



Associations between problems with crying, sleeping and/or feeding in infancy and long-term behavioural outcomes in childhood: a meta-analysis

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ABSTRACT

Background Excessive crying, sleeping or feeding problems are found in approximately 20% of infants and may predict behavioural problems in childhood.

Methods A quantitative meta-analysis of 22 longitudinal studies from 1987 to 2006 that statistically tested the association between infant regulatory problems and childhood internalising, externalising and attention-deficit/hyperactivity disorder (ADHD) problems was carried out; 1935 children with regulatory problems were tested. Cohen's *d* was used to express the association between regulatory problems and behavioural problems. Heterogeneity of the effect sizes was assessed using the I^2 statistic and meta-analysis of variance and meta-regressions were conducted to assess the influence of moderators. Rosenthal's classic fail-safe *N* and correlation of sample sizes to effect sizes were used to assess publication bias.

Results The weighted mean effect size for the main regulatory problems-behavioural problems association was 0.41 (95% CI 0.28 to 0.54), indicating that children with previous regulatory problems have more behavioural problems than controls. Externalising and ADHD problems were the strongest outcome of any regulatory problem, indicated by the highest fail-safe *N* and lowest correlation of sample size to effect size. Meta-analyses of variance revealed no significant moderating influences of regulatory problem comorbidity ($I^2=44.0$, $p>0.05$), type ($I^2=41.8$, $p>0.05$) or duration ($I^2=44.0$, $p>0.05$). However, cumulative problems and clinical referral increased the risk of behavioural problems.

Conclusions The meta-analyses suggest that children with previous regulatory problems have more behavioural problems than controls, particularly in multi-problem families. Further studies are required to assess the behavioural outcomes of previously sleep, feeding or multiply disturbed children.

INTRODUCTION

Approximately 20% of all infants show symptoms of excessive crying, sleeping difficulties and/or feeding problems, often referred to as regulatory problems, in the first year of life.¹⁻⁴ Regulatory problems are a common concern of parents, resulting in frequent help seeking, family disruption and considerable costs for the health services.^{5,6} Clinical classification systems⁷ describe infants with regulatory problems as having difficulties with self-regulation of fussiness, irritability or coping with change, that is, they cry longer, need longer despite assistance to settle back to sleep once awoken or have problems overcoming neophobia to new foods.

What is already known on this topic

- ▶ Excessive crying, sleeping or feeding problems, often referred to as infant regulatory problems, are found in approximately 20% of all infants.
- ▶ Early regulatory problems can have an adverse effect on behavioural or cognitive development, but findings have been inconsistent.

What this study adds

- ▶ Regulatory problems in infancy increase the risk of behavioural problems in childhood.
- ▶ The risk is highest in those with multiple regulatory problems in infancy in multiple risk families.
- ▶ Future studies should include reliable measures of multiple infant regulatory problems and outcome assessments by experts in addition to parent reports.

Although regulatory problems are transient in the majority of infants, they are stable across the preschool years for a considerable minority of children.⁸ Questions arise as to whether regulatory problems are associated with adverse child behaviour. Transient regulatory problems, most notably excessive crying within the first 3 months, have been reported to show an overall good prognosis without any negative long-term consequences in behaviour,⁹⁻¹¹ whereas persistent and/or multiple regulatory problems have been reported to affect the child's behaviour long term.^{4,12-15} Some aetiological models suggest that hyper-sensitivity to stimuli,¹² ineffective regulatory competences¹⁶ or early deficit in executive control^{13,15} may be early precursors of less effective regulation of behaviour later in childhood.

The aim of this meta-analysis was to identify the nature and strength of associations between regulatory problems in early infancy and behavioural problems in childhood. Analysis of moderator variables was conducted in order to help explain any relationships between early regulatory problems and behavioural problems in childhood.

METHODS

Selection of studies

A computer based literature search for studies presenting quantitative data on the association between regulatory problems in infancy and behavioural problems in childhood was performed using PubMed, PsychInfo and the Google Scholar database, with the following keywords: colic, excessive/persistent crying, sleeping/feeding problem, infant sleep, night waking, infant feeding/refusal to eat, choosy, picky, psychopathology, behaviour problem, behavioural outcome, preschool, childhood, attention, ADHD, hyperactivity, hyperkinetic, characteristic, follow-up, longitudinal study, prospective. In addition, the bibliographies of all relevant studies were reviewed and authors were contacted for further unpublished manuscripts. These steps produced a study pool of 72 studies (reported in 70 articles) published during the period 1987–2006. Twenty-two studies met the inclusion criteria.

Inclusion criteria

The inclusion criteria were as follows: (1) regulatory problems were confined to crying, sleeping and/or feeding problems within the first year of life occurring as an isolated problem or in combination with each other; (2) studies had to include a measure of internalising, externalising, attention-deficit/hyperactivity disorder (ADHD) or general behavioural problems of the target infant in childhood and the association between infant regulatory problems and childhood behavioural problems had to be tested statistically; and (3) only prospective studies including at least one follow-up assessment were included.

Studies reporting on child characteristics not related to regulatory problems, such as difficult temperament, cognitive functioning or developmental status, were excluded.

Study set

Of the final 22 studies, 10 reported on the consequences of excessive crying, four on sleeping problems, three on feeding problems and five on multiple regulatory problems (table 1). The mean (SD) age of children at the baseline measurement of regulatory problems was 5.2 (4.8) months, being 2.6 (0.98) months for excessive crying, 5.8 (3.8) months for sleeping disturbance, 8.1 (7.5) months for feeding problems and 8.8 (7.1) months for multiple regulatory problems. The mean age of children with a crying problem was later than the typical peak crying period in community studies,^{17 18} suggesting that the crying problem had persisted in these infants. The participants' ages at follow-up assessments ranged from 1.3 to 10 years (mean (SD) age 4.5 (2.3) years). Overall, 16 848 children (1935 with regulatory problems) participated in the studies. Sufficient information on the sociodemographic characteristics of the study sample was only available for 10 studies (table 1). Most of the children were Caucasian (85%), the majority of the mothers were married or in a stable relationship (96%) and 77% of the families were classified as having middle or high socioeconomic status. Finally, 59% of the studies referred to community based samples and 41% to clinically referred samples.

Regulatory problems

The identification of regulatory problems was a major challenge for our meta-analysis since consistent diagnostic criteria are lacking.¹⁹ All studies where regulatory problems were considered a serious problem by the care giver or a clinician were included (table 1). Excessive crying was defined as crying with

intense, unsoothable crying bouts for no apparent reason in the first 3 months of life.²⁰ Sleeping problems were categorised as either difficulties in settling at bedtime, or failure to sleep through the night without interruption.^{3 21} Feeding problems comprised vomiting, food refusal, little appetite or swallowing problems.^{1 22} Persistent regulatory problems were defined as excessive crying beyond the third month of life and sleeping and feeding problems that occurred at initial assessment and at follow-up. Isolated regulatory problems referred to one of these three types of regulatory problem, whereas multiple regulatory problems were a combination of two or three such problems. Studies used combinations of parent interviews (60%), questionnaires (41%), infant diaries (32%) and observations (18%) to assess regulatory problems. The majority of informants were parents; experts (eg, paediatricians, child health nurses) gave additional information in some studies. Comorbidity was reported in nine studies, but only five studies analysed multiple regulatory problems (table 1).

Behavioural problems

Childhood behavioural problems were divided into four categories: internalising, externalising, ADHD and general behavioural problems (table 2).²³ Internalising behaviour comprised anxiety, depression or withdrawal. Externalising problems referred to aggressive or destructive behaviour, conduct problems or temper tantrums. ADHD symptoms included hyperactivity, ADHD diagnosis, inattention and concentration problems. General behavioural problems referred to any behavioural problems that were reported in the studies (ie, internalising, externalising, ADHD or total scores of behavioural problems) (table 2). The informants of behavioural problems were the care givers; the child, teacher or clinician gave additional information in some studies. Fifteen studies reported the outcomes of externalising behavioural problems, 11 the outcomes of internalising behavioural problems, 13 the outcomes of ADHD problems and 16 the outcomes of multiple behavioural problems.

Number of risk factors

A variable 'number of risk factors' was constructed to assess the impact of cumulative initial family risk factors and regulatory problem characteristics on the regulatory problems-behavioural problems associations. Regulatory problem characteristics (isolated/multiple, transient/persistent) and family risk factors (table 1), both measured at baseline, were added together to produce the number of risk factors. A score of 1 indicated isolated or transient regulatory problems without any family risk factors prevailing, while a maximum score of 6 indicated multiple persistent regulatory problems and negative parent-infant interaction, social adversities, a depressed or stressed mother and a negative family environment.

Coding of the studies

The first author and a research trainee independently coded the information extracted from the selected studies. To assess intercoder agreement, regular meetings were held to discuss any differences regarding the data extraction. Intercoder agreement was high (range 0.89–1.00) after discussion to resolve disagreement.²⁴

Meta-analytic method

We used Cohen's *d* to express the standardised mean difference for the occurrence of behavioural problems between children

Table 1 Study characteristics: samples and definition of regulatory problems at baseline of included studies

Study	Participants		Age†	Sample	Type of RP	RP duration	M-tech†*	Informant on RP	RP diagnosis criteria	SOC	Family†*	Number of risk factors
	N _{RP}	N _{Control}										
Canivet <i>et al</i> ⁴³	50	102	3	Comm	Crying	Transient	D/I	M	Wessel <i>et al</i> ²⁰	No	-	1
DeSantis <i>et al</i> ⁴²	14	14	2	Clin	Crying	Persistent	D/I	M	Number of hours of crying and/or fussing	No	-	2
Elliot <i>et al</i> ⁴⁴	10	72	1.8	Comm	Crying	Transient	Q	M	Wessel <i>et al</i> ²⁰	No	-	1
Neu and Robinson ⁴⁵	20	20	2.5	Comm	Crying	Transient	I/Q	M	Minimum 2.8 h/day crying for at least 3 days in 1 month	Yes	Parent–infant interaction	1
Papousek <i>et al</i> ⁴⁶	60	45	4.1	Clin	Crying	Persistent	D	M	Wessel <i>et al</i> ²⁰	No	Psychosocial situation, maternal psychopathology, family functioning, parent–infant interaction	5
Rao <i>et al</i> ⁴⁷	9	165	2.4	Comm	Crying	Persistent	I/Q	M/E	Daily uncontrolled crying for no apparent reason for at least 2 weeks	No	-	2
Rautava <i>et al</i> ⁴⁸	338	527	3	Comm	Crying	Transient	Q	M/E	Colic questionnaire, scores 1–3 (no colic), 4 (moderate colic) or 5 (severe colic)	Yes	-	1
Savino <i>et al</i> ⁴⁹	48	48	2	Clin	Crying	Transient	-	-	Wessel <i>et al</i> ²⁰	No	-	2
St James-Roberts <i>et al</i> ¹¹	67	38	1	Comm	Crying	Transient	I/D	M	Modified Wessel <i>et al</i> ²⁰	Yes	Parent–infant interaction, maternal psychopathology, family functioning	3
Wolke <i>et al</i> ¹³	64	64	4	Clin	Crying	Persistent	D	M	Modified Wessel <i>et al</i> ²⁰	Yes	-	2
Lam <i>et al</i> ⁵⁰	36	78	9	Comm	Sleeping	Transient	Q	M	Care giver considers baby's sleep as problematic	Yes	Maternal psychopathology	2
Scher <i>et al</i> ¹⁴	13	12	3	Comm	Sleeping	Persistent	Q	M	Care giver considers baby's sleep as problematic	No	-	2
Thunström ⁵¹	25	25	8.5	Comm	Sleeping	Transient	I/D	M	More than 2 night wakings/night; baby needs more than 15 min to fall asleep	No	Psychosocial situation, parent–infant interaction	4
Zuckerman <i>et al</i> ⁵²	23	33	8	Comm	Sleeping	Persistent	I	M	More than 3 night wakings/night; baby needs more than 1 h to fall asleep (after night waking) or any problem causing severe disruption to the mother's sleep	Yes	Psychosocial situation, maternal psychopathology	3
Dahl ^{22†}	25	25	7.8	Clin	Feeding	Transient	I/O	M/E	RTE for at least 1 month without medical reason	No	Parent–infant interaction, psychosocial situation	1
Lindberg ⁵³	10	21	10.5	Clin	Feeding	Persistent	I/O	M/E	Minimum of 1 month of RTE	No	Psychosocial situation, parent–infant interaction	5
Motion <i>et al</i> ⁵⁴	373	10 669	1	Comm	Feeding	Transient	Q	M	Feeding difficulties for 4 weeks	No	-	1
Becker <i>et al</i> ^{55†}	55	264	3	Clin	Crying/sleeping/feeding	Transient	I/O	M/E	1 SD above the mean for one factor=isolated RP; 1 SD above the mean for irritable and somatic functioning= multiple RP	Yes	Psychosocial situation, parent–infant interaction	4
DeGangi <i>et al</i> ⁵	9	13	9.5	Clin	Crying/sleeping/feeding	Transient	I/O	M/E	Crying: difficulties with self-consoling, hypersensitive to new stimulations; baby needs more than 20 min to fall asleep, frequent night wakings (>2/night); baby shows distress at feeding time	No	-	2

continued

Table 1 Continued.

Study	Participants		Age1	Sample	Type of RP	RP duration	M-tech1*	Informant on RP	RP diagnosis criteria	SOC	Family1*	Number of risk factors
	N _{RP}	N _{Control}										
DeGangi <i>et al</i> ⁶	22	38	18.5	Clin	Crying/sleeping/feeding	Transient	I/O	M	Crying: difficulties with self-consoling, hypersensitive to new stimulations; baby needs more than 20 min to fall asleep, frequent night wakings (>2/night); baby shows distress at feeding time	Yes	Parent–infant interaction	2
Forsyth and Canny ³	115	205	4	Comm	Crying/feeding	Transient	I	M	Care giver considers baby's crying and feeding as a problem	Yes	–	2
Wake <i>et al</i> ⁶	84 RP (sleep problems) 55 RP (cry/fuss problems)	313	8 (sleeping) 2 (crying)	Comm	Crying/sleeping	Transient	O/D	M	Care giver considers baby's crying and sleeping as a problem	Yes	–	1

N_{RP} and N_{Control} may be different from total participants at follow-up due to subgroup analyses in some studies.

*Details on specific regulatory problems or family risk factor assessment instruments available from the first author on request.

¹Duplicated data, one assessment point randomly selected.

N_{RP}: number of RP infants; N_{Control}: number of control children; RP: regulatory problems; Age1: mean age at baseline (months); Sample: Clin, Clinically referred sample; Comm, community based sample; M-tech1: measurement technology1; D, diary; I, interview; O, questionnaire; Q, observation; Informant on RP: M, mother; E, Expert; SOC, sociodemographic information available; Family1, family risks assessed at baseline.

with previous regulatory problems and children without regulatory problems.²⁵ The standardised mean difference is a measure of overlap between distributions, that is, when different studies use diverse instruments to assess behavioural problems, as was the case in this meta-analysis. The effect size reflects the difference between the distributions in the two groups.²⁶ The random effects model was used for all calculated weighted mean effect sizes because of the heterogeneity of the study set. Each effect size was weighted by the inverse of its variance²⁶ and was interpreted as followed: 0.2, 0.5 and 0.8 indicated a small, medium and large effect, respectively.²⁵ Positive effect sizes imply that children with previous regulatory problems have more behavioural problems than children without previous regulatory problems. Additionally, the z statistic (test of the null) was two-tailed and the p value was set at <0.05. To ensure independence of observations, each study contributed only one effect size to the analysis by averaging across all regulatory problem and behavioural problem comparisons contained within each study. When research groups reported multiple follow-ups of the same study sample, one measurement point was randomly selected to avoid a selective bias of effect size overestimation for a specific child age (table 1). Heterogeneity of the effect sizes was assessed using the I² statistic, a measure that assesses the proportion of the observed variance, which reflects real differences in effect size. An I² near zero indicates that almost all of the observed variance is spurious, whereas high values indicate that the variation may not be due to sampling error and that moderators may explain the variability.²⁶ Analyses were carried out in two steps. Primary analyses included testing of the main regulatory problems–behavioural problems association (ie, any regulatory problems–general behavioural problems) and all individual regulatory problem (crying, feeding, sleeping and multiple problems) and behavioural problem (general, internalising, externalising and ADHD) combinations. In a second step, subgroup analyses using meta-analysis of variance and meta-regressions were conducted with regulatory problem characteristics (regulatory problem type, transient/persistent regulatory problems, isolated/multiple regulatory problems), methodological characteristics (regulatory problem measurement instrument, regulatory problems/behavioural problems informant and sample characteristics), number of risk factors and the child's age at follow-up for the main and individual regulatory problems–behavioural problems associations. No attempt at Bonferroni correction was made since the procedure is too conservative and therefore not appropriate for explorative research.²⁷ However, Rosenthal's classic fail-safe N (FSN)²⁸ and correlation of sample size to effect size²⁹ were used to assess publication bias for each association. A negative correlation between sample size and effect size is an indicator against publishing findings that are not statistically significant, indicating overestimated effect size.²⁹ For all meta-analytic computations, Comprehensive Meta-Analysis v 2 was used.³⁰

RESULTS

The weighted mean effect size for the main regulatory problems–behavioural problems association was 0.41 (95% CI 0.28 to 0.54), indicating a medium effect size (table 3). Children with previous regulatory problems had more behavioural problems in childhood than controls. The homogeneity analyses for the main association (I²=44.02, p<0.05) as well as for externalising (I²=65.6, p<0.001) and ADHD

($I^2=73.0$, $p<0.001$) problems were high and significant, indicating that moderating variables were likely to exist. A significant medium effect size was found for externalising ($d=0.51$) and low-to-medium effect sizes for internalising ($d=0.34$) and ADHD problems ($d=0.36$) for any regulatory problem. Crying problems led to the highest effect sizes: general behavioural problems ($d=0.51$), externalising ($d=0.56$), internalising ($d=0.50$) and ADHD ($d=0.42$). Multiple regulatory problems and feeding difficulties were only associated with general behavioural problems (multiple: $d=0.45$; feeding: $d=0.21$). Sleeping problems showed inconsistent effect sizes ranging from small to high: internalising ($d=0.24$), general behavioural problems ($d=0.42$) and ADHD ($d=1.30$) (the

findings remained similar if samples with sleeping problems reported below 6 months were excluded).

FSN and negative correlations of sample size and effect size indicated possible publication bias in studies for feeding, sleeping and multiple regulatory problems, and where internalising outcomes were examined (table 3).

Moderator analysis

Regulatory problem characteristics

Comorbidity (isolated vs multiple; $I^2=44.0$, $p>0.05$), type of regulatory problem (crying, feeding or sleeping; $I^2=41.8$, $p>0.05$) and duration (transient vs persistent; $I^2=44.0$, $p>0.05$) were not moderators for the main and all individual associations.

Table 2 Assessment of behavioural outcomes in childhood of included studies

Study	Participants		Age2	Type of BP	M-tech2*	Informant on BP	ES (d)
	N _{RP}	N _{Control}					
Canivet <i>et al</i> ⁴³	50	102	4	E/I/ADHD	Rutter Preschool Questionnaire	M	0.47
DeSantis <i>et al</i> ¹²	14 persistent RP	14 transient RP	5.6	E/I/ADHD/G	Sensory Profile, CBCL and TRF	M/T	-0.04
Elliot <i>et al</i> ⁴⁴	10	72	3	G	CBCL	M	0.21
Neu and Robinson ⁴⁵	20	20	7	E/I/ADHD	BSQ, ADHD Checklist of the Diagnostic Interview for Children and Adolescents, Revised, CBCL	M/E	0.56
Papousek <i>et al</i> ¹⁶	60	45	2.5	E/I	ICQ, CBCL	M	0.76
Rao <i>et al</i> ⁴⁷	9	165	5	ADHD	PIC	E	0.97
Rautava <i>et al</i> ⁴⁸	338	527	3	E	CBCL, DDST	M	0.26
Savino <i>et al</i> ⁴⁹	48	48	10	E	-	M	1.31
St James-Roberts <i>et al</i> ¹¹	67 persistent RP (referred to colic)	38 evening criers 55 moderate criers	1.3	E/ADHD/G	BSQ Bayley Scales of Infant Development and IBR	M/E	0.46
Wolke <i>et al</i> ¹³	64	64	9.7	E/I/ADHD/G	SDQ	M/C/T	0.64
Lam <i>et al</i> ⁵⁰	36	78	3.6	E/I	CBCL	M	0.34
Scher <i>et al</i> ¹⁴	13 poor sleepers	12 good sleepers	3.5	G	CBCL	M	0.88
Thunström ⁵¹	25	25	5.5	ADHD	PPQ, PSQ, Griffiths Developmental Scale II, Scandinavian MPU, Standardised Interview Schedule for Criteria for ADHD	M/E	1.67
Zuckerman <i>et al</i> ⁵²	23	33 transient RP	3	E/I/ADHD	BSQ	M	0.98
Dahlf ^{22†}	25	25	2	E/I/ADHD	Preformulated list: sleeping problems, shyness/fears, whining, hyperactive and restless, temper tantrums	M	1.07
Lindberg ⁵³	10	21	7.5	I/G	Rutter Child Questionnaire EAS	M/T	0.09
Motion <i>et al</i> ⁵⁴	373	10 669	3.9	E/ADHD	SDQ	M	0.21
Becker <i>et al</i> ^{55†}	55	264	6.4	ADHD/G	Mannheim Parent Interview	M/C/E	0.34
DeGangi <i>et al</i> ¹⁵	9	13	4	ADHD/G	Sensorimotor History Questionnaire	E	1.82
DeGangi <i>et al</i> ⁴	22	38	3	E/I	CBCL	M	0.96
Forsyth and Canny ¹	115	205	3.5	ADHD/G	BCL	M	0.08
Wake <i>et al</i> ⁵⁶	84 RP (sleep problems) 55 RP (cry/fuss problems)	313	2	E/I/G	CBCL	M	0.20

N_{RP} and N_{Control} may be different from total participants at follow-up due to subgroup analyses in some studies.

*References of the behavioural problem assessment instruments available from the first author on request.

†Duplicated data, one assessment point randomly selected.

N_{RP}, number of RP infants; N_{Control}, number of control children; RP, regulatory problems; Age2, mean age at follow-up (years); Type of BP: ADHD, attention-deficit/hyperactivity disorder; E, externalising; G, general; I, internalising; M-tech2, measurement technology 2: BCL, Richman Behaviour Checklist; BSQ, Behavioural Style Questionnaire; CBCL, Child Behavior Checklist; DDST, Denver Development Screening Test; EAS, Emotionality, Activity and Sociability questionnaire; IBR, Infant Behaviour Record; ICQ, Infant Characteristics Questionnaire; MPU, Motor-Perceptual Scale; PIC, Personality Inventory for Children; PPQ, Psychomotor Questionnaire; PSQ, Preschool Questionnaire; SDQ, Strength and Difficulties Questionnaire; TRF, Teacher Report Form; Informant on BP: C, child; E, expert; M, mother; T, teacher; ES (d), weighted mean effect size (d).

Method factors

Behavioural problem informant was a moderator for the main regulatory problems-behavioural problems comparison. Posthoc analysis revealed that the effect size (ES) was larger if an expert reported the behavioural problems rather than the care giver ($ES_{\text{expert}}=1.09$ vs $ES_{\text{caregiver}}=0.35$; $I^2=45.5$, $p<0.05$; table 4). There was a trend for the method of regulatory problem assessment to moderate any regulatory problems-externalising problems association ($I^2=60.83$, $p=0.07$). Posthoc analysis revealed that questionnaires and interviews differed significantly in their effect size ($ES_{\text{questionnaire}}=0.22$ vs $ES_{\text{interview}}=0.89$; $I^2=53.41$, $p<0.01$) but not with respect to infant diaries. The association between any regulatory problems and general behavioural problems ($ES_{\text{clinical}}=0.61$ vs $ES_{\text{community}}=0.30$; $I^2=44.02$, $p<0.05$) was higher and stronger in samples recruited from referred populations than from community based samples (table 4).

Number of risk factors

Children with previous sleep and multiple regulatory problems who experienced numerous adverse regulatory and family

risk factors as infants showed more behavioural problems than children with a small number of risk factors in univariate meta-regressions: any regulatory problems-externalising problems associations: $\beta=0.15$, $SE=0.08$, $p=0.08$; sleeping-general behavioural problems associations: $\beta=0.35$, $SE=0.17$, $p<0.05$; sleeping-externalising associations: $\beta=0.39$, $SE=0.21$, $p=0.06$; and multiple-ADHD problems associations: $\beta=0.23$, $SE=0.09$, $p<0.05$.

Age at follow-up

Results of univariate meta-regression analyses indicated that the difference between the child's age at follow-up and at initial assessment was a predictor for the main regulatory problems-behavioural problems association ($\beta=0.04$, $SE=0.02$, $p=0.05$), whereby larger effect sizes were observed in middle than early childhood. This effect remained stable for the following individual associations: crying-general behavioural problems ($\beta=0.06$, $SE=0.03$, $p<0.05$), crying-ADHD problems ($\beta=0.07$, $SE=0.03$, $p<0.05$) and sleeping-general behavioural problems ($\beta=0.22$, $SE=0.12$, $p=0.06$).

Table 3 Significant ($p<0.05$) effect sizes of the main and individual associations

Associations	K	ES	Variance	95% CI	I^2	FSN	r
Any RP							
General BP	22	0.412	0.004	0.281 to 0.544	44.0*	433	-0.382
Externalising	15	0.507	0.009	0.318 to 0.697	65.6***	276	-0.361
Internalising	11	0.345	0.005	0.203 to 0.488	0.000	46	0.437
ADHD	13	0.363	0.014	0.130 to 0.596	73.0***	106	-0.435
Crying problems							
General BP	10	0.506	0.010	0.308 to 0.704	33.465	94	0.248
Externalising	9	0.562	0.017	0.309 to 0.815	56.428*	93	0.100
Internalising	5	0.498	0.014	0.270 to 0.726	0.000	17	0.600
ADHD	6	0.417	0.033	0.059 to 0.774	64.442**	20	0.600
Feeding problems							
General BP	3	0.211	0.003	0.102 to 0.319	0.000	6	0.500
Sleeping problems							
General BP	5	0.423	0.028	0.094 to 0.752	35.637	15	-0.700
Internalising	3	0.239	0.011	0.035 to 0.443	0.000	1	-1.000***
ADHD	2	1.303	0.318	0.198 to 2.408	0.000	0	-1.000***
Multiple RP							
General BP	4	0.445	0.045	0.031 to 0.859	54.361*	12	-1.000***

Positive effect sizes indicate higher rating of behavioural problems for children with regulatory problems.

No effect was found for the associations feeding-externalising ($z=1.07$; $p>0.05$), feeding-internalising ($z=-0.11$; $p>0.05$), feeding-ADHD ($z=1.05$; $p>0.05$), sleeping-externalising ($z=1.667$; $p>0.05$), multiple-ADHD outcomes ($z=0.550$; $p>0.05$) or multiple-internalising and externalising outcomes (referred to only one study). * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

ADHD, attention-deficit/hyperactivity disorder; BP, behavioural problems; ES, weighted mean effect size (d); FSN, Rosenthal's fail-safe N; I^2 , ratio of true heterogeneity to total variation in observed effects; K, number of studies; r, correlation of sample sizes to ES (negative correlations indicate that ES may be overestimated²⁹); RP, regulatory problems.

Table 4 Meta-analysis of variance of moderator variables

Domain	Association	Moderator	I^2	p Value	K	ES	Variance	95% CI	FSN	r
Rating at follow-up	Any RP-general BP	Expert	45.5	0.02	2	1.09	0.10	0.46 to 1.72	0	-1.00***
		Mother			14	0.34	0.01	0.21 to 0.49	156	-0.28
RP assessment method	Any RP-externalising	Questionnaire	53.41	0.00	3	0.22	0.00	0.12 to 0.32	12	-0.76
		Interview			4	0.89	0.05	0.45 to 1.32	15	0.74
Sample characteristics	Any RP-general BP	Clinically referred	44.02	0.05	9	0.61	0.02	0.31 to 0.91	70	-0.23
		Community based			13	0.30	0.00	0.18 to 0.42	143	-0.28

*** $p<0.001$.

BP, behavioural problems; ES, weighted mean effect size; FSN, Rosenthal's fail-safe N; I^2 , ratio of true heterogeneity to total variation in observed effects; K, number of studies; r, correlation of sample sizes to effect size (negative correlations indicate that effect size may be overestimated²⁹); RP, regulatory problems.

DISCUSSION

Children with regulatory problems in infancy were more likely to experience behavioural problems in childhood than children without previous excessive crying or sleeping problems. The associations between any regulatory problems and internalising, externalising and ADHD problems were found to be particularly strong. The associations for externalising and ADHD problems were moderate and fairly solid considering that it would take 276 and 106 studies, respectively, to falsify the effects found. There were stronger associations between regulatory problems and behavioural problems for referred samples and where regulatory problems were assessed with more rigorous methods including interviews and behavioural outcome assessed by experts, or when multiple risk factors were present. Moreover, persistent crying mainly accounted for the effect size as the mean age of infants at initial assessment was later than the cry peak reported in community samples.^{17 18}

This meta-analysis highlights the need for better understanding of the early development of child mental disorders. To explain the association between regulatory problems and behavioural problems, it has been suggested that initial deficits in regulatory competences and stimuli control may be early markers for similar processes of inadequate or under-controlled behaviour in toddlerhood and childhood.^{12 16 31} For example, a particular gene polymorphism of the dopaminergic system has been found to be associated with both ADHD and externalising problems in childhood³² and multiple regulatory problems in infancy.³³ Others have proposed that early caregiving relationships, infant temperament and cognitive functioning may affect infant self-regulation and the development of subsequent behavioural problems.^{16 34}

Concerns about their baby's crying, sleeping or feeding problems are a major reason for many parents to seek professional help.⁶ Clinically referred children often came from families with a range of risk factors (eg, obstetric, interactional or psychosocial problems) in addition to multiple regulatory problems.² The accumulation of child symptoms and negative family characteristics was thus more predictive for behavioural problems than any particular combination of them.^{35 36}

This meta-analysis suggests the need for early intervention for and prevention of regulatory problems. A reduction in regulatory problem symptoms after altering parenting behaviour was repeatedly reported.³⁷⁻⁴⁰ Behavioural intervention programmes for regulatory disturbed children may promote a positive parent-child relationship and also positively influence behavioural development.

Limitations

A few limitations should be mentioned. First, our study set was highly heterogeneous and hence comparability of these studies was restricted. We tried to address this issue by conducting moderator analyses with relevant influencing variables and used the random effects model. Second, the Child Behavior Checklist was the main instrument used for the assessment of behavioural problems although the validity of the anxiety/depression scale has been criticised.⁴¹ Additionally, non-reported or lack of assessment of the comorbidity of regulatory problems may have led to biased conclusions regarding the effects of a single regulatory problem. Several studies showed that crying, feeding and sleeping problems coexist in infancy,^{3 42} however, the majority of the studies only focused on a single regulatory problem without

controlling for any others. Finally, the study set was characterised by uneven reporting practices, which hindered the identification of all potential moderators and limited power.

Conclusion

Regulatory problems in infancy can increase the likelihood of developing behavioural problems in childhood. Children of multi-problem families have the worst outcomes in terms of externalising and ADHD problems, particularly if they had sleep or multiple problems in infancy. Our findings highlight the requirement for prospective follow-up studies of regulatory disturbed infants and the need for reliable assessments of crying, sleeping and feeding problems. The evidence from this systematic review suggests that those with persisting regulatory problems in families with other problems may require early interventions to minimise or prevent the long-term consequences of infant regulatory problems.

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REFERENCES

1. Forsyth BW, Canny PF. Perceptions of vulnerability 3 ½ years after problems of feeding and crying behavior in early infancy. *Pediatrics* 1991;**88**:757-63.
2. Von Hofacker N, Papousek M. Disorders of excessive crying, feeding, and sleeping: the Munich interdisciplinary research and intervention program. *Infant Ment Health J* 1998;**19**:180-201.
3. Wolke D, Meyer R, Orth B, et al. Co-morbidity of crying and feeding problems with sleeping problems in infancy: concurrent and predictive associations. *Infant Child Dev* 1995;**4**:191-207.
4. DeGangi GA, Breinbauer C, Roosevelt JD, et al. Prediction of childhood problems at three years in children experiencing disorders of regulation during infancy. *Infant Ment Health J* 2000;**21**:156-75.
5. Forsyth BW, Leventhal JM, McCarthy PL. Mothers' perceptions of problems of feeding and crying behaviors. A prospective study. *Am J Dis Child* 1985;**139**:269-72.
6. St James-Roberts I. Infant crying and sleeping: helping parents to prevent and manage problems. *Prim Care* 2008;**35**:547-67.
7. Zero to Three. *Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood Revised Edition*. Washington, DC: Zero to Three Press 2005.
8. Schmid G, Schreier A, Meyer R, et al. A prospective study on the persistence of infant crying, sleeping and feeding problems and preschool behaviour. *Acta Paediatr* 2010;**99**:286-90.
9. Stifter C, Braungart J. Infant colic: a transient condition with no apparent effects. *J Appl Dev Psychol* 1992;**13**:447-62.
10. Sloman J, Bellinger DC, Krentzel CP. Infantile colic and transient developmental lag in the first year of life. *Child Psychiatry Hum Dev* 1990;**21**:25-36.
11. St James-Roberts I, Conroy S, Wilsher C. Stability and outcome of persistent infant crying. *Infant Behav Dev* 1998;**21**:411-35.
12. DeSantis A, Coster W, Bigsby R, et al. Colic and fussing in infancy, and sensory processing at 3 to 8 years of age. *Infant Ment Health J* 2004;**25**:522-39.
13. Wolke D, Rizzo P, Woods S. Persistent infant crying and hyperactivity problems in middle childhood. *Pediatrics* 2002;**109**:1054-60.
14. Scher A, Zuckerman S, Epstein R. Persistent night waking and settling difficulties across the first year: early precursors of later behavioural problems? *J Reprod Infant Psychol* 2005;**23**:77-88.
15. DeGangi GA, Porges SW, Sickel RZ, et al. Four-year follow-up of a sample of regulatory disordered infants. *Infant Ment Health J* 1993;**14**:330-43.
16. Olson SL, Bates JE, Sandy JM, et al. Early developmental precursors of impulsive and inattentive behavior: from infancy to middle childhood. *J Child Psychol Psychiatry* 2002;**43**:435-47.
17. Barr RG. The normal crying curve: what do we really know? *Dev Med Child Neurol* 1990;**32**:356-62.
18. St James-Roberts I, Halil T. Infant crying patterns in the first year: normal community and clinical findings. *J Child Psychol Psychiatry* 1991;**32**:951-68.

19. **Postert C**, Averbeck-Holocher M, Beyer T, *et al*. Five systems of psychiatric classification for preschool children: do differences in validity, usefulness and reliability make for competitive or complimentary constellations? *Child Psychiatry Hum Dev* 2009;**40**:25–41.
20. **Wessel MA**, Cobb JC, Jackson EB, *et al*. Paroxysmal fussing in infancy, sometimes called colic. *Pediatrics* 1954;**14**:421–35.
21. **Richman N**. A community survey of characteristics of one- to two- year-olds with sleep disruptions. *J Am Acad Child Psychiatry* 1981;**20**:281–91.
22. **Dahl M**. Early feeding problems in an affluent society. III. Follow-up at two years: natural course, health, behaviour and development. *Acta Paediatr Scand* 1987;**76**:872–80.
23. **Achenbach TM**, Edelbrock C, Howell CT. Empirically based assessment of the behavioral/emotional problems of 2- and 3- year-old children. *J Abnorm Child Psychol* 1987;**15**:629–50.
24. **Fleiss JR**. *Statistical Methods for Rates and Proportions*. 2nd edition. New York, NY: John Wiley 1981.
25. **Cohen J**. *Statistical Power Analysis for the Behavioural Sciences*. 2nd edition. Hillsdale NJ: Erlbaum 1988.
26. **Borenstein M**, Hedges LV, Higgins JPT, *et al*. *Introduction to Meta-Analysis*. John Wiley & Sons 2009.
27. **Moran MD**. Arguments for rejecting the sequential Bonferroni in ecological studies. *OIKOS* 2003;**100**:403–5.
28. **Rosenthal R**. The file drawer problem and tolerance for null results. *Psychol Bull* 1979;**86**:638–41.
29. **Levine R**, Asada K. Sample sizes and effect sizes are negatively correlated in meta-analyses: evidence and implications of a publication bias against nonsignificant findings. Presented at the Annual Meeting of the International Communication Association, May 23, 2007, San Francisco, CA.
30. **Borenstein M**, Hedges LV, Higgins JPT, *et al*. *Comprehensive Meta-Analysis Version 2*. Englewood, NJ: Biostat 2005.
31. **Barkley RA**. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychol Bull* 1997;**121**:65–94.
32. **El-Faddagh M**, Laucht M, Maras A, *et al*. Association of dopamine D4 receptor (DRD4) gene with attention-deficit/hyperactivity disorder (ADHD) in a high-risk community sample: a longitudinal study from birth to 11 years of age. *J Neural Transm* 2004;**111**:883–9.
33. **Becker K**, El-Faddagh M, Schmidt MH, *et al*. [Dopaminergic polymorphisms and regulatory problems in infancy]. *Z Kinder Jugendpsychiatr Psychother* 2007;**35**:145–51.
34. **Räihä H**, Lehtonen L, Huhtala V, *et al*. Excessively crying infant in the family: mother-infant, father-infant and mother-father interaction. *Child Care Health Dev* 2002;**28**:419–29.
35. **Rutter M**, Quinton D. Psychiatric disorder: ecological factors and concepts of causation. In: McGurk M., ed. *Ecological Factors in Human Development*. Amsterdam: Noord-Holland 1977:173–87.
36. **Green JG**, McLaughlin KA, Berglund PA, *et al*. Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: associations with first onset of DSM-IV disorders. *Arch Gen Psychiatry* 2010;**67**:113–23.
37. **Taubman B**. Clinical trial of the treatment of colic by modification of parent-infant interaction. *Pediatrics* 1984;**74**:998–1003.
38. **Wolke D**, Gray P, Meyer R. Excessive infant crying: a controlled study of mothers herald mothers. *Pediatrics* 1994;**94**:322–32.
39. **Ramchandani P**, Wiggs L, Webb V, *et al*. A systematic review of treatments for settling problems and night waking in young children. *BMJ* 2000;**320**:209–13.
40. **Kerwin ME**. Empirically supported treatments in pediatric psychology: severe feeding problems. *J Pediatr Psychol* 1999;**24**:193–214; discussion 215–16.
41. **Ferdinand RF**. Validity of the CBCL/YSR DSM-IV scales Anxiety Problems and Affective Problems. *J Anxiety Disord* 2008;**22**:126–34.
42. **von Kries R**, Kalies H, Papoušek M. Excessive crying beyond 3 months may herald other features of multiple regulatory problems. *Arch Pediatr Adolesc Med* 2006;**160**:508–11.
43. **Canivat C**, Jakobsson I, Hagander B. Infantile colic. Follow-up at four years of age: still more 'emotional'. *Acta Paediatr* 2000;**89**:13–17.
44. **Elliott MR**, Pedersen EL, Mogan J. Early infant crying: child and family follow-up at three years. *Can J Nurs Res* 1997;**29**:47–67.
45. **Neu M**, Robinson J. Infants with colic: their childhood characteristics. *J Pediatr Nurs* 2003;**18**:12–20.
46. **Papoušek M**, Wurmser H, von Hofacker N. Clinical perspectives on unexplained early crying: challenges and risks for infant mental health and parent-infant relationships. In: Barr RG, St James-Roberts I, Keefe MR., eds. *New Evidence on Unexplained Early Infant Crying: It Origins, Nature and Management*. Somerset, NJ: Skillman 2001.
47. **Rao MR**, Brenner RA, Schisterman EF, *et al*. Long term cognitive development in children with prolonged crying. *Arch Dis Child* 2004;**89**:989–92.
48. **Rautava P**, Lehtonen L, Helenius H, *et al*. Infantile colic: child and family three years later. *Pediatrics* 1995;**96**:43–7.
49. **Savino F**, Castagno E, Bretto R, *et al*. A prospective 10-year study on children who had severe infantile colic. *Acta Paediatr Suppl* 2005;**94**:129–32.
50. **Lam P**, Hiscock H, Wake M. Outcomes of infant sleep problems: a longitudinal study of sleep, behavior, and maternal well-being. *Pediatrics* 2003;**111**:e203–7.
51. **Thunström M**. Severe sleep problems in infancy associated with subsequent development of attention-deficit/hyperactivity disorder at 5.5 years of age. *Acta Paediatr* 2002;**91**:584–92.
52. **Zuckerman B**, Stevenson J, Bailey V. Sleep problems in early childhood: continuities, predictive factors, and behavioral correlates. *Pediatrics* 1987;**80**:664–71.
53. **Lindberg L**. Long-term outcomes of early feeding problems related to infant behaviours, attachment, and maternal behaviours. Paper presented at the 7th Congress of the World Association for Infant Mental Health, Montreal, 26-30 July, 2000.
54. **Motion S**, Northstone K, Emond A, *et al*. Persistent early feeding difficulties and subsequent growth and developmental outcomes. *Child Care Health Dev* 2001;**7**:231–7.
55. **Becker K**, Holtmann M, Laucht M, *et al*. Are regulatory problems in infancy precursors of later hyperkinetic symptoms? *Acta Paediatr* 2004;**93**:1463–9.
56. **Wake M**, Morton-Allen E, Poulakis Z, *et al*. Prevalence, stability, and outcomes of cry-fuss and sleep problems in the first 2 years of life: prospective community-based study. *Pediatrics* 2006;**117**:836–42.