that mothers who violated the SF instructions to comfort their infants were more likely to have an infant classified as having a secure attachment at 12 months and less likely to have an infant classified as having a disorganized/disoriented attachment compared to mothers who violated the SF for other reasons.

Taken together, our findings suggest that mothers who violate the SF instructions during the FFSF at 3 months do so for distinct reasons, and those reasons are associated with variations in the mother-infant relationship assessed in other contexts, including mother-infant interactive behavior during an independent play session at the same age, and infants' attachment organization at 12 months. Thus, mothers who violate the SF exhibit different profiles that warrant further investigation. In the current study, the type of maternal SF violations proved to be a predictor of outcomes, rather than the intensity or the form (verbal or non-verbal) of mothers' SF violations.

Another notable finding in this sample of mothers who violated the SF during the FFSF at 3 month is the high prevalence of infants with a disorganized/disoriented attachment at 12 months (nearly 40%). This is the first instance where such a high percentage has been reported in Portuguese studies, even among samples involving infants at high developmental or social risk [for review, see 19]. These findings corroborate the need to re-examine archival longitudinal samples to better understand the cases that are routinely excluded from analyses due to maternal SF violations. Given that maternal sensitivity is a moderate predictor of attachment security [20], we question whether highly sensitive mothers who break the SF to soothe their infants, in particular, should be excluded from this line of research [26]. Excluding mothers who violate the SF also means that, in each sample, a considerable number of infants classified as having a disorganized/disoriented attachment are removed from final analyses, which may mask infants' true attachment patterns. We suggest that these cases be evaluated more closely in future studies.

In this exploratory study, results of mixed-model analyses indicated that the key predictors of the type of maternal SF violation were maternal sensitivity during free play and the Social-Positive Oriented pattern of infant regulatory behavior during the FFSF at 3 months. Although both factors are significantly associated with the type of maternal SF violation, the magnitude of the effect for the Positive Oriented pattern of infant regulatory behavior was large, whereas the magnitude of the effect for maternal sensitivity was small.

Although caution is warranted given the small sample, these findings align with Tronick's Mutual Regulation Model [23] which suggests that both the infant and caregiver actively influence and respond to each other and the quality of the mother-infant interaction. Infants express their emotional states through facial expressions, vocalizations, and gestures, while caregivers regulate these emotions by providing soothing, attention, or stimulation [27]. Coregulation occurs when the caregiver successfully attunes to the infant's needs, leading to a process where the infant's emotions are regulated through the caregiver's responsiveness [28]. This mutual exchange allows both partners to learn from each other, adapt their behaviors, and build a shared emotional understanding [1]. We speculate that our results reflect this learned coregulation between mothers and infants. Possibly, mothers and infants behaved as they typically do, guided by their expectations of each other's behavior and needs, even though they agreed to participate in the FFSF experiment. It is likely that this learned intersubjectivity plays a crucial role in developing the infant's secure attachment and promoting healthy emotional development [24, 25].

Findings from the current study showed that the subset of mothers who violated the SF to soothe their infants were more sensitive to their infants' needs than those who violated the SF for other reasons. We also miss the opportunity to learn more about mothers who violate the SF for other reasons. These mothers may have difficulty coping with the stress of maintain a still-faced demeanor or supporting their infant through stressful events such as the SF.

Another important finding was the elevated prevalence of disorganized attachment among infants of mothers who violated the SF instructions compared to infants of mothers who complied with the SF instructions. This finding warrants further investigation. Infants of mothers who violate the SF (especially those who violate the SF for reasons other than soothing the infant) appear to be at heightened risk for maladaptive socioemotional development. Unfortunately, these infants are not currently studied in longitudinal attachment research.

We also need to acknowledge that we included infants varying in perinatal characteristics, including infants born preterm or full-term. Previous research in Portuguese samples indicates that the prevalence of insecure attachment is higher among infants born preterm than among infants born full-term, which could explain the low prevalence of secure attachment in our study [21]. However, in the current sample, infant prematurity status or other perinatal variables were not significantly associated with whether or not mothers violated the SF

instructions. Similarly, within the group of mothers who violated the SF instructions, infant perinatal characteristics were not significantly associated with the type, intensity, or form of maternal violations during the SF episode. Further exploration of these associations in a larger sample would be informative.

A question emerges from the current findings that was not part of the present study's focus. Did any mothers in the original sample ($N = 350$) violate the Strange Situation instructions at 12 months, and if so, were these mothers also more likely to violate the SF instructions? In the current study, 15% violated the SF instructions in the FFSF at 3 months, and a negligible percentage did so during the Strange Situation at 12 months. Although the reason for this discrepancy is unknown, we speculate that mothers were more likely to violate the SF instructions than the Strange Situation instructions for three reasons. First, the FFSF requires parents to remain still, tapping their self-regulatory skills, and some parents may find this challenging even when their infants are calm. Second, some parents may feel compelled to comfort their infants during the SF episode of the FFSF, despite instructions to remain non-responsive. In contrast, parents are permitted to comfort their infant during the Strange Situation. For instance, during reunion episodes, which follow a parental separation, parents can pick up and soothe their distressed infant if they wish. Third, during the Strange Situation, a researcher remains outside the room during separations to help guide parents' behavior and remind them of the instructions across episodes. Future studies should consider retaining all parents in their longitudinal research projects, even when some parents violate the SF instructions during the FFSF.

Limitations, strengths, and future directions

This exploratory study presents several limitations. First, because mothers who violate the SF are relatively rare, the number of women who violated the SF in this sample was necessarily small. A small sample size reduces the statistical power to find significant findings, especially when the magnitude of effects is small. Although many findings had large effect sizes and appear to be meaningful, findings with a small effect size should be interpreted with caution. Second, we derived the sample of mothers who violated the SF from participants in four distinct longitudinal studies that were carried out in our lab during the past 10 years. Although each study utilized identical procedures and measures, each sample varied in infant and maternal/familial factors, and variations in birth and sociodemographic risk can introduce variability and complexity into the analysis. Thus, the current sample may have unique characteristics that limit the generalizability of the findings and make it challenging to draw conclusions. Third, we evaluated maternal SF violations only at 3 months postpartum. Findings might vary at older infant ages. Finally, we did not interview mothers about their experiences during the SF, nor did we relate their perceptions to observations of their SF behavior during the FFSF. Doing so in future studies would be informative,

Despite these limitations, our study offers several strengths. First, it provides novel insights into an understudied group of mothers who violated the SF instructions during the FFSF and how different types of SF violations are linked to variations in mother-infant interactions in other contexts and infant attachment at 12 months. Although replication is needed in larger, more diverse samples, our study provides further information that contributes to the growing body of knowledge about early relational factors that are correlated with individual differences in attachment formation, raising directions for future research. Importantly, future research should retain participants who violate the SF in their longitudinal research projects to allow comparisons of those who violate the SF instructions to those who do not over time.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40359-025-02570-x.

Supplementary Material 1

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Author contributions

Conceptualization: MF (Marina Fuertes) & MB (Marjorie Beeghly); Software: JG (Joana Gonçalves), MF, & MBB (Miguel Barbosa); Data scoring: JG, MF, & MBB; Formal analysis, MF; Investigation: JG, MF, & MBB; Data curation: MF; Writing—original draft preparation: MF & MB; Writing—review and editing, MF, MB, MBB & JG; Visualization: MF, MB, MBB & JG; Supervision: MF; Project administration: MF & MB; Funding acquisition: MBB & MF.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Hospital de São João (protocol code CES 36 – 14 and date of approval 21-01-2015) for studies involving humans, Ethics Committee of the Centro Académico de Medicina de Lisboa (Consent at 06/2010) and Conselho de Administração CHLO - Centro Hospitalar de Lisboa Ocidental (Entrada nº 2791, and date of approval 09-10-2015), as well as by the Portuguese Data Protection Commission. Written informed consent has been obtained from the participants or their parents (in the case of infants) to participate in this study and publish the results.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Human ethics and consent to participate
Not applicable.

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