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Exploring Perinatal Indicators of Infant Social-Emotional Development: A Review of the Replicated Evidence

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Abstract

The importance of infant social-emotional development for outcomes across the lifecourse has been amply demonstrated. Despite this, most screening measures of social-emotional development are designed for children 18 months of age and over, with a clear gap in earlier infancy. No systematic review has yet harvested the evidence for candidate indicators in the perinatal window. This paper examines modifiable risk and protective factors for two seminal early markers of social-emotional development: attachment security and behavioral regulation mid-infancy. We searched meta-analytic and longitudinal studies of developmental relationships between modifiable exposures in the perinatal window (pregnancy to 10 months postpartum) and attachment and behavioral regulation status measured between 12 and 18 months. Six electronic databases were used: ERIC, PsycINFO, Medline Complete, Informit, Embase, and Scopus. Twelve meta-analytic reviews and 38 original studies found replicated evidence for 12 indicators across infant, caregiving, and contextual domains predictive of infant behavioral regulation and attachment status between 12 and 18 months. Key among these were caregiving responsiveness, maternal mental health, couple relationship, and SES as a contextual factor. Perinatal factors most proximal to the infant had the strongest associations with social-emotional status. Beyond very low birthweight and medical risk, evidence for infant-specific factors was weaker. Risk and protective relationships were related but not always inverse. Findings from this review have the potential to inform the development of reliable tools for early screening of infant social-emotional development for application in primary care and population health contexts.

Keywords Infant · Social · Emotional · Development · Screening

Introduction

Where the very construct of infant mental health was once debated (Fitzgerald & Barton, 2000), its place in developmental pathways is increasingly well documented, and its importance for public health policy and practice largely accepted (S.2680 - 114th Congress, 2015–2016; World Health Organization, 2019). The United Nations Committee on the Rights of the Child (General Comment No. 7, 2005) upholds the rights of infants from the beginning of their lives to the highest attainable standard of health and the right to develop to their full potential through the implementation of prevention and health promotion programs that address the underlying determinants of health. Contemporary understanding of infant mental health is fundamentally relational, and embraces the dynamic interplay between neuro-maturational processes and caregiving context, to understand

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the emergence of capacities within the infant to experience, express, and regulate emotional states, to explore the environment, and to learn (Clinton et al., 2016; Greenough et al., 2001; Zeanah, 2009).

Despite broad agreement about the centrality of early infancy for later development, screening of socio-emotional risk status in early infancy is rare (Halle & Darling-Churchill, 2016), with instrumentation "far from completely adequate to meet early childhood education, policy, and research purposes" (Campbell et al., 2016, p. 28). The World Health Organization (2013, p. 11) identified "a clear gap [in] the lack of adaptable, holistic indicators for children younger than three years of age" and listed its remediation as a research priority. Where instrumentation is lacking, international impetus is not.

In this study, we focus on emergent relational and regulatory capacities within the relatively neglected developmental epoch of the sub18-month period. The 12–18-month bracket in particular is a sensitive period of development, yet one within which attachment patterns and affect regulatory capacities become more consistent, and better differentiated from transitory behaviors (Gluckman et al., 2010; Kuhlthau et al., 2011; Opie et al., 2020; Skovgaard, 2010). Prediction from this period to later risk status is increasingly well evidenced (Groh et al., 2012; Skovgaard, 2010). Our research investment in this period reflects a critical question: Could we reliably locate potential risk pathways ahead of this period? If so, what modifiable risk and promotive factors in the first year of life anticipate infant relational and regulatory status within the 12–18-month window? In addressing this question, we hope to contribute new insights to enable optimized screening in the first year of life, for well-targeted prevention efforts that may ameliorate emergent socio-emotional problems early in the second year of life.

Perinatal Risk and Emergent Social-Emotional Functioning in Infancy

Disorders that first appear in childhood are among those ranked highest in the World Health Organization's estimates of the global burden of disease (Costello et al., 2006). Diagnostic criteria for the DC: 0–5 classification system for infants specify recognizable symptoms of emotional disturbance in children less than one year of age (Zero To Three, 2005). Estimates of young children expressing significant and non-transitory emotional/behavioral problems vary, ranging from 5 to 26% in developed countries (Brauner & Stephens, 2006; Sterba et al., 2010). The Copenhagen Child Birth Cohort (6090 children born in 2000) found 16% of infants age 18 months had at least one ICD-10 Axis 1 diagnosis, and 18% had at least one DC: 0–3 Axis 1 diagnosis, with 8.5% also having an Axis 2 relationship disorder (Skovgaard, 2010; Skovgaard et al., 2007).

The influence of *non-modifiable* factors on developmental status is increasingly understood, including genetically and biologically based differences and their dynamic interaction with temperament (Bakermans-Kranenburg & Van IJzendoorn, 2007; Bridgett et al., 2015; Rueda & Rothbart, 2009). Key to public health initiatives is greater knowledge about *modifiable* risk pathways for infant mental health and their interplay with the family ecological context (Bornstein, 2014; Bronfenbrenner & Ceci, 1994; Gluckman et al., 2010; McLuckie et al., 2019). Context is key: few risk exposures in infancy play a determinative role in mental health, many play a moderating role, and some are only expressed through interaction with other exposures, especially in contexts of accumulating risk. For example, early difficult temperament does not predict later attachment insecurity except in the context of insensitive or overly harsh parenting (Belsky et al., 2007; Kochanska et al., 2009; van Ijzendoorn, 1995). In this light, our study sought evidence from a broad array of candidate risk and promotive factors within the family ecological context.

Obstacles to Earlier Screening of Infant Mental Health

Significant challenges to effective screening of infant emotional growth include definitional clarity about early social-emotional development. Social-emotional development in early infancy is rapid, multi-faceted, and non-linear in formation, and researchers rightly grapple to distinguish transitory 'developmentally appropriate' or temperamentally driven infant behaviors from the emergence of stable behavioral and emotional problems (Bagner et al., 2012, p. 114), and to understand their prognostic value.

The majority of psychometric data for infant measures are not peer-reviewed (Pontoppidan et al., 2017). Of 75 validated measures of social-emotional development for early infancy, only the Infant Toddler Social-Emotional Assessment (ITSEA; Carter et al., 2003) is recommended for use, albeit that its predictive validity at a community surveillance level is unknown (Halle & Darling-Churchill, 2016). Work toward infant mental health screening in the first 18 months of life is progressing (Ammitzbøll et al., 2016, 2019). An early form is under development through The Copenhagen Infant Mental Health Screening Project, for use in the 9–11 month postpartum period (CIMHS; Ammitzbøll et al., 2016), with a promising first validation study now completed (Ammitzbøll et al., 2019).

Procedural challenges to early screening include tension between the pragmatic needs of population surveillance for valid, brief, and easy to administer assessment

approaches, with accurate detection of clinical risk. More reliable observational assessments and psychometric tools for clinical assessment exist but are often costly, labor intensive, and beyond the reach of population-level indication (Jones et al., 2016). Significant resource demands have led to a reliance on nurse practitioner, parent and/or teacher report survey methodology, with poor or variable agreement between observer and parent-rated observations in both the attachment field, and in broader developmental assessment (Campbell et al., 2016; Rossen et al., 2018). Thus, despite agreement about the centrality of early infancy for development, screening of socio-emotional risk status in infancy is to date "far from completely adequate to meet early childhood education, policy, and research purposes" (Campbell et al., 2016, p. 28).

The Aims of this Review

The primary aim of this systematic review is to assess the evidentiary support for modifiable perinatal predictors of early infant social-emotional development. To this end, we (1) conduct a comprehensive review of the literature focused on the prediction of social-emotional development, behavioral regulation and attachment organization measured > 12 and < 18 months; and (2) identify the sub-set of predictors with greatest replicated evidence across studies. A tertiary aim is to inform the development of applied tools for population-level screening in the perinatal window, to detect risk and promote optimized social-emotional development in a critical stage of infancy, between 12 and 18 months.

Method

We systematically reviewed the relevant literature and synthesized the replicated evidence. We first summarized existing meta-analytic studies, and then examined individual studies not included in meta-analyses, for which two or more findings in identified domains were available. We assessed study quality using the Systematic Assessment of Quality in Observational Research (SAQOR; Ross et al., 2011) to guide evaluation and interpretation of findings (see Supplementary Materials, Table 2). The domains considered in the SAQOR include sampling and sample attrition, control/comparison group, quality of exposure/outcome measurements and accounting for confounders.

Selecting Outcome Measures of Infant Socio-Emotional Development

The literature was first searched for validated measures of social, emotional, and behavioral regulation, assessed > 12 and < 18 months, and checked against prior reviews (e.g., (Halle & Darling-Churchill, 2016). Candidate social-emotional measures were: Adaptive Behavior Assessment System (ABAS-II; Oakland & Harrison, 2011); Ages and Stages Questionnaire-Social-Emotional (ASQ-SE; Squires et al., 2002); The Alarm Distress Baby Scale (ADBS; Guedeney & Fermanian, 2001); Batelle Developmental Inventory, Personal-Social and Adaptive Subscales (BDI-PS&A; Newborg & Company, 2005); the Bayley Scales of Infant Development-II Social-Emotional Subscales (Bayley II-SE; Bayley, 1993); the Brief Infant Toddler Social-Emotional Assessment (BITSEA; Briggs-Gowan et al., 2002); and its longer form Infant Toddler Social-Emotional Assessment (ITSEA; Carter et al., 2003); Behavior Assessment System for Children-Second Edition (BASC-2; Kamphaus, 2015); Brigance Infant and Toddler Screen-Social-Emotional Skills (Brigance & Glascoe, 2002); Denver Developmental Screening Test-Personal-Social Subscale (DDST-PS; Frankenburg & Dodds, 1967); Greenspan Social-Emotional Growth Chart (Greenspan; Greenspan, 2004); the Still Face Procedure (SFP; Adamson & Frick, 2003), and the Vineland Adaptive Behavior Scales II and Vineland Social-Emotional Early Childhood Scales SEEC (VL-II and SEEC; Beltrán-Dussán, 1984).

Given our focus on prediction to social-emotional status in the > 12 and < 18 window, we applied two further essential inclusion criteria. Each measure needed to have published validation data for the age bracket of interest, namely > 12 and < 18 months, *and* use in a longitudinal study as an outcome measure within the age bracket of interest. We then utilized the methods proposed by Gokiert et al. (2014) and Jones et al. (2016) to verify the technical adequacy of measurement instruments, including purpose, standardization process, representativeness of the normative sample, reliability, validity, and usability. In this way, several of the above candidate measures were eliminated for our unique purposes (notwithstanding their validation for clinical and research use in other contexts).

Three instruments met all selection criteria for an outcome measure of social-emotional status in the > 12 and < 18 months window. These were the Bayley Scales of Infant Development-II– Social-Emotional Subscales (Bayley II-SE; Bayley, 1993); the Brief Infant Toddler Social-Emotional Assessment (BITSEA; Briggs-Gowan et al., 2002); and the Infant Toddler Social-Emotional Assessment (ITSEA; Carter et al., 2003). Two outcome measures of infant attachment organization met all criteria: Infant Strange Situation (SSP; Ainsworth et al., 2015) and the

Table 1 Selected outcome measures of social-emotional for infants under 18 months

Measure	Age range; Data source; Administration	Domains subscales	Psychometric properties
Bayley Scales of Infant and Toddler Development, 2nd and 3rd edition Bayley (2006)	1–42 months; Parent/caregiver interview and behavior observation; 50–90 min	Social-emotional (35 items); Adaptive behaviors assessment system-II (ABAS-II; 193 items); Cognitive (91 items); Motor (fine 66 items, gross 72 items); Language (receptive 49 items; expressive 48 items)	Internal consistency α .83–.94; Composite average reliability .91–.93; Test–retest .94 (Salmonsson & Sleed, 2010; Heo & Squires, 2012)
Infant Toddler Social-Emotional Assessment (ITSEA) Carter et al. (2003)	12–36 months; Parent/caregiver questionnaire; 25–30 min	17 subscales, four domains: Externalizing, Internalizing, Dysregulation, and Competence in Social-Emotional Behaviors (total 166 items)	Test–retest: .82–.90 (domains) and .69–.85 (scales); Inter-rater agreement between mother-father dyads .58–.79 (domains), .43–.78 (scales) (Carter et al., 2003); Convergent validity .34–.69 (Gokiert et al., 2014)
Brief Infant Toddler Social-Emotional Assessment (BITSEA) Briggs-Gowan et al. (2004)	12–36 months; Parent/caregiver questionnaire; 7–15 min	Two subscales: Problems and Competence (total 42 items)	Internal consistency .83-.89 (Problems) and .66-.75 (Competence) (Karabekiroglu, et al., 2010); Internal consistency .85–.90 (full scale); Test–retest .76–.91; Inter-rater reliability .72–.79; Convergent validity .34–.60 (Gokiert et. al., 2014)
Attachment Q-Set (AQS) Vaughn and Waters (1990), Waters and Deane (1985)	12–48 months; Trained observer conducted in home; 2–3 h	Q-sort methodology, 100 cards each describing a specific behavioral characteristic. Cards are sorted for strength of characteristic or absence of behavior, nine intervals	Predictive validity and sensitivity .39; Convergent validity with SSP .31 (Van Ijzendoorn et al., 2004)
Infant Strange Situation Procedure (SSP) Ainsworth and Bell (1970), Ainsworth et al. (1978)	12–20 months; Trained observers (reliability obtained with an external lab, of 80%+, for ABCD); 21-min procedure plus coding classification	Seven 3-min episodes of attachment-related behaviors in infants when with and separated from their parent/caregiver. Observer classification of attachment based on contact seeking, contact maintaining, resistance to contact and avoidance of proximity, with a focus on reunion episodes	First standardized on white, middle-class samples, $n = 106$ infants at 51 weeks, 23 for test–retest (Ainsworth, Blehar, Waters & Wall, 1978). Since widely validated across cultures (e.g., Bakermans-Kranenburg & van IJzendoorn, 1993; Belsky & Rovine, 1988; Jin et al., 2012)

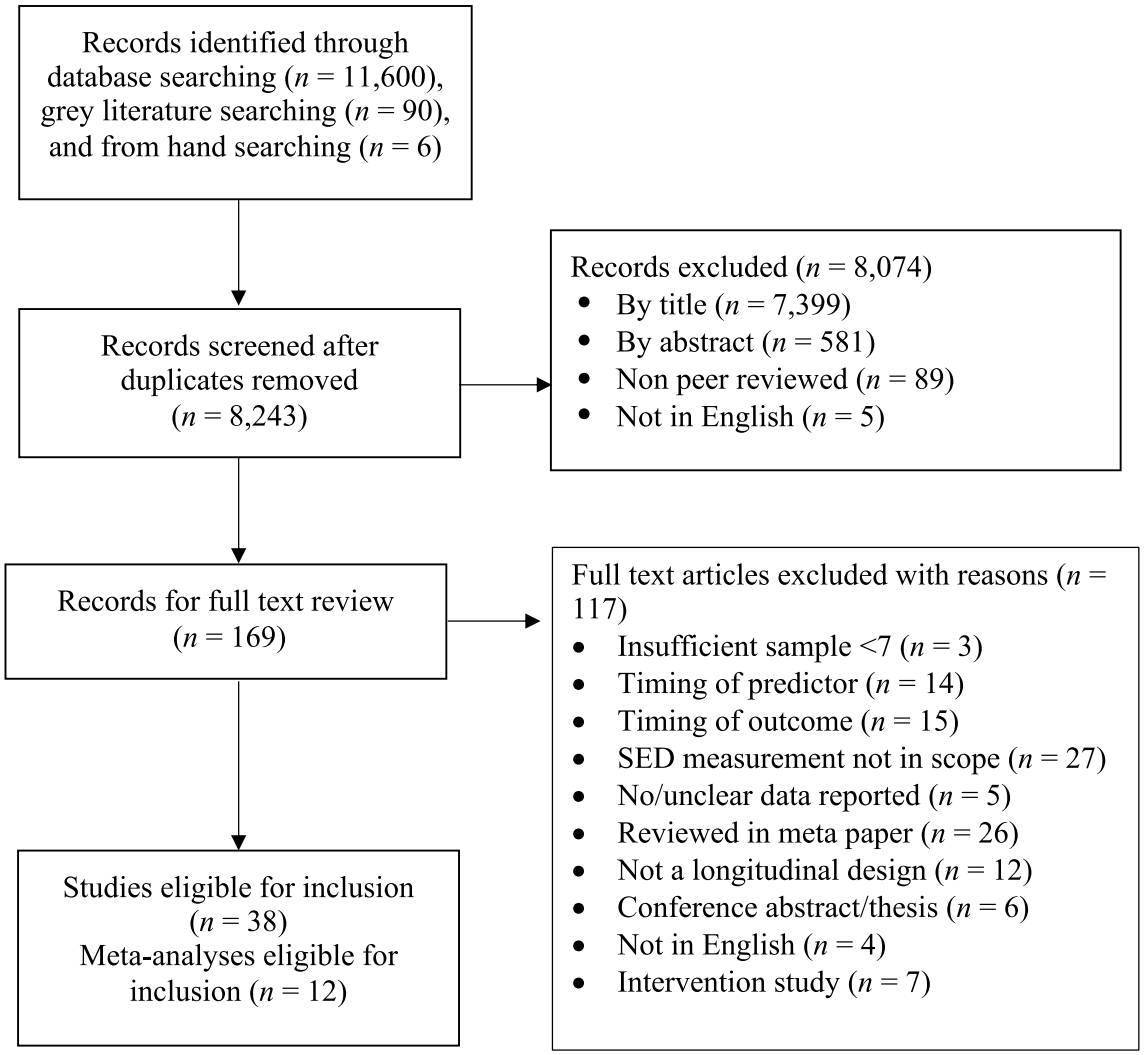

Fig. 1 Search strategy: PRISMA (2009) flow diagram

Observer Rated Attachment Q-Set (AQS—Observer Rated; Van Dam & Van Ijzendoorn, 1988), with the exclusion of parent-rated AQS. Key psychometric properties of each of the five outcomes measures of infant social-emotional development are described in Table 1.

Search Strategy

Following PRISMA guidelines (Moher et al., 2009), a systematic search was registered with the Prospero international register of systematic reviews (CRD42016052053) and conducted for studies examining modifiable factors predictive of infant social-emotional development in the > 12 and < 18 months window (see Fig. 1), employing our selected outcome measures. The search was first completed in September 2019, and repeated in July 2020, prior to preparation of the final manuscript. Six electronic databases were searched: EBSCOhost (ERIC, PsycINFO, and Medline Complete), Informit, Embase and Scopus. Search terms were: attachment OR social and emotional OR emotion* OR behav* OR regulat* OR adapt* AND predict* OR predispos* OR indicat* OR "risk factor*" OR implicat* OR influenc* OR identif* OR effect OR associat* AND infan* OR *ITSEA OR Bayley OR strange situation OR SSP OR attachment q* OR AQS. Search terms were adapted based on the specifications of each database. For manual searching of studies not detected in database searches, a forward and backward citation analysis was employed. A gray literature search was also conducted via Google, with the first ten pages of results screened.

The initial search identified 8243 articles (after removal of duplicates) based on database, gray literature, and manual searching. Following a title and abstract screen, 8,074 articles did not meet the inclusion criteria, leaving 169 records for full-text review. Empirical studies were included if they were original, peer-reviewed, written in English, and

used at least one of the five key social-emotional development measures noted above as a primary outcome > 12 and < 18 months. If the infant age range exceeded 17 months, studies were included when the mean age was at the midpoint of 15 months or younger. Papers were excluded if all effects were included in a reported meta-analysis, the predictor was assessed at the same time as the outcome measure, or if an overlapping predictor was measured and effects could not be disaggregated, such as infant fear and negative emotionality (see Supplementary materials, Table 1 for exclusion reasons for each study). Studies focused on genetic inheritance were out of scope, given our focus on modifiable risk.

Meta-analytic reviews were excluded if they were not peer-reviewed, not available in English, did not reference the studies included in their review, or if the analytic focus was on interventions rather than predictors of social-emotional development. The 12 reviews identified were conducted from 1987 to 2017; all but five were completed over 10 years ago. All identified meta-analytic reviews reported infant social-emotional development outcomes between > 12 and < 18 months, although some studies were not confined to this age range.

Data Extraction

Data extraction was informed by the Systematic Assessment of Quality in Observational Research (SAQOR; Ross et al., 2011) and the Cochrane group Method Guidelines for Systematic Reviews (Furlan et al., 2009). The following factors were examined: Study author/s, year, country, sample source and selection, representativeness, clinical, nested, representativeness of larger sample, sample size, participant parent and infant characteristics, control/comparison groups and design, predictor construct, measurement and adequacy of assessment of exposure, infant age at measurement points, outcome measures, reporting of attrition, explanation of missing data, control for, or consideration of, confounders, effect sizes, and completeness of reporting.

Analysis of Meta-analytic Reviews and Individual Studies

Findings from meta-analytic and empirical studies were grouped and described by exposure variables. Thirty-eight individual studies were also identified, for which new meta-analytic examination was not possible given singular study pools or heterogeneity of exposure and outcome variables. Narrative synthesis was therefore conducted for these studies, grouping findings by predictor categories for which repeated significant indication of infant social-emotional development outcomes was found, for the specified age group.

Results

Meta-analytic Reviews

Twelve meta-analytic studies fitting the search domains were identified (see Table 2). All were focused on attachment outcomes.

Individual Empirical Studies

Thirty-eight original empirical studies were identified. Population and design characteristics are described in Tables 3 and 4. SAQOR ratings are outlined in Supplementary material, Table 2. We note two of the 38 studies received the lowest SAQOR score, and we indicate caution in interpretation where relevant. All other studies were rated moderate/low for a weakness in one reporting domain through to high for adequate reporting on all domains.

Summary of Combined Meta-analytic and Empirical Evidence

A synthesis of evidence across all studies is provided below. For conceptual purposes, we group the findings within an ecological frame (Bronfenbrenner & Ceci, 1994), from factors most proximal to the infant to those most distant; (1) individual infant factors; (2) relational factors, including the caregiving/relational environment and impacts upon it, most notably maternal mental health and partner relationship quality; and, (3) contextual factors, including socio-economic resources and broader cultural indicators such as ethnicity. Perinatal predictors are described in sequential order; from strongest through to weakest empirical evidence for an association with infant social-emotional development. Available meta-analytic evidence is presented first, followed by the additional independent empirical studies. See Table 5 for a summary of findings across meta-analytic and independent studies, grouped by domain. Studies with low SAQOR ratings are excluded from this table.

Individual Infant Factors

Infant Prematurity/Medical Risk

The evidence for direct effects of prematurity is mixed, in contrast to strong replicated evidence of an association between combined prematurity and medical risk with later attachment insecurity. Employing a cut off of less than 36 weeks gestation, the van Ijzendoorn et al. (1999) meta-analysis of three studies found higher risk for disorganized attachment in preterm infants ($Zresid = 3.02$). In contrast, using very low birth weight cutoffs (< 1500 g to < 2500 g),

Table 2 Meta-analytic reviews

Study	Primary exposure	No. studies (sample size)	Outcome measure	Moderator variables	Effect sizes
Atkinson et al. (2000a, b)	Maternal sensitivity	41 (2243)	SSP and/or AQS	Time lag*; Age of child; Environmental risk status	$r = 0.27$
Baer and Martinez (2006)	Child maltreatment	8 (791)	SSP and/or AQS		OR 3.99 (insecure); OR 0.57 (secure)
De Wolff and van Ijzendoorn (1997)	Maternal sensitivity	30 (1666)	SSP or AQS(O)	Publication; Impact factor; Year; Size*; SES*; Clinical*; Firstborns; Global*; Duration; Home/lab*; Age*; SSP; Age-SSP*; Time interval*; Independent	$r = 0.22$
	Contiguity	14 (825)			$r = 0.10$
	Physical contact	9 (637)			$r = 0.09$
	Caregiving cooperation/interference	9 (493)			$r = 0.13$
	Optimized mutuality	28 (1928)			$r = 0.19$
	Negative parental attitude & Impoverished stimulation	24 (1233)			$r = 0.19$
Fox et al. (1991)	Attachment to parent 1	11	SSP with parent 2		OR 1.69; $\kappa = 0.309$ (secure vs insecure) OR 7.79; $\kappa = 0.73$ (avoidant vs resistant) OR 4.60; $\kappa = 0.58$ (B1–B2 vs B3–B4)
Goldsmith and Alansky (1987)	Maternal sensitivity	15 (892)	SSP		$d = 0.36$
	Temperament (proneness to distress)	18 (1605)	SSP or AQS		$r = 0.16$
Korja et al. (2012)	Preterm birth	8	SSP		Pooled proportions *N.S*
Martins and Gaffan (2000)	Maternal depression	7	SSP		Weighted pooled Z: − 3.83 (secure), 2.37 (avoidant), 0.56 N.S. (ambivalent), 2.34 (disorganized)
Nievar and Becker (2008)	Maternal sensitivity (sensitivity, mutuality, synchronicity) and other behaviors	30		SES*; Observation length*; SSP setting*	$r = 0.24$ (sensitivity) > $r = 0.15$ (other behavior types)
Tan et al. (2018)	Inter-parental conflict	8	SSP or AQS	Attachment measure*; Child age at exposure assessment and at attachment assessment; Time lag; Target parent/dyad; Reporter of conflict; Measurement of conflict; Risk status	$r = -0.28$
	Dyadic adjustment	5			*N.S*
van Ijzendoorn et al. (1999)	SES	80	SSP/*D*	Various	$r = 0.11$
	Various clinical groups				20–48% *D*
	Temperament	12			*N.S.*
	Concordance mother & father	3			*N.S.*
	Child maltreatment	2			$r = 0.41$
	Marital discord	2			$r = 0.25$
	Parental depression	11			$r = 0.09$
	Parental insensitivity	12			$r = 0.10$
	Parental dissociation and frightening behaviors	2			$r = 0.19$ (Schuengel) $r = 0.34$ (Lyons-Ruth)

Table 2 (continued)

Study	Primary exposure	No. studies (sample size)	Outcome measure	Moderator variables	Effect sizes
van Ijzendoorn et al. (1992)	Maternal conditions (maltreatment, drug use, mental illness, teen mother, adoption), and infant conditions (deafness, Down syndrome, prematurity)	34 (1624)	SSP		Pooled SR: − 6.04 (secure); Pooled SR: 9.6 (disorganized)
Verhage et al. (2016)	Adult attachment status	78 (4819)	SSP or AQS(O)	Publication status*; Risk status*; Biological caregiver*; Child age*; Caregiver gender; Study design; Coder training; Caregiver sensitivity (mediator)	κ = .28

Korja et al. (2012) found preterm infants and their mothers were not at higher risk of insecure attachment relative to full-term dyads (k = 8).

Other studies examined combined effects of perinatal problems/medical risk and prematurity. Van Ijzendoorn et al. (1992) report on infant groups with a primary child health related problem (e.g., Down's syndrome, deafness) and show disorganized attachment distributions deviated significantly from the control sample, (*Zresid* = 6.34), although organized categories did not differ. In a meta-analysis of six studies (van Ijzendoorn et al., 1999), infants with a neurological abnormality were also more likely to be classified in the disorganized attachment group. Higher rates of attachment insecurity at 12 months were found among 33 preterm infants born less than 33 gestational weeks with major perinatal problems ($F = 7.72$, $p = 0.01$; Udry-Jorgensen et al., 2011).

Three studies identified moderators of the relationship between infant prematurity and infant social-emotional outcomes. Mehler et al. (2011) found early connection (i.e., preterm infants whose mothers had seen them within three hours after birth) was associated with a higher rate of secure attachment than for preterm infants with no early contact (76% versus 41%). Firstborns also showed a significantly higher rate of insecure attachment behavior (93% versus 67%). Within a study of 171 infants born preterm, more daytime sleep and positive/responsive parenting predicted infant attachment security (Schwichtenberg et al., 2013). The Shah et al. (2011) study of 74 preterm infants found that mothers' resolved grief regarding the preterm birth experience was associated with secure infant-mother attachment at 16 months, after controlling for covariates (adjusted odds ratio: 2.94).

Infant Temperament

The evidence here is inconsistent. Goldsmith and Alansky (1987) examined meta-analytic associations in 18 studies in normal populations. Proneness to distress had a small positive association with resistant attachment behavior only ($r = 0.16$). Heterogeneity of estimates was notable. In a subsequent meta-analysis of 13 samples with 2028 infants, van Ijzendoorn (1999) found no significant association between disorganized attachment and constitutional and temperamental variables. Findings of two individual studies also conflict. Using the Infant Behavior Questionnaire–Revised (IBQ-R) low infant positive affect at 3 to 7 months was associated with later ambivalent attachment ($\beta = -0.10$, $p < 0.01$; Braungart-Rieker et al., 2014). In contrast, using the Infant Characteristics Questionnaire at 9 months, Scher and Mayseless (2000) found ambivalent attachment pattern was not associated with infant perceived difficult temperament.

Table 3 Characteristics of included studies: sampling, participant characteristics, and overall study quality

Study & Country	Sample	Sample size	Participant characteristics	Overall study quality*
Barglow et al. (1987) USA	Community	110 dyads (mother-infant)	SES: High	High
Beebe et al. (2010) USA	Clinical	84 dyads (mother-infant)	Maternal age: M = 29 years | Maternal education: 87.4% some college education or more | Ethnicity: 51.2% Caucasian, 29.8% Hispanic, 16.7% African American, 2.4% Asian | Infant gender: 47 male, 37 female	Moderate/high
Bigelow et al. (2018) USA	Community	87 dyads (mother-infant)	Maternal age: M = 29.4 years | Marital status: All married/living with partner | Education: 3.8% no high school completion, 7.7% completed high school, 25.6% some college, 33.3% college, 29.5% post college | Ethnicity: 56.3% Caucasian, 18.4% African American, 25.3% Hispanic | Primiparous: All | Birth: All full-term, singleton, and without major complications | Infant gender: 60% male, 40% female	Moderate/low
Braungart-Rieker et al. (2014) USA	Cohort	135 triads (mother-father-infant)	Parent gender: Mothers 90.3%, fathers 87.4% | Maternal age: M = 29.3 years | Education: > 50% some/completed college | Ethnicity: Caucasian | SES: Middle-class	High
Broussard (1995) USA	Cohort	38 dyads (mother-infant)	Maternal age: 14–18 years | Marital status: 89% single | Infant gender: 14 male, 24 female | Infant ethnicity: 12 Caucasian, 26 African American	Low
Brown et al. (2010) USA	Community	68 triads (mother-father-infant)	Parent gender: Mothers 82%, fathers 77% | Maternal age: M = 29.24 years | Paternal age: M = 31.89 years | Education: 90% (mothers) and 79% (fathers) Bachelor's degree | Ethnicity: European American | Income: M = $51,000–60,000 | Infant gender: 25 male, 33 female	Low
Carter et al. (2001) USA	Clinical	69 dyads (mother-infant)	Maternal age: M = 31.9 years | Marital status: 94% married | Ethnicity: 88% Caucasian | Primiparous: 49% | Infant gender: 39 male, 30 female	Moderate/high
Chase-Lansdale and Owen (1987) USA	Community	91 triads, 6 dyads	SES: Middle-class	Moderate
Costa and Figueiredo (2013) Portugal	Cohort	94 dyads (mother-infant)	Marital status: Mostly married | Education: > 9 years of school | Primiparous: All	Moderate/high
de Almeida et al. (2012) Portugal	Clinical	204 dyads (mother-infant)	Maternal age: M = 29 years | Marital status: 54% married, 16.9% de facto, 20.8% single, 7.7% divorced/separated | Maternal education: 23.8% undergraduate degree | Health behaviors during pregnancy: 21.4% smoked, 3% drank alcohol	Moderate

Table 3 (continued)

Study & Country	Sample	Sample size	Participant characteristics	Overall study quality*
Emery et al. (2008) Canada	Cohort	138 dyads (mother-infant)	Maternal age: M = 16.89 years | Marital status: 75% single | Maternal education: M = 9.07 years | Ethnicity: 84.1% Canadian born	High
Enlow et al. (2011) USA	Cohort	52 dyads (mother-infant)	Ethnicity: Primarily ethnic/racial minority sample | SES: Primarily low income, urban	High
Evans and Porter (2009) USA	Community	84 dyads (mother-infant)	Maternal age: M = 25.22 years | Marital status: 99.2% married | Education: Well-educated | Ethnicity: 94% Caucasian, 5% Hispanic, 1% Asian	Moderate/high
Gerardin et al. (2011) France	Clinical	164 dyads (mother-infant)	Marital status: 9% single | Ethnicity: 88% French citizens | SES: Diverse	High
Harrison and Ungerer (1997) Australia	Community	145 dyads (mother-infant)	Maternal age: M = 28.9 years | Paternal age: M = 31 years | Education: Broad educational status | SES M = 9.27 (1 = low to 15 = high)	High
Hart and Behrens (2013) USA	Community	72 dyads (mother-infant)	Maternal age: M = 29.36 years | Ethnicity: 83% European American, 12% Latina, 3% Asian, 2% African American | SES (Hollingshead): M = 2.58 | Infant gender: 49% male, 51% female | Infant age: T1 M = 45.18 weeks; T2 M = 53.83 weeks |	Moderate/high
Hawkins et al, 2015 Canada	Clinical/ Community	77 dyads (mother-infant)	Marital status: Predominantly married | Ethnicity: Predominantly Caucasian | SES: Predominantly middle class	High
Hayes et al. (2013) USA	Clinical	79 dyads (mother-infant)	Maternal age: M = 30.3 years | Marital status: 73% married | Education: 70% college graduate | Ethnicity: 71% European American, 29% African American | Income: High and low income groups | Infant gender: 46% male, 54%female	High
Holochwost et al. (2014) USA	Cohort	95 dyads (mother-infant)	Ethnicity: 53.7% African American, 46.3% European American | Income: High, mid, and low income groups	Moderate/low
Isabella and Belsky (1985) USA	Cohort	51 dyads (mother-infant)	Maternal age: M = 26.8 years | Marital status: 100% married | Education: M = 14.6 years Ethnicity: 100% Caucasian | SES: Middle class	High

Table 3 (continued)

Study & Country	Sample	Sample size	Participant characteristics	Overall study quality*
Leerkes and Zhou (2018) USA	Community	259 dyads (mother-infant)	Maternal age: M = 25.1 years | Marital status: 57% married/living with father, 24% dating (not living with) father, 19% single | Education: 24% high school or less, 27% some college, 46% college | Ethnicity: 128 European American, 123 African American, 8 multiracial | Primiparous: All | Family income: Mdn = $35,000 | Infant gender: 49% male, 51% female	High
Lickenbrock and Braungart-Rieker (2015) USA	Community	124 dyads (mother-infant) 117 dyads (father-infant)	Maternal age: M = 29.3 years | Paternal age: M = 30.8 years | Marital status: 84.4% married, 11.9% de facto | Maternal education: 27.4% postgraduate training | Paternal education: 29.1% postgraduate training | Ethnicity: 90.4% (mothers), 87.4% (fathers) Caucasian | SES: Middle class	Moderate/high
Luijk et al. (2011a, b) Netherlands/USA	Cohort	Gen *R*: 506–547 dyads (parent-infant);NICHD: 478–522 dyads (parent-infant)	Gen *R:* Maternal education: Highly educated | Ethnicity: Homogenous Dutch | Birth: Normal birth parameters | Infant gender: Normal gender distribution NICHD: Maternal education: Highly educated | Ethnicity: Caucasian | Infant gender: Normal gender distribution	Moderate/high
Madigan et al. (2015) Canada	Community	84 dyads (mother-infant)	Maternal age: M = 29.48 years | Marital status: 97% married/co-habiting | Education: M = 15.73 years | Income: M = $50,000–80,000	Moderate/high
Mehler et al. (2011) Germany	Clinical	62 dyads (mother-infant)	Maternal age: M = 31.2 years | Maternal education: 59.7% completed high school | Paternal education: 32.3% completed high school	Moderate
Mileva-Seitz et al. (2016) Netherlands	Cohort	550 dyads (mother-infant)	Maternal age: M = 32 years | Education: Highly educated | Infant gender: Near equal gender distribution	High
Peltola et al. (2015) Finland	Cohort	62 dyads (mother-infant)	Ethnicity: Caucasian | SES: Middle-class, urban families | Infant gender: 61% male, 39% female	Moderate/high
Raby et al. (2012) USA	Cohort	155 dyads (mother-infant)	Maternal age: M = 20.8 years | Marital status: 63% single | Ethnicity: 67% Caucasian, 20% multiracial, 9% African American, 3% Native American, < 1% Hispanic or Asian | SES: All below poverty line | Infant gender: 74 male, 81 female	Moderate
Ramsauer et al. (2014) Germany	Clinical	39 dyads (mother-infant)	Index: Living with partner: 78.9% | Education: M = 11.9 years | Infant gender: 68% male Control: Living with partner: 85% | Income: Higher household income Infant gender: 50% male	Moderate

Table 3 (continued)

Study & Country	Sample	Sample size	Participant characteristics	Overall study quality*
Scher and Mayseless (2000) Israel	Cohort	98 dyads (mother-infant)	Maternal age: M = 28.4 years | Marital status: Mostly intact families | Education: M = 14.1 | Ethnicity: 58% Ashkenazi, 42% Oriental | Residence: Mostly urban families	Moderate
Scher (2001) Israel	Cohort	79 dyads (mother-infant)	Maternal age: M = 28.5 years | Education: M = 14.2 years | Infant gender: 47% male, 53% female | First born: 32%	Moderate
Schwichtenberg et al. (2013) USA	Cohort	171 preterm infants	Maternal age: M = 29 years | Education: M = 14 years | Family income: M = $59,287	High
Shah et al. (2011) USA	Cohort	74 dyads (mother-infant)	Maternal age: M = 29.7 years | Marital status: 73% married | Education: M = 14.3 years | Ethnicity: 70% Caucasian, 10% African American, 20% multiracial | Family income: M = $56,541 | Gestational age: M = 31.4 weeks | Infant gender: 38 male, 36 female	Moderate/high
Shao et al. (2015) China	Cohort	58 dyads (mother-infant)	NR	Moderate/high
Tharner et al. (2012) Netherlands	Cohort	731 dyads (mother-infant)	Maternal age: M = 32 years | Education: Highly educated | Infant gender: Nearly equal genderdistribution	Moderate/high
Udry-Jorgensen et al. (2011) Switzerland	Clinical	33 dyads (mother-infant)	Infant gender: 49% male, 51% female	Moderate/high
Umemura and Jacobvitz (2014) USA	Cohort	1281 dyads (mother-infant) NICHD	Education: 10% no high school completion, 21% high school, 34% college, 21% degree, 15% postgrad | Infant gender: 52% male, 48% female | Infant ethnicity: 76.9% Caucasian, 12.3% African American, 4.0% Hispanic, 6.8% other	Moderate/high
Vafai et al. (2016)	Cohort	247 dyads (mother-infant)	Maternal age: M = 28.42 years | Marital status: 53.4% married | Education: 11.3% no high school completion, 29.5% completed high/technical school, 19.8% some college, 39.3% college or higher | Ethnicity: 74.1% Caucasian/non-Hispanic, 25.9% other	Moderate/low

[i]Joffe, L. S., Vaughn, B. E., Barglow, P., & Benveniste, *R*. (1985). Biobehavioral antecedents in the development of infant-mother attachment. In M. Reite & T. Field (Eds.), *Psychobiology of infant attachment* (pp. 323–349). Orlando, FL: Academic Press.[ii]Ekas, *N*. V., Braungart-Rieker, J. M., Lickenbrock, *D*. M., Zentall, S. *R*., & Maxwell, S. M. (2011). Toddler emotion regulation with mothers and fathers: Temporal associations between negative affect and behavioral strategies. *Infancy, 16*(3), 266–294.[iii]Further information available: Ungerer, J., Waters, B., Bamett, B., Dolby, *R*., Bouffard, *R*., & Kelk, *N*. (1992). The Sydney Family Development Project: A longitudinal study of children's emotional development in the first three years of life. *The Australian Educational and Developmental Psychologist, 9*(2), 12–17.[iv]Sroufe, L. A., Egeland, B., Carlson, E. A., & Collins, W. A. (2005). *The development of the person: The Minnesota study of risk and adaptation from birth to adulthood*. New York, NY: Guilford Press.[v]Information sourced from Poehlmann, J., Schwichtenberg, A. J. M., Shlafer, *R*. J., Hahn, E., Bianchi, J-P., & Warner, *R*. (2011). Emerging self-regulation in toddlers born preterm or low birth weight: Differential susceptibility to parenting? *Development and Psychopathology, 23*(1), 177–193

*SAQOR ratings (Systematic Assessment of Quality in Observational Research) followed the coding guidelines recommended by Ross et. al. (2011). Full category scores can be found in Supplementary materials, Table 2

Table 4 Included studies: constructs, measurement, timing, significant predictors, and covariates

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
Barglow et al. (1987)	Mothers' return to work: *Self-report*	8	ATT: *SSP (ABCD)*	12–13	None	Maternal early return to work	Parity status (primi vs. multiparous)
Beebe et al. (2010)	Infant contingent response: *Observer coded*	4	ATT: *SSP (ABCD)*	12–13	None	Low parent sensitivity Low infant responsiveness	Age, ethnicity, education, gender
Bigelow et al. (2018)	Maternal depression: *CES-D; M*ind-mind-edness: *Observer rated*	1. 5, 4, 12	ATT: *SSP (ABCD)*	12	Maternal appropriate mind-mindedness	Depression risk (at 1.5 months postpartum)	Maternal age
Braungart-Rieker et al. (2014)	Parental sensitivity: *SFP;* Infant affective response: *SFP* Temperament: *IBQ-R adapted*	3, 5, 7	ATT: *SSP (ABCD)*	12, 14	None	Low parent sensitivity Low infant responsiveness	Infant gender, family income, maternal, paternal education, cohabitation, minority status
Broussard (1995)	Demographics (age, infant gender, race): *Self-report*	Birth	ATT: *SSP (ABCD modified)*	12	Infant gender (female); Maternal race (Caucasian)	Younger maternal age	Infant age, infant gender, race
Brown et al. (2010)	Co-parenting observed: *Cowan & Cowan;* Co-parenting reported: *PAI;* Co-parenting reported: *PAI;* Parent play sensitivity: *Ainsworth SS*	3.5	ATT: *SSP (ABCD)*	12, 13	Co-parenting quality; Infant gender (male)	None	Mothers' and fathers' sensitivity
Carter et al. (2001)	Maternal depression: *CES-D;* Current & lifetime psycho pathology: *SCID-NP;* Emotional availability: *EAS adapted*	4	ATT: *SSP (ABCD)* SED: *ITSEA*	14	Higher income	Co-morbidity (mental health & substance)	Maternal age, maternal education, income, number of children, child sex
Chase-Lansdale and Owen (1987)	Postpartum maternal employment: *Self-report*	2–6 weeks	ATT: *SSP (ABC)*	11, 13	None	Higher maternal employment	Infant gender
Costa and Figueiredo (2013)	Infant behavior: *NBAS;* Social withdrawal: *ADBB* Mother-infant interaction: *Global rating scales*	2, 3, 4	ATT: *SSP (ABC)*	12–14	Parent sensitivity/ availability	Low infant responsiveness	Maternal age, education, marital status, parity, type of gestation, type of delivery, type of anesthesia, time of gestation, sex

Table 4 (continued)

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
de Almeida et al. (2012)	Maternal mental disorder: *BSI;* Maternal mental health: *IACLIDE*	Pregnancy, 3.5	SED: *BITSEA*	**2**	None	None	None reported
Emery et al. (2008)	Maternal adult attachment: *ASQ;* Maltreatment history: *CTQ;* Depression: *CDIS; EPDS;* Parenting stress: *PSI;* Maternal sensitivity: *CARE-Index;* Infant temperament: *ICQ;* Social support: *ASSIS*	Pregnancy, 4, 10	ATT: *SSP (ABCD)*	**15**	Higher maternal education; Lower parenting stress; Higher parent social support	None	Maternal birthplace, ethnicity, age at delivery, place of recruitment, living with mother's parents in pregnancy, income source, presence of partner during pregnancy and at 10 months infant gender, years of schooling
Enlow et al. (2011)	Maternal lifetime trauma exposure:*LSC-Revised;* PTSD: *PCL-C;* Depression: *EPDS;* Infant trauma exposure: *TESI-PR*	6	ATT: *SSP (ABCD)* SED: *ITSEA BSID-II*	13	None	Higher maternal mental health problems	Financial strain, infant race
Evans and Porter (2009)	Mother-infant co-regulation: *FGRCS*	6, 9, 12	ATT: *SSP (ABCD);* SED: *BSDI-II*	12	Co-regulation	None	None Reported
Gerardin et al. (2011)	Maternal depression: *CES-D; SCL-90-R; STAI; MADRS; MINI*	Pregnancy, 2, 6	SED: *ITSEA*	12	None	Higher maternal depression	Infant gender
Harrison and Ungerer (1997)	Childcare hours per week, maternal satisfaction with care: *Self-report*	4, 12	ATT: *SSP (ABCD)*	12	Higher education Regulated childcare	Unstable/ multiple care arrangements	Maternal education, child age at entry into childcare, maternal age, SES
Hart and Behrens (2013)	Infant behavioral responses: *Observer coded*	10	ATT: *SSP (ABC)*	12	None	Greater touch and proximity seeking by infant	None reported

Table 4 (continued)

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
Hawkins et al (2015)	Maternal insight: *Oppenheim and Koren-Karie (2002);* Maternal sensitivity; *MBQS;* Adult Attachment: *AAI;* Secure base scripts: *Waters & Rodriguez (2004)*	3, 4, 10	ATT: *SSP (ABCD)*	13	Interaction of insight, sensitivity and autonomous attachment status		Maternal age, education, household income
Hayes et al. (2013)	Maternal antenatal depression: *SCID-I/P, BDI-II*	Pregnancy, 3	ATT: *SSP (ABCD)*	12	None	Greater maternal depressive symptoms; Low parent sensitivity	Maternal age, race, marital status, household income, education, antidepressant usage and infant gender
Holochwost et al. (2014)	Parenting behavior: *SFP*	6	ATT: *SSP (ABCD)*	12	None	Low parent sensitivity	Gender, ethnicity
Isabella and Belsky (1985)	Marital quality: *Huston's scales; BKI*	Pregnancy, 3, 9	ATT: *SSP (ABC)*	12	None	Low couple relationship quality	Maternal age, age at marriage, education, years married, length of relationship, planned pregnancy
Leerkes and Zhou (2018)	Maternal sensitivity: *Observer rated* Infant temperament: *IBQ-R*	6, 12	ATT: *SSP (ABCD)*	12	Sensitivity to infant distress	Sensitivity to non-distress	Maternal sensitivity at 1 year
Lickenbrock and Braungart-Rieker (2015)	SES; parent involvement: *Self-report;* Marital satisfaction: *SMAT* Parental sensitivity: *SFP*	3, 5, 7	ATT: *SSP (ABCD)*	12, 14	Higher maternal sensitivity Paternal involvement	None	Cohabitation status, infant ethnicity, infant gender, parity
Luijk, et al. (2011), Luijk, et al. (2011))	Maternal sensitive responsiveness: Gen *R*: *Ainsworth SS.* NICHD: *non-distress, positive regard & intrusiveness;* Feeding: *Self-report*	Gen *R*: Birth, 2, 14 NICHD: 2. 6	ATT: *SSP (ABCD)*	Gen *R*: 15 NICHD: 15	Breastfeeding over 6 months	Low parent sensitivity	Child gender, birth weight, gestational age, Apgar score, mother's age at intake, maternal education, hours working per week, marital status, smoking/ alcohol use, parity
Madigan et al. (2015)	Maternal attachment representations: *AAI, WMCI*	Pregnancy	ATT: *SSP (ABC)*	11	Positive prenatal WMCI	None	Maternal age, education, income

Table 4 (continued)

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
Mehler et al. (2011)	Maternal contact after birth: *Observer rated;* Infant SED: *BSID-II;* Caregiving representations: *WMC*	Birth, 3	ATT: *SSP (ABCD)*	11–19	Maternal newborn interaction Non-firstborn	None	Gestational age, birth weight, cesarean section, Apgar, neonatal complications, maternal age, SES of mother and father, pregnancy history
Mileva-Seitz et al. (2016)	Infant night-time sleep location: *Self-report*	2	ATT: *SSP (BAC/D)*	14	Firstborn	No early bed-sharing (solitary sleeping)	Maternal age, education, parity, depression, infant temperament, breastfeeding, crowding in home
Peltola et al. (2015)	Infant attention to facial expressions and face-shaped control stimuli: *Eye-tracking Overlap paradigm;* Maternal sensitivity: *EAS*	5, 7	ATT: *SSP (ABCD)*	14	Attentional bias to fearful faces	Aversion to/low attentional bias to fearful faces	Infant gender
Raby et al. (2012)	Maternal responsiveness: *Ainsworth SS*	6	ATT: *SSP (ABC)*	12	Maternal sensitivity		Infant sex, ethnicity
Ramsauer et al. (2014)	Maternal psychopathology: *BDI, SCL-90-R, SCID-I (German);* Sensitivity, Insight: *Ainsworth SS, Clinical diagnosis*	3–11	ATT: *SSP (ABCD)*	12–24	Description complexity, insightfulness, openness, flexibility	None	Age, living status, age of infant, maternal education level, household income
Scher and Mayseless (2000)	Parenting stress: *PSI* Maternal separation: *MSAS;* SES: *Index;* Working status & childcare: *Self-report;* Infant temperament: *ICQ*	2, 4–6, 9	ATT: *SSP (ABCD)*	12	Higher Maternal education	High parenting stress; Low parent social support; Longer maternal work hours & hours in childcare	Infant gender, birth order
Scher (2001)	Maternal orientation: *FRQ, ICQ*	6, 9	ATT: *SSP (B/ACD)*	12	Parent sensitivity	None	None

Table 4 (continued)

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
Schwichtenberg et al. (2013)	Infant sleep patterns: *Sleep log, parent report;* Quality of mother-infant interactions: *PCERA*	4, 9	ATT: *SSP (ABCD)*	16	Parent sensitivity Daytime sleep	Infant prematurity	Marital status, gender, multiple births, birth weight, Apgar, days hospitalized
Shah et al. (2011)	Maternal grief resolution: *RPBI;* Parenting: *PCERA*	Birth, 9	ATT: *SSP (ABCD)*	16	Maternal grief resolution Parent sensitivity	Infant prematurity	Family socio-economic risk, maternal depression, maternal vocabulary, neonatal health risk,
Shao et al. (2015)	In utero drug exposure history: *Self-report*	2, 6	SED: *BSID-III*	12	None	None	Maternal age, occupation, planned pregnancy; During pregnancy: antipsychotic treatment, smoking, diabetes, hypertension, vitamin use, living arrangements, body mass index; feeding, infant gestational age & sex
Tharner et al. (2012)	Duration of breast feeding: *Self-report;* Maternal sensitivity: *Ainsworth SS*	Birth, 2, 6	ATT: *SSP (ABCD)*	14	Breastfeeding (months)	None	Maternal age, SES, parity, birth weight, Agpar, delivery, psychological health, family functioning, infant sex
Udry-Jorgensen et al. (2011)	Severity of perinatal problems, survival risks: *PERI;* Maternal sensitivity, and responsiveness: *CARE Index*	4	ATT: *SSP (B/AC)*	12	None	Prematurity, Infant medical risk, Low parent sensitivity, Low infant responsiveness	Gender, singleton, twins, SES, maternal age, nationality
Umemura and Jacobvitz (2014)	Non-maternal care: *Self-report;* Temperament: *ITQ*	3, 5, 6, 9, 12	ATT: *SSP (ABCDU)*	15	Fewer hours in non-Maternal care	More hours in non-maternal care; Poor infant responsiveness	Maternal sensitivity, income-to-needs ratio, birth order, maternal age, ethnicity, years of education, child sex

Table 4 (continued)

Study	Predictor measurement		Outcome measurement^		Significant predictors		Covariates
	Construct & measure	Infant age (mths)	Construct & Measure^	Infant age (mths) +	Social-emotional health	Social-emotional problems	
Vafai et al. (2016)	Postnatal depression: *EPDS*	2	SED: ITSEA	12	None	Younger maternal age; Ethnicity (non-Caucasian)	Maternal age, race, education, homeownership, postpartum smoking, marital status, parenting stress, happiness in parenting

Only outcome measures defined in this systematic review are reported. + Only study outcomes within the age specified for this review are reported (12–17 months)

AAI Adult Attachment Interview (George et al., 1996), *ADBB* Alarm Distress Baby Scale (Guedeney & Fermanian, 2001), *Ainsworth SS* Ainsworth Sensitivity Scales (Ainsworth et al., 2015), *ATT* Infant Attachment Status, *ASSIS* Arizona Social Support Interview Schedule (Barrera, 1981), *ASQ* Attachment Style Questionnaire (Feeney et al., 1994), *BDI-II* Beck Depression Inventory–II (Beck et al., 1996), *BKI* Braiker & Kelley Index (Felmlee et al., 1990), *BSI* Brief Symptom Inventory (Derogatis & Spencer, 1993), *BSID-II* Bayley Scales of Infant Development-II, *CARE-Index* Child–Adult Relationship Experimental Index (Belsky & Nezworski, 2015), *CDIS* Computerized Diagnostic Interview Schedule (Blouin et al., 1988), *CES-D* The Center for Epidemiologic Studies-Depression Scale (Roberts & Vernon, 1983), *CTQ* Child Trauma Questionnaire (Bernstein et al., 2003), *EAS* Emotional Availability Scales (Pipp-Siegel & Biringen, 1998), *EPDS* Edinburgh Postnatal Depression Scale (Cox et al., 1987), *FGRCS* Fogel's Global Relational Coding System (Fogel et al., 1992), *FRQ* Facilitator-Regulator Questionnaire (Scher & Blumberg, 1999), *IACLIDE* Inventory of the Clinical Evaluation of Depression, *IBQ-R* Infant Behavior Questionnaire-Revised (Parade & Leerkes, 2008), *ICQ* Infant Characteristics Questionnaire (Kohnstamm, 1984), *ITQ* Infancy Temperament Questionnaire (Carey & McDevitt, 1978), *LSC* Lifetime Stressor Checklist, *MBQS* Maternal Behavior Q-Sort (Pederson et al., 1999), *MSAS* Maternal Separation Anxiety Scale (Hock, McBride, & Gnezda, 1989), *NBAS* Neonatal Behavioral Assessment Scale (Brazelton & Nugent, 1995), *PAI* Parenting Alliance Inventory (Abidin & Brunner, 1995), PCERA Parent–Child Early Relational Assessment (Clark, 1999), *PCL-C* Posttraumatic Stress Disorder Checklist–Civilian version (Ruggiero et al., 2003), *PERI* Perinatal Risk Inventory (Schemer & Sexton, 1991), *PSI* Parenting Stress Index (Abidin & Abidin, 1990), *RPBI* Reaction to Preterm Birth Interview, *SCID (IP Patient/NP Non-Patient)* The Structured Clinical Interview for the DSM-III-*R* (Spitzer et al., 1990), *SCL-90-R* Symptom Checklist-90-Revised (Derogatis, 1975), *SED* Social-Emotional Developmentl, *SFP* Still Face Procedure, *SMAT* Short Marital Adjustment Test (Locke & Wallace, 1959), *TESI-PR* Traumatic Events Screening Inventory-Parent Report Revised (Ippen et al., 2002), *WMCI* Working Model of the Child Interview (Zeanah, Benoit, & Barton, 1995)

Abbreviations Outcome Constructs and Measures *ATT* Attachment Security, *BITSEA* Brief Infant Toddler Social-Emotional Assessment, *BSID-II & BSID-III* Bayley Scales of Infant Development-II & III; *ITSEA* Infant–Toddler Social-Emotional Assessment, *SSP* Strange Situation Procedure, *ABCDU* (5-way attachment classification, B = Secure, A = Avoidant, C = Resistant, *D* = Disorganized, U = Cannot Classify); ABCD (4-way attachment classification), *ABC* (3-way attachment classification, *B/AC and B/ACD* (2- way classification)

Table 5 Grouped predictor factors by significant risk and protective outcomes, for meta-analytic reviews and replicated individual studies**^

Infant factors	Secure attachment/well developing	Insecure/disorganized attachment	Behavioral dysregulation or Internalizing problems	Non-significant association
Infant gender (male)		Carter et al. (2001), Chase-Lansdale & Owen (1987)*	Gerardin et al. (2011)	
Prematurity/medical risk		van Ijzendoorn et al. (1999) [M], van Ijzendoorn et al. (1992) [M], Udry-Jorgensen et al. (2011)		Korja et al. (2012) [M]
Infant temperament	Leerkes and Zhou (2018)*	Goldsmith and Alansky (1987) [M], Braungart-Rieker et al. (2014)		van Ijzendoorn et al. (1999) [M],Scher and Mayseless (2000)
More daytime sleep	Schwichtenberg et al. (2013)*			
Affective withdrawal, low engagement		Beebe et al. (2010), Braungart-Rieker et al. (2014), Costa and Figueiredo (2013), Hart and Behrens (2013)		
Caregiving factors				
Prenatal insecure attachment/caregiving representations		Verhage et al. (2016)* [M], Madigan et al. (2015); Mehler et al. (2011)		
More months breastfed	Luijk et al. (2011a, b), Tharner et al. (2012)			
Antenatal depression		Hayes et al. (2013)*	Gerardin et al. (2011)	
Postnatal depression		Martins and Gaffan (2000) [M]	Bigelow et al. (2018), Carter et al. (2001), Enlow et al. (2011), Martins and Gaffan (2000) [M], Ramsauer et al. (2014)*	de Almeida et al. (2012), Ramsauer et al. (2014), Vafai et al. (2016)
Maternal grief/PTSD		Shah et al. (2011)*	Enlow et al. (2011)	
Co-morbid mental illness & substance use		van Ijzendoorn et al. (1992) [M], Carter et al. (2001)		
Sensitive response, involvement, positive interaction, insightfulness	Atkinson, et al. (2000a, b) [M], Baer and Martinez (2006) [M], Goldsmith and Alansky (1987) [M], Nievar and Becker (2008)*, Costa and Figueiredo (2013), Evans and Porter (2009), Hawkins et al (2015), Madigan et al. (2015), Lickenbrock and Braungart-Rieker (2015)*, Raby et al. (2012), Ramsauer et al.(2014), Schwichtenberg et al. (2013), Shah et al. (2011)*,Bigelow et al. (2018), Leerkes and Zhou (2018)*			

Table 5 (continued)

Infant factors	Secure attachment/well developing	Insecure/disorganized attachment	Behavioral dysregulation or Internalizing problems	Non-significant association
Low emotional availability; poor timing; low orientation; low facilitation; maltreatment		De Wolff and van Ijzendoorn (1997)* [M], van Ijzendoorn et al. (1999) [M], Beebe et al. (2010), Braungart-Rieker et al. (2014), Holochwost et al. (2014), Lickenbrock and Braungart-Rieker (2015)*, Scher (2001), Udry-Jorgensen et al. (2011), Leerkes and Zhou (2018)*		
Low parenting stress	Emery et al. (2008), Scher and Mayseless (2000)			
Couple relationship factors				
Poor couple relationship		Tan et al. (2018) [M], van Ijzendoorn et al. (1999) [M], Isabel & Belsky (1985), Lickenbrock & Braungart Rieker (2015), Luijk et al. (2011a, b)		
Dyadic adjustment				Tan et al. (2018)* [M]
Contextual factors				
Younger maternal age			Vafai et al. (2016)	
Ethnicity (Caucasian)			Vafai et al. (2016)	
Lower income, education, occupation		van Ijzendoorn et al. (1999) [M], Scher and Mayseless (2000)		Madigan et al. (2015)
Higher income, education, occupation	Carter et al. (2001), Emery et al. (2008), Harrison and Ungerer (1997)			Madigan et al. (2015)
Longer hours in group childcare	Harrison and Ungerer (1997)*	Scher and Mayseless (2000), Umemura and Jacobvitz (2014)		
Unstable/multiple care arrangements		Harrison and Ungerer (1997), Scher and Mayseless (2000)		

Table excludes studies with overall low SAQOR rating. [M] Meta-analytic study

*Indicates a significant interaction/ moderating relationship

**Only factors within the age specified for this review are reported (predictors from pregnancy to 10 months postnatal, outcomes between 12 and 17 months)

^Only outcome measures defined in this systematic review are reported

+The study did not control for other night-time contact (feeding) or day time contact, or comforting behaviors, and an overall caution regarding higher risk for SIDS in co-sleeping should be noted

Conflicting results reflect varied timing of administration and the mixed use of reactivity and negative temperament measures.

Infant Sleep

No studies of full-term infants met the inclusion criteria for this review. Preterm infants ($n = 171$) with higher daytime sleep scores at 4 and 9 months were more likely to be securely attached at 16 months ($Z = 5.83$ and 4.58, $p < 0.01$, respectively). Infant night-time sleep was not associated (Schwichtenberg et al., 2013).

Affective Withdrawal/Engagement/Touch

In a sample of 84 clinical dyads, Beebe et al. (2010) found insecure attachment at 12 months was predicted by lower scores on infant-initiated touch ($\beta = -0.25$, $p = 0.04$); maternal engagement ($\beta = -0.40$, $p = 0.01$) and coordination with mother's touch ($\beta = -0.06$, $p = 0.02$); in addition to higher contingent touch by the infant ($\beta = 0.03$, $p = 0.04$). In a nested sample of 94 dyads, Costa and Figueiredo (2013) found associations between higher infant withdrawal or under-arousal at 3 months and higher insecure attachment proportions at 12 months of age ($\chi^2_{\text{Wald}}(2) = 4.93$, $p < 0.05$). Higher quality of mother-led interaction with the infant mediated the relationship. Hart and Behrens (2013) also found higher infant-initiated touch ($n = 72$ dyads, $F = 4.50$, $p < 0.05$) and proximity to mother ($F = 3.43$, $p < 0.05$) at 10 months predicted later classification of insecure-resistant attachments relative to secure. Finally, in a study of 33 preterm infants (Udry-Jorgensen et al., 2011), infant compulsive-compliance at 4 months was associated with later insecure attachment at 12 months ($F = 5.69$, $p = 0.02$).

Caregiver/Relational Factors

Prenatal Caregiving and Attachment Representations

The direction of this association is consistent across all studies reviewed. Consistent with van IJzendoorn's (1995) findings, a meta-analysis by Verhage et al. (2016) ($k = 78$, $n = 4819$) found a prospective association between parents' secure prenatal attachment representations (George et al., 1996) and infant secure attachment (SSP or observer-rated AQS; $r = 0.31$). Risk status of the sample, biological relatedness of child-caregiver dyads, and offspring age moderated the relationship. Caregiver sensitivity explained approximately 25% of the association. Small but significant associations were found for parents' unresolved attachment representations and subsequent infant insecure attachment status ($r = 0.21$).

Consistent with this meta-analytic evidence, a Canadian study of 62 preterm-infant-mother dyads (Mehler et al., 2011) found a strong association between prenatally assessed working models of caregiving (WMC; maternal) and infant attachment security at 12 months (OR 9.71, $p < 0.01$). Postnatal WMC did not contribute to the prediction (OR 1.44, $p > 0.05$).

Breastfeeding Duration

Two studies found direct associations between longer periods of breastfeeding and infant attachment security. In the Gen *R* cohort study of 601 dyads (Luijk et al., 2011a, b), children breastfed at 6 months postpartum had higher rates of attachment security at 15 months ($p < 0.01$). Tharner et al. (2012) also found longer duration of breastfeeding was associated with attachment security ($n = 731$, $\beta = 0.10$, $p < 0.05$) and lower risk of disorganized attachment ($\beta = -0.01$, $p < 0.05$). Maternal sensitivity did not mediate this association.

Antenatal Depression

Two studies from France and the USA found risk associations between maternal antenatal depression and infant social-emotional development outcomes at 12 months. Antenatal depressive symptoms predicted higher attachment disorganization, regardless of postpartum depressive symptoms ($n = 79$ dyads; OR 1.23, $p < 0.05$; Hayes et al., 2013). High maternal parenting quality at 3 months significantly reduced the association between antenatal depressive symptoms and attachment disorganization (OR 0.81, $p < 0.05$). Antenatal depression was associated with greater activity/impulsivity, oppositional aggression, and sleep problems in infants at 12 months ($n = 164$ dyads; $p = 0.04$, 0.02, and 0.02, respectively), especially for male infants ($p = 0.009$) (Gerardin et al., 2011). Sex differences were identified in a clinical sample of 69 dyads, where exposure to maternal antenatal depression was associated with a greater likelihood of attachment insecurity in infant males (Carter et al., 2001).

Postnatal Depression

Four meta-analyses were identified. Results are consistent with regard to an association of maternal postpartum depression with attachment insecurity, while the evidence is less established for other indices of infant socio-emotional functioning. Across 34 studies of child-mother dyads the van Ijzendoorn et al. (1992) meta-analysis utilized correspondence analysis in clinical and community samples. Maternal

depression was associated with a higher distribution of ambivalent attachment classifications (*Zresid* = 6.98). Similarly, a later meta-analysis by van Ijzendoorn et al. (1999) found that retrospectively self-reported maternal lifetime depression was weakly associated with attachment disorganization ($r = 0.09$, $N = 11$ studies), with smaller samples and samples of younger infants yielding higher effect sizes. The Martins and Gaffan (2000) meta-analysis of seven studies examined the effects of maternal depression with patterns of infant attachment (SSP). Infants born to mothers clinically diagnosed with depression had a reduced likelihood of secure attachment and a marginally higher likelihood of avoidant and disorganized attachment (weighted pooled $Z = -3.83$ for secure, 2.37 for avoidant, 0.56 for ambivalent, 2.34 for disorganized). Subsequently, Bigelow et al. (2018) also found maternal depressive symptoms at 6 weeks were associated with infant disorganized attachment at 12 months ($n = 87$ dyads, $r = 0.24$, $p = 0.042$).

Enlow et al. (2011) found maternal depressive symptoms at 4 and 6 months postpartum were associated with internalizing and behavioral dysregulation symptoms at 13 months ($n = 52$ dyads, $r = 0.30$ and 0.31, respectively, $p < 0.05$). However, three other studies with samples ranging from 34 to 247 dyads found no statistically significant differences in infant social-emotional development between clinically depressed and non-depressed groups, net of confounders (de Almeida et al., 2012; Ramsauer et al., 2014; Vafai et al., 2016).

Mental Illness and Co-morbidities

Taken together, there is strong evidence that combined maternal difficulties with mental health confers greater risk to attachment security in the mother–child dyad than depression alone. The van Ijzendoorn et al. (1992) meta-analysis of 34 clinical studies examined the relative influences of mothers' mental illness, maltreatment, teen age, and alcohol/drug misuse. Main findings were reported as standardized residuals, showing the extent to which attachment categories in clinical samples deviated from normal samples. Each clinical group and subgroup showed a significant deviation ($p < 0.05$) in attachment classification compared to data from 21 studies of non-clinical participants ($n = 1584$). For the total maternal problem sample ($n = 191$) a significant decrease in infant secure attachment (*Zresid* = − 6.04) and a significant increase in disorganized attachment (*Zresid* = 9.06) were reported. Each of the subgroups deviated from the total normal sample on classification of secure attachment; mental illness ($n = 285$, *Zresid* = − 2.54); maltreatment ($n = 130$, *Zresid* = − 4.41); drug misuse ($n = 19$, *Zresid* = − 1.46), and teen motherhood ($n = 69$, *Zresid* = − 1.86). In contrast, there were few demonstrated effects of child problems (such as developmental difficulties) on any attachment distribution.

A subsequent study of maternal depression, co-morbidity, and effects on attachment (Carter et al., 2001) examined 69 mother-infant dyads from pregnancy to 30 months postpartum. Comparisons between the no-psychopathology, depression only, and co-morbid psychopathology groups (depressive illness with an anxiety, substance, or eating disorder) showed higher rates of insecure attachment in infants of the co-morbid group ($\chi^2 = 10.68$, $p = 0.01$) and no differences in insecurity between the depression only and no-psychopathology groups.

Maternal Grief/Post-Traumatic Stress Disorder (PTSD)

Two studies found associations between maternal unresolved trauma and infant social-emotional development outcomes. Enlow et al. (2011) found that maternal PTSD symptoms at 6 months were associated with infant externalizing, internalizing, and emotional dysregulation symptoms at 13 months ($r = 0.32$, 0.37, and 0.45, respectively, $p < 0.05$). Infant exposure to traumatic events did not influence prediction in this study. As a protective factor, Shah et al. (2011) found that resolution of maternal trauma related to premature birth was associated with 2.9 higher odds of a secure infant attachment classification at 16 months of age ($n = 74$ dyads).

Sensitive Response, Involvement, Positive Interaction, Insightfulness

All meta-analytic studies found small to moderate ($r = 0.19$ to 0.34) associations between maternal sensitivity/responsiveness and infant attachment security. The Goldsmith and Alansky (1987) meta-analysis focused on community population samples ($d = 0.36$, $N = 15$ studies). De Wolff and van Ijzendoorn (1997) examined 30 studies of child-mother dyads, reporting a moderate effect size ($r = 0.24$) with offspring attachment security (SSP or observer-rated AQS) moderated by sample size, socio-economic status (SES), child age at maternal sensitivity assessment, and time interval between assessments. Nievar and Becker (2008) re-examined the De Wolff and van Ijzendoorn (1997) meta-analysis by re-structuring the maternal sensitivity, mutuality, and synchrony constructs into an overall marker of maternal sensitivity. Defined in this way, maternal sensitivity was a stronger predictor of attachment than other types of maternal behavior ($r = 0.24$ for sensitivity, $r = 0.15$ for other behavior types), moderated by low income. These findings held in a later meta-analysis of 41 studies ($r = 0.27$; Atkinson, et al., 2000a, b), but moderation by infant age or risk status did not.

These meta-analytic findings are supported by eight further studies from USA, Portugal, Germany, and Canada

reporting on longitudinal associations between parental responsiveness and infant attachment security. A study conducted in Portugal with 94 mother-infant dyads (Costa & Figueiredo, 2013) found higher quality maternal responsiveness assessed at 8 weeks was associated with secure attachment at 12 months (OR 1.40, $p < 0.05$). Two USA studies reported similar results. Namely, in a study of 101 mother-infant dyads (Evans & Porter, 2009), greater symmetrical and less unilateral co-regulation by mothers at 6 months of age was associated with secure attachment in 12-month-old infants ($t = -2.03$, $p < 0.05$ for symmetrical, and $t = 2.02$, $p < 0.05$ for unilateral). A larger USA study (Raby et al., 2012) found greater maternal responsiveness at 6 months predicted higher likelihood of secure attachment at 12 months (OR 1.42, $p < 0.01$). Fourth, in a study of 135 parent-infant dyads (Lickenbrock & Braungart-Rieker, 2015), parental sensitivity between 3 and 9 months was associated with attachment security between 12 and 14 months ($F = 6.85$, $p < 0.01$ for mothers; $F = 7.81$, $p < 0.01$ for fathers). Notably, maternal sensitivity and paternal involvement were more strongly predictive of infant attachment than parental age or socio-economic resources. A study of 171 preterm infants in the USA (Schwichtenberg et al., 2013) found parenting affect and response at 4 to 9 months was predictive of later attachment security ($Z = 17.08$ for positive affect, $Z = 57.47$ for negative affect, $Z = 31.43$ for intrusiveness, $p < 0.01$). Shah et al. (2011) found increased odds of secure infant attachment when mothers of preterm babies demonstrated more positive affect and communication (OR 1.87, $p = 0.03$), less intrusiveness (OR 2.66, $p = 0.004$), and less anger (OR 3.03, $p = 0.003$) at 9 months. A Canadian study (Hawkins et al., 2015) found maternal insight into the psychological motives underlying infant behavior at 10 months predicted secure infant attachment ($\chi^2_{Wald} = 4.14$, $p < 0.05$), after controlling for maternal age, education and household income.

Three studies, based in Finland (Peltola et al., 2015) and the USA (Bigelow et al., 2018; Leerkes & Zhou, 2018), found weaker associations between maternal relational factors and infant attachment. Differences appear fully accounted for by variation in study quality (sample size, attrition) differing focus (e.g., exploration of different modifying pathways), lower rate of attachment insecurity in community samples, variation in measurement and measurement timing.

Low Emotional Availability, Sensitivity, Timing of Response

Two meta-analyses found moderate to strong associations between child maltreatment by the attachment figure and attachment disorganization: $r = 0.41$ in the van Ijzendoorn et al. (1999) meta-analysis; OR 7.5 for physical abuse and OR 3.7 for failure to thrive in the Baer and Martinez (2006) meta-analysis. Meta-analysis of 12 studies by van Ijzendoorn et al. (1999) found that frightening maternal behaviors predicted attachment insecurity in two studies ($r = 0.19$, $r = 0.34$). No significant association was found with self-reported parental dissociation.

Seven additional studies demonstrated associations between low parental responsiveness and infant attachment insecurity and disorganization. In an urban community sample of 84 mother-infant dyads (Beebe et al., 2010), infants insecurely attached at 12 months were more likely than securely attached infants to have experienced mothers' intrusive touch (21.6% versus 6.5%, $p = 0.05$), mothers' looming into infant's face ($\chi^2 = 8.68$, $p = 0.01$), chase-and-dodge interactions (Mann–Whitney $U = 465$, $p = 0.01$), mothers' lowered gaze ($\beta = -0.51$, $p = 0.01$), and lower contingent spatial orientation ($\beta = -0.09$, $p < 0.001$). Leerkes and Zhou (2018) found that low maternal sensitivity to infant distress in conjunction with high sensitivity to infant non-distress at 6 months was positively associated with avoidant attachment at 12 months ($\beta = 0.27$, $p = 0.04$). Braungart-Rieker et al. (2014) found avoidant attachment was preceded by lower parental sensitivity assessed during the Still Face Paradigm ($\beta = -0.38$, $p < 0.01$ mothers; $\beta = -0.42$, $p < 0.001$ fathers), and by infant low positive affect at 3, 5 and 7 months of age ($\beta = -0.10$, $p < 0.05$). Disorganized attachment at 12 months was associated with low parent orientation during the SFP ($\beta = -0.03$, $p < 0.05$ mothers; $\beta = 0.09$, $p < 0.05$ fathers). Likewise, in a study of 33 preterm infants (Udry-Jorgensen et al., 2011), insecure attachment at 12 months was associated with earlier controlling maternal interactions ($\chi^2 = 8.66$, $p = 0.03$). Holochwost et al. (2014) found high levels of maternal negative intrusiveness at 6 months predicted attachment disorganization at 12 months ($r = 0.30$, $p < 0.01$). Conversely, in a low-risk sample (Scher, 2001) mothers' facilitating parenting style at 6 months was associated with later attachment security at 12 months, relative to ambivalent attachment ($t = 2.61$, $p < 0.05$).

Parenting Stress

A Canadian study of 138 mother-infant dyads (Emery et al., 2008) found that lower parenting stress at 4 months postpartum was positively associated with secure infant attachment at 12 months [$F(2,128) = 3.76$; $p < 0.05$]. Similarly, a study of 98 infant-mother dyads from Israel (Scher & Mayseless, 2000) found that mothers of infants with ambivalent attachment reported higher preceding parenting stress compared to mothers of securely attached infants ($\lambda = 0.75$, $p < 0.01$).

Couple Conflict and Relationship Quality

Meta-analytic evidence supports a small to moderate association between couple relationship conflict and infant

attachment insecurity. In a meta-analysis by van Ijzendoorn et al. (1999), marital discord was moderately associated with attachment disorganization ($r = 0.25$, $N = 2$ studies). Similarly, Tan et al. (2018) found a moderate association between inter-parental conflict and attachment security (SSP or ASQ; $r = -0.28$, $N = 8$ studies). No protective association with positive couple/dyadic adjustment was found ($r = 0.14$, $N = 5$ studies).

Other studies examining couple relationship quality included a USA study of 68 families (Brown et al., 2010), in which father-to-infant attachment security at 13 months was associated with supportive co-parenting at three-and-a-half months for boys only ($r = 0.49$, $p < 0.01$). Co-parenting was unrelated to mother-infant attachment security. We interpret this finding with caution given its low SAQOR quality rating. Isabella and Belsky (1985) found infant attachment insecurity at 12 months was associated with an antecedent decline in postpartum marital quality ($F = 4.32$, $p < 0.05$) and an antecedent increase in negative marital relations ($F = 3.40$, $p < 0.05$). Prenatal marital quality was not associated. In a longitudinal US study of 135 families (Lickenbrock & Braungart-Rieker, 2015), marital conflict at one month postpartum was negatively associated with mother-infant attachment security at 15 months ($r = -0.20$, $p < 0.01$). In dyads where father reported low marital satisfaction, infant-father attachment was more likely to be classified secure as fathers' involvement increased (55% vs 89%; OR 0.15), yet equally likely to be secure for father's reporting high satisfaction, as paternal involvement increased (83% vs 81%; OR 1.15).

Contextual Factors

Maternal Age

The evidence in this domain for a direct risk association between younger maternal age and problematic infant development is consistent. Women's reproductive years generally range from about 15 to 45 years but are typically dichotomised in infant mental health research into teen versus not-teen first birth. Since 1995, the average maternal age at first birth has increased at a rate of 0.10 years per year in Organization for Economic Co-operation and Development countries. In 2017, age of first birth exceeded 30 years in all but eight of these countries (OECD, 2017). Within this, first births in the teen years remain a focus of research for their potential to carry higher risk for non-optimal offspring mental health (Zondervan-Zwijnenburg et al., 2019).

Two studies with US samples ranging from 38 to 247 dyads found moderate risk relationships between teen maternal age at birth and later infant attachment insecurity (Bakermans-Kranenburg & Van IJzendoorn, 2007; Broussard, 1995) and infant externalizing and internalizing behaviors at 12 months (Vafai et al., 2016). In two clinical samples (Broussard, 1995), attachment distributions for a teen mother group varied significantly from non-teen samples (Secure 23.7% vs 65%; Disorganized 31.6% vs 12%). Likewise, in a community sample of 247 dyads (Vafai et al., 2016), lower maternal age at birth predicted infant externalizing problems at 12 months ($\beta = -0.07$, $p = 0.01$). While we interpret the Broussard (1995) finding with caution, given the overall poor quality reporting of data, no clearly defined control group and small sample size (see Supplementary materials, Table 2), the balance of the evidence supports an association between teen maternal age at birth and later infant attachment insecurity. Further research is warranted, to replicate this association.

Ethnicity

Only two studies were identified in this domain. Their results contrast and the low number of studies prohibit conclusions. These two US studies found risk relationships between a mother's ethnicity and infant attachment. In a small sample of 38 teen mother-infant dyads (Broussard, 1995), infant attachment security was predicted by maternal race (African American/Caucasian, $\chi^2 = 6.72$, $p < 0.01$). Vafai et al. (2016), in a large community sample, found mother's ethnicity (white non-Hispanic) predicted infant internalizing problems at 12 months ($\beta = -1.33$, $p < 0.01$). These findings should, however, be interpreted cautiously, given low quality reporting evident in each study (see Supplementary material, Table 2).

Education

Emery et al. (2008) found higher levels of maternal education were associated with infant attachment security ($OR = 0.68$, $p < 0.05$), as did Harrison and Ungerer (1997), [$F(1,102) = 3.04$, $p = 0.04$]. Reciprocally, a study of 98 dyads found lower levels of maternal education at birth predictive of infant attachment insecurity (ambivalent) at 12 months ($\lambda = 0.82$, $p = 0.01$; Scher & Mayseless, 2000). Again, the low number of studies prohibits conclusions.

Socio-Economic Status (SES)

The evidence for promotive associations of high SES and risk associations of low SES with infant social-emotional outcomes is small to moderate. The meta-analysis by van Ijzendoorn et al. (1999) found a higher proportion of infants with a *D* classification among low SES samples relative to middle-class samples ($r = 0.11$, $N = 80$ studies). Two studies (Carter et al., 2001; Lickenbrock & Braungart-Rieker, 2015)

identified higher SES (income and occupation status) in the perinatal period as promotive of infant social-emotional development outcomes at 12 months, samples ranging from 68 to 143 dyads, and including general population, high risk, and ethnically diverse groups.

The above findings are consistent, despite different aggregates of indicators used to measure SES. The only contrasting finding comes from a predominantly middle-class sample ($n = 77$), where Madigan et al. (2015) found no association of maternal education or SES with infant attachment status. The discrepancy is accounted for methodologically: low income, education, and occupation are all under-represented in the (Madigan et al., 2015) study, which also collapsed the avoidant, ambivalent, and disorganized classes into one insecure attachment classification.

Also notable, interactions were found between socio-economic resources at 3 months postpartum and infant-father attachment security at 12 months (Lickenbrock & Braungart-Rieker, 2015). Specifically, infants of fathers with low SES were equally likely to be classified secure as paternal involvement increased (80% vs 72%, OR 1.55). Elsewhere, higher income was also associated with lower externalizing scores [$\lambda = 0.76$, $F(2,61) = 9.84$, Eta square $= 0.24$, $p < 0.05$; Carter et al., 2001].

Concordance of Infant Attachment to Mother and Father

The Fox et al. (1991) meta-analysis found infants classified with a secure attachment (SSP) to one parent were less likely to be classified as having an insecure attachment to the other parent ($\kappa = 0.31$, $N = 11$ studies). An infant-parent attachment categorized as avoidant or ambivalent was likely to be similarly categorized with both parents ($\kappa = 0.73$, $N = 10$ studies). Concordance at the subcategory classification level within the secure category (e.g., B1 to B2, B3 to B4) was also identified ($\kappa = 0.58$, $N = 9$ studies). The finding may reflect the protective nature of a first secure attachment in the generation of expectation for another, or equally may reflect greater likelihood of adult secure attachment pairings.

Maternal Work Status

Findings in this domain conflict. A US study of 110 dyads (Barglow et al., 1987) found that mothers who had returned to work before 8 months postpartum were more likely to have firstborn infants classified insecure in attachment ($\chi^2 = 6.11$, $p < 0.05$). In contrast, another US study published in the same year with a comparably sized sample (Chase-Lansdale & Owen, 1987) found no direct association between mothers' return to work full-time between 2 weeks and 6 months postpartum and infant-mother attachment. However, boys' risk for insecure attachment to father was higher when mothers were employed outside the home ($\chi^2 = 7.60$, $p < 0.03$). Attachment outcomes were moderated by higher maternal employment. Overall, a low number of studies prohibits conclusions.

Longer Hours in Group Childcare

Findings in this domain are conflicting. Longer hours of maternal work and more hours of infant daycare were associated with higher rates of ambivalent attachment ($\chi^2 = 5.92$, $p < 0.05$; Scher & Mayseless, 2000). In contrast, Umemura and Jacobvitz (2014) found that compared to infants with ambivalent attachment, infants classified avoidant were more likely to spend fewer hours in non-maternal care in their first year of life (OR 0.84, $p < 0.05$). The effect size, however, was small. In an Australian study of 145 firstborn children (Harrison & Ungerer, 1997), after controlling for maternal education levels, children in high quality part-time or full-time childcare had increased odds of attachment security (OR 3.63, $p = 0.01$, and OR 3.79, $p = 0.02$, respectively) when contrasted with those who attended minimal hours of care.

Multiple Non-family Carers

Harrison and Ungerer (1997) also found that children with a disorganized pattern of attachment had experienced more care changes ($M = 2.1$, SD $= 1.0$) and had the highest number of carers per week ($M = 2.8$, SD $= 0.9$) compared to children in the three other attachment groups (in which the number of care changes averaged 1.5 per week and the number of carers averaged 2.3 per week). However, only descriptive statistics were provided in this study. In another study of 98 mother-infant dyads in Israel (Scher & Mayseless, 2000), being in a group daycare situation contributed to infants' attachment insecurity, over the impact of longer time spent by their mothers at work.

Non-replicated Evidence

Individual longitudinal studies of adequate to excellent quality were identified in eight further domains, but are not elaborated here, given our focus on replicated evidence. Their details are included in Tables 3 and 4. The domains are: *Infant self-soothing* as a precursor to disorganized attachment to father (Braungart-Rieker et al., 2014); *Gaze aversion from fearful faces* at 5 months as a precursor to insecure attachment at 12 months (Peltola et al., 2015); *Infant co-sleeping* at 2 months and higher rates of insecure attachment at 12 months (Mileva-Seitz et al., 2016); *Close mother-infant contact soon after birth* predicting later secure infant attachment status in very low birthweight babies (Mehler

et al., 2011); *Co-morbid mental health problems with substance abuse* predicting higher risk of insecure attachment at 14 months (Carter et al., 2001); *Clozapine (Anti-psychotic medication) use during pregnancy* not predicting a difference in social-emotional development outcomes for infants at 12 months on the Bayley SE scale (Shao et al., 2015); *Maternal separation anxiety* and later insecure infant attachment classification (Scher & Mayseless, 2000); *High social support* across the perinatal period and secure infant attachment at 12 months (Emery et al., 2008).

Discussion

This review takes an important step toward synthesizing the available replicated evidence on risk and protective influences in the perinatal window for subsequent social and emotional development in the > 12 and < 18 month period. To date this has been a significant gap in the research literature, hampering progress toward effective early surveillance. Twelve meta-analytic reviews and 38 original studies found replicated evidence for 12 indicators across infant, caregiving and contextual domains predictive of infant behavioral regulation and attachment status by age 18 months (Table 5). Critically, evidence from this review indicates that while risk and protective factors are often related, they are not always the inverse of one another, supporting the inclusion of both risk and protective perspectives in early screening of infant social-emotional development.

Indicators with Evidence of a Direct Protective Association with Infant Social-Emotional Development

Our review found considerable evidence for associations between the caregiving relational context in the first year postpartum on infant SED status between 12 and 18 months. Replicated, direct protective associations were found for four indicators: *maternal sensitivity, involvement, positive interaction with the infant,* and *insightfulness*. This result is consistent with an extensive theoretical base on the role of the mother responsiveness in child development (Bowlby, 1969, 1973, 1980; Egeland & Carlson, 2004), and with treatment demonstrating the efficacy of targeting maternal sensitivity (Berlin, 2007; Cicchetti et al., 2006).

We also found strong evidence for a direct protective relationship between a *mother's autonomous/resolved adult attachment status* and positive offspring outcomes. This refers to mother's current secure attachment representation with respect to her own childhood attachment figures, independent of any experience of trauma during childhood. This finding is consistent with a large associated body of theory and research supporting a link between adult autonomous attachment status with respect to past loss or trauma, and mothers' greater tolerance for the infant's negative affective states (Fonagy et al., 1991).

There was also evidence for a direct protective effect of *breastfeeding duration* of 6 months or more for SED status by 18 months. This is consistent with prior research showing similar benefit for physical and cognitive development (Dieterich et al., 2013; Hayatbakhsh et al., 2012; Quinn et al., 2001; Strathearn et al., 2009). A number of explanations for the benefits to social-emotional development are possible. First, breastmilk confers direct nutritional benefit to the growing infant. Nutrition is linked to emotion regulation (Avan et al., 2010) and feeding is linked through regular maternal physical touch and attunement to infant needs during a peak period of development in the attachment promoting pre-frontal cortex regions (Dieterich et al., 2013; Schore, 2015). In addition to those mechanisms, breastfeeding also likely involves more time spent together with the baby (i.e., bottle-fed babies more likely to be fed by other caregivers) and more intense levels of physical contact with the infant.

Finally, our review found strong replicated evidence for the direct protective effects of *higher income, education, occupation,* and *older maternal age*. These contextual factors were relatively smaller in effect size in comparison to caregiving sensitivity, in keeping with the view that factors proximal to the individual tend to have greatest influence (Bronfenbrenner & Ceci, 1994).

Indicators with Evidence of a Risk Association for Infant Social-Emotional Development

Strong effect sizes were consistently found for compromised maternal caregiving indicators, including *low maternal emotional availability/sensitivity*, *orientation* and/or *facilitation*, *poorly timed interactions*, and a *mother's own unresolved attachment status*. This is consistent with foundational theories of development (Ainsworth et al., 2015), and accruing etiological evidence (Verhage et al., 2016). Findings support assessment of risk and protective processes in maternal sensitivity for optimized early indication of infant social-emotional development.

Maternal mental health problems showed strong replicated associations with poorer infant SED status. *Antenatal depression* during pregnancy was associated with a small, independent increase in the risk for insecure attachment, higher activity/impulsivity, oppositional aggression, and sleep problems in infants at 12 months. *Postnatal depression* was associated with attachment disorganization specifically. There is robust evidence of elevated risk through *maternal PTSD and unresolved trauma and loss*, independent of other factors, such as maternal depression. Explanatory mechanisms include biological and/or hormonal changes during pregnancy which directly impact the developing fetus in

utero, and postnatally interfere with the capacity for emotionally sensitive response to the infant (Rogers et al., 2020; Stein et al., 2014). Both pathways are particularly relevant in the case of substance abuse (Hutchinson et al., 2014).

Couple discord, conflict, and parenting stress in the perinatal period consistently predicted subsequent insecure and disorganized infant attachment, in keeping with the extant literature (McIntosh et al., 2010; Pruett et al., 2014). Parental stress has been similarly linked to poorer quality parenting behavior, as well as increased inter-partner conflict (Neece et al., 2012), which may together increase the risk for poorer infant social-emotional development status.

Evidence also suggests that *younger maternal age*, below approximately 20 years, may be a risk factor for early social-emotional development; however, further studies are needed to replicate this finding due to the generally poorer quality of existing studies. A ceiling at which older maternal age may be a risk factor is not established. While the intra-uterine environment of advanced maternal age is associated with higher chromosomal and medical risk, and related negative offspring cardiovascular and health outcomes (Myrskylä & Fenelon, 2012), greater life experience and socio-economic ease may scaffold socio-emotional advantage for the offspring of older mothers (Carslake, et al., 2017).

Infant factors were less predictive of later problems in social-emotional development than those identified in the parental context. Specifically, the association between infant temperament measured post 6–10 months and subsequent attachment status remains negligible. However, neurobehavioral markers at 3–6 months, such as proneness to distress and affective withdrawal, may be stronger markers of later developmental difficulties. As discussed elsewhere, indication of risk status may benefit from disaggregation of state regulation and neuro-physiological competence from temperament constructs (DeSantis et al., 2011).

Evidence for *specific medical and developmental conditions* (e.g., Down's syndrome, deafness, and respiratory sinus arrhythmia) is conflicting, but on balance suggests risk of disorganized attachment when the caregiving context is negative-intrusive. *Prematurity* in combination with major perinatal problems and/or medical risk carries higher risk for infant outcomes (Cheong et al., 2017; Lundqvist-Persson et al., 2012).

Finally, *unstable* or *multiple out of family care arrangements* predicted higher rates of attachment disorganization, albeit that this evidential base remains limited. Specifically having a higher number of carers (average of 2.8) and more care changes per week (average of 2.1) may reduce the consistency and/or predictability of the care environment, in turn challenging infant affect regulation (Belsky, 2009; Belsky & Rovine, 1988).

Replicated Interaction Effects

Interaction occurs when the effect of one risk or protective factor on an outcome depends on the state of a second risk or protective factor. Evidence of interaction effects was documented in a number of studies, with implications for the design of screening instrumentation. Most notably, *low parenting quality* and *harsh* or *insensitive caregiving environments* increased the association with negative infant SED status (Hayes et al., 2013; Holochwost et al., 2014; Luijk et al., 2011a, b; Ramsauer et al., 2014). Low socio-economic status (Chase-Lansdale & Owen, 1987; Harrison & Ungerer, 1997) and infant prematurity (Mehler et al., 2011; Schwichtenberg et al., 2013; Shah et al., 2011) interacted with a range of risk factors to predict elevated risk status by 18 months. This suggests that when maternal depression occurs in isolation, adequate sensitivity in parent-infant interactions may buffer the impact, and that with surrounding life adversity, "risk to the parent-infant system may be amplified and adaptive developmental progress disrupted" (Carter et al., 2001, p. 24).

Summary of Key Predictors of Infant Social-Emotional Development

Taken together, the results of this review suggest a summative framework of 12 risk and promotive categories from pregnancy to 10 months of age that may optimize early screening of infant social-emotional development:

Individual Domain (1) Infant low engagement, withdrawal; (2) Prematurity/very low birthweight with major perinatal problems, medical risk; (3) Infant medical and developmental conditions.

Caregiver/Relational Domain (4) Timing and sensitivity of caregiving response, involvement, and insightfulness (5) Maternal PTSD related to grief and loss; (6) Marital and couple conflict; (7) Maternal mental health problems and co-morbidity (8) Parenting stress; (9) Maternal adult attachment status; (10) Breastfeeding duration.

Contextual Domain (11) SES: income, education, occupation, maternal age, and (12) Unstable and multiple substitute care arrangements.

As shown in Table 5, a range of other factors have emerging support and may also be considered with adequate replication in future research.

Implications for Theories of Development

These results are consistent with the Developmental Origins of Health and Disease position (DOHaD; Gluckman et al., 2010) that throughout fetal life and early infancy, the care environment induces critical changes in development that may impact the course of health and disease risk. Our findings show that both the broader ecological system in which growth occurs as well as person-context interrelatedness need to be considered. Within this, factors most proximal to the infant during the perinatal period most strongly associated with infant social and emotional status by 18 months. Our findings may also reflect the continued significance of prenatal social and biological influences on fetal development ((Bridgett et al., 2015; Nederhof & Schmidt, 2012; Rueda & Rothbart, 2009).

Strengths, Limitations, and Recommendations for Future Research

The review followed a defined protocol, examining 501 studies from 12 meta-analyses and 38 unique studies published over the past three decades. A key strength of this review is the systematic, broad search strategy across a range of exposures (20 perinatal indicators) and social-emotional development outcome measures (five gold-standard assessments instruments). Further to this, we minimized the risk of missing relevant articles by: (1) including a range of free text terms and subject headings to describe the domains of interest; (2) not applying limits to searches (to ensure we capture articles without categorization); (3) including a gray literature search and forward and backward citation analysis; and, (4) using a rigorous screening process, involving key informants and multiple assessors.

There are a number of limitations to note. First, the majority of empirical studies included in this review focus on the prediction of clinical and/or sub-threshold clinical disorders and other pathology. By contrast, few included a focus on protective factors and/or mechanisms that promote healthy development and infant well-being. Improving knowledge of protective pathways in future research is important. Second, the extant literature typically focuses on individual rather than accruing risk factors, despite evidence that risks typically co-occur (i.e., sensitivity of parenting is linked to antecedent psychosocial and demographic factors). A multi-variate approach to individual, relational, and contextual domains remains important (Bornstein, 2014; Bronfenbrenner & Ceci, 1994). Third, heterogenous sampling, timing and measurement of predictor variables exists in the studies reviewed and should be brought to bear in interpretation of conflicting results across studies. Fourth, with the exception of attachment security, for which there is a comparatively stronger empirical base our search underscores the lack of meta-analytic evidence available on prospective pathways to infant social-emotional well-being. Fifth, we found few prospective studies examining the role that fathers play in fostering optimal social-emotional development in infancy, particularly in the context of the couple relationship (i.e., marital quality and functioning). This is an important area for future research, especially given the increasing participation of fathers in child rearing (Yeung et al., 2001). Sixth, a dominant focus exists across the suite of studies on predictors proximal to the infant (e.g., individual and maternal factors). Markedly less evidence exists for the role of broader ecological systems likely to impact parenting quality and infant social-emotional development (Bronfenbrenner & Ceci, 1994); and the interplay between proximal and distal factors, including socio-economic status (Dodge et al., 1994; Lickenbrock & Braungart-Rieker, 2015). Future research could have greater focus on applying the social ecological framework to our understanding of how proximal and distal systems interrelate to influence social-emotional development in infancy. Additionally, few prospective studies have disaggregated theorized periods of sensitivity in early fetal and infant development in which exposures may lead to heightened risks for infant SED status by 18 months. This remains a novel area for future research with potential to inform the timing of perinatal interventions.

Finally, use of longitudinal designs, even within a specified framework for confounder selection may not support claims of causality. We have included in Table 4 a list of covariates accounted for within study designs, and although our explication of study characteristics was thorough and transparent, it is not possible to lay bare all sources of potential bias (VanderWeele, 2020). Where possible, the explicated data in our tables highlight these, and our integrated discussion attempts to help the reader evaluate the strength of evidence for or against a particular causal proposition.

Implications for Population Level Indication

The results of this review suggest that there are a range of risk and protective factors for infant social-emotional development that could feasibly be indicated in the first year of life via broad surveillance tools. There is rigorous, replicated support for 12 indicators, and emerging levels of support for a range of other indicators (see Table 5). The next stage in extending the application of these indicators to population-level indication is to: (1) design and test the sensitivity and specificity of the indicators within a population health framework; (2) further test and replicate the empirical base for indicators requiring stronger empirical support, particularly via reviews and meta-analyses; and, (3) contrast the

predictive utility of parent report, objective report (e.g., by early childhood care visitors), or combined parent and practitioner completion methods. Further to this, new population tools need to be well accepted by parents and community health nurses, developed and tested in partnership, and easy to administer. To ensure effectiveness, they would need to be readily linked with relevant supports and interventions. Psychosocial interventions and prevention initiatives for infant and preschool populations has grown steadily since the emergence of the infant mental health sub-speciality in the 1970s. More recently, aside from the parent–child relationship as the primary focus of such initiatives, the role of the child's family and broader contexts are also viewed as important and included in prevention interventions and treatment approaches (McLuckie et al., 2019).

Summary and Conclusions

Toward the end of the first year, infants show stabilizing patterns of frontal neural activation and predictable behavioral strategies for emotion regulation (Bell & Fox, 1994; Eisenberg et al., 2010). This begs the question as to why most screening of infant emotional development commences after 18 months and/or focuses on infant and toddler-centered behaviors. Broadening behaviorally focused instrumentation (Ammitzbøll et al., 2019) to include the contextual domains identified here may optimize early identification of risk pathways. As Shonkoff and Fisher (2013) entreat the early intervention field to cease child-centric enrichment approaches and invest instead in a two-generation evidence-based perspective on intervention, the need for both earlier and wider focus on detection of risk in the perinatal window is clear. Optimally, such early population indication would serve the dual purpose of identifying infant-parent dyads at risk and informing public policy. The potential personal, public, and economic gains of early population-level indication of emotional growth appear significant and compelling.

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