THE ROLE OF THE MOTHER-CHILD RELATIONSHIP IN DEVELOPMENTAL OUTCOMES OF INFANTS AND YOUNG CHILDREN WITH AND WITHOUT PRENATAL ALCOHOL EXPOSURE

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ABSTRACT

Background
Prenatal alcohol exposure has been associated with deficits in many developmental areas. Effects on developmental outcomes can be exacerbated by cumulative risk across the pre- and postnatal environments. Given that the parent-infant relationship provides the primary context for healthy child development, it is possible that maternal caregiving may play a substantial role in mitigating these effects.

Objectives
To clarify the role of the quality of the mother-child relationship in the relation between cumulative risk and neurodevelopmental outcomes.

Methods
Participants were 40 infants/children and their mothers with substance-use problems who were taking part in an early mental health intervention program. Cumulative risk, across the pre- and postnatal period was measured, and quality of the mother-child relationship was rated based on clinical file reviews and observation of mother-child interactions. Outcome measures were infant/child IQ, and neurobehavioral functioning rated across several developmental domains.

Results
The quality of the mother-child relationship mediated the direct relation between cumulative risk and neurobehavioral functioning, and cumulative risk was related with IQ indirectly through the mother-child relationship.

Conclusions
These findings indicate an important role for quality of the mother-child relationship in determining outcomes for infants and young children of substance-using women, and emphasize the need to consider both the larger context of risk, as well as the mother-child relationship for best intervention outcomes.

Key Words: *Prenatal substance exposure, cumulative risk, mother-child relationship, caregiving quality*

Maternal substance use is a serious public health problem in North America[1], which not only has a negative impact on the mother's health, but places infants and young children at risk for a multitude of medical and developmental difficulties.[2] Over the last two decades, research has established a clear link between prenatal alcohol exposure and cognitive and behavioral outcomes.[3] These developmental difficulties can largely be attributed to alcohol exposure in utero in combination with an unhealthy postnatal environment.[4,5]

The teratogenic effects of alcohol have received substantial attention in the literature, and the neurobehavioral sequelae of prenatal alcohol exposure are well established.[6] Studies report a continuum of fetal alcohol effects consistent with

the continuous nature of alcohol's teratogenecity. At the one extreme are children of chronic alcohol users born with the characteristic craniofacial dysmorphology of Fetal Alcohol Syndrome (FAS), which tends to be associated with serious physical and intellectual growth deficiencies. At the other end are children born relatively healthy, but with more subtle behavioral and cognitive difficulties detectable within the first year of life.[7,8] These difficulties include problems with emotion regulation, impaired language and motor development, which have been found in infants as young as 6 months of age.[9-11] Importantly, delays in cognitive development apparent at 8 months have been shown to persist into adolescence and adulthood as decrements in overall IQ, as well as impairments in a broad range of neuropsychological domains including executive difficulties with attention and impulsivity, reasoning, manipulating information, following directions and persistence.[12] Heavier exposure in utero is also linked with alcohol use in adolescents, as well as alcohol dependence and psychiatric illness in adulthood.[12] Studies on the effects of prenatal exposure to substances other than alcohol such as cocaine, cannabis, opioids, and nicotine on developmental outcomes have produced less consistent results but generally show an impact on: language development[13-16], attention[17-23], and executive function.[19,24,25]

Although difficulties in many developmental areas have been associated to varying degrees with prenatal alcohol and drug exposure, recent research has shown that these effects on developmental outcomes can be exacerbated by postnatal environmental factors that often accompany prenatal substance exposure.[4,13] In a review of the postnatal environments of children of substance-using women, Hans (2002) found that these children were indeed at risk for problems in the quality of care they receive postnatally, including lack of stimulation, maternal insensitivity, poor parental monitoring, disruptions in care, and child maltreatment.[26] More recently, in a sample of school-age children with alcohol exposure, Coggins, Timler and Olswang, (2007) provided evidence for the comorbidity between FASD and adverse environmental conditions, both of which contributed to the social-communicative deficits seen.[27] Current, rather than prenatal maternal alcohol use, has also been found to adversely affect developmental outcomes over time, resulting in lower levels of intellectual stimulation, a less cohesive and organized family environment and more domestic violence.[28] Similarly, in a large, population-based sample of pregnant and/or parenting mothers currently addicted to substances and requiring treatment, Conners et al. (2004) found that mothers faced many challenges to parenting and providing adequately for their children, including ongoing, chronic drug use, unstable finances and housing, legal problems, physical and mental health problems, and lack of social supports.[29] In turn, the life circumstances of the children were also characterized by multiple risk factors, each of which was twice as prevalent for these children as in the general population. These included homelessness, poor father-child relationships, maternal mental illness and low education, neglect and abuse.[29,30] Such findings suggest that environmental risk needs to be taken into consideration when examining effects of prenatal alcohol exposure on development.

Research on environmental risk has shifted away from focusing on any one particular type of environmental risk, towards considering the cumulative impact of various risk factors, both pre- and post-natal. The risk and resiliency literature has shown that having just one or two risk factors does not necessarily lead to less optimal developmental outcomes. Rather, risk factors combine in an additive and interactive fashion, dramatically increasing vulnerability to various developmental difficulties.[31] One study revealed that cumulative risk accounted for more of the variance in children's developmental trajectories than prenatal exposure alone.[4] Furthermore, Appleyard, Egeland, van Dulmen, and Sroufe (2005) have shown that the sheer number of risk factors present (additive model), as opposed to a particular level of risk (threshold model), is most predictive of behavioral outcomes.[32] Therefore, one aim of this study was to identify how cumulative risk in a sample of children, with and without prenatal alcohol exposure, relates to developmental outcomes in the areas outlined above, which are known to be affected by alcohol exposure in utero. We hypothesize that although alcohol may play a

moderating role in outcomes, that cumulative risk will ultimately be a key predictor.

Despite the association between cumulative risk and poor developmental outcomes[13], certain conditions in the postnatal environment also have the potential to serve as protective factors.[33] Given that the parent-infant relationship provides the primary context for healthy child development, it has been suggested that the quality of maternal caregiving may play a substantial role in mitigating the effects of parental alcohol exposure on infant outcomes.[34] For example, recent research has demonstrated the importance of quality caregiving in reducing the impact of prenatal substance exposure on cognitive outcomes.[35-37]

Positive parent-child interactions play an important role in children's cognitive and social development. Longitudinal research emphasizes the importance of observed maternal sensitivity in mother-infant face-to-face interactions[38] and in free-play interactions[39] in predicting a child's cognitive outcome. The association between parenting characteristics and infant and child development outcomes, particularly social outcomes, has been examined in both prenatally exposed[26,3] and non-exposed children.[40]

Although the caregiving context may act as a protective factor for children prenatally exposed to alcohol, it can also act as a risk factor. Whereas some past research focused on specific behaviors of substance-involved women when interacting with their infants and recent research has included a holistic measure of the quality of the mother-infant relationship, emotional availability.[41,42] Fraser and colleagues (2010) found that mothers in substance abuse treatment program demonstrated lower emotional availability than those in a comparison group, pointing to some of the challenges mothers with substance-use problems face in parenting their infants.[41] Difficulties with parenting are closely related to the other challenges, outlined above, which mothers with alcohol and drug use problems face.

Past research has made it clear that both the broader context of risk and difficulties in the mother-infant relationship impact the development of infants and young children. Further, there is an emerging consensus among researchers on the importance of considering environmental influences, in particular the caregiving environment, when examining developmental outcomes.[43] Maternal alcohol use, cumulative risk, and difficulties in the mother-infant relationship are not mutually exclusive but the unique contributions of each, as well as the inter-relations among these three variables need to be considered in order to better understand how prenatal alcohol exposure affects developmental outcomes and to be able to appropriately focus early intervention services.

The aim of the current study was to explore the relations among cumulative risk, the quality of the mother-infant relationship, and the developmental outcomes of infants and young children of substance-using mothers. As noted above, research on the impact of alcohol exposure in the prenatal period has yielded more consistent results related to developmental delays in children than has research related to other prenatal substance exposure. For this reason, we hypothesized that the infants and young children in this study who were exposed to alcohol in the prenatal period would have less optimal developmental profiles than infants and young children whose mothers did not report use of alcohol during their pregnancy. Further, we hypothesized that infants and young children who had experienced higher levels of cumulative risk would have poorer developmental outcomes, in terms of IQ and overall developmental profile. We also sought to examine whether the quality of the mother-infant relationship relates to child developmental outcomes. We hypothesized that infants and young children of substance-using mothers who have a more dysfunctional mother-infant relationship would have poorer developmental outcomes. Additionally, we examined whether the quality of the mother-infant relationship mediates the relation between cumulative risk and developmental outcomes of infants and young children of substance-using mothers. This finding would demonstrate the importance of focusing on the mother-child relationship for dyads at risk as a result of maternal substance use.

METHOD

Participants

The participants for this study were recruited from Breaking the Cycle, a Toronto-based infant mental health intervention program for children and their mothers who have substance-use

problems.[30] The program is designed to reduce the risk of substance use on child development by addressing maternal addictions, as well as by promoting a healthy mother-child relationship. Participants were 40 mother-child dyads who had accessed clinical services between October 2001 and February 2008, and who had consented to participate in research. Inclusion criteria for the current study were as follows:

1) the child was in the care of his/her biological mother;
2) the child was between the ages of 0.5 – 5.0 years; and
3) the child received a developmental assessment between the ages of 0.5 – 5.0 years.

Mothers in the current study (N = 40) were 29.8 years of age on average (SD = 5.7 years; range = 20 to 41 years), the majority (80.0%) of whom were born in Canada. Although some mothers had a post-secondary level of education, over half (57.5%) had only an elementary level of education, 93% were unemployed and 83% earned less than $15,000 per year.

Mothers reported experiencing high rates of abuse within their romantic and/or familial relationships. Sixty-eight percent of mothers reported being involved in a romantic relationship and nearly half of these mothers (48.1%) indicated that the relationship was abusive. Mothers also reported experiencing high rates of abuse throughout their lives. Sixty-three percent of the mothers indicated a history of sexual abuse, 87.5% reported experiencing physical abuse, and 92.5% reported a history of emotional abuse. The majority of mothers also experienced problematic substance use and associated behaviors within their families and other close relationships. Not surprisingly, the majority of mothers (97.5%) were experiencing mental health difficulties, with depression reported most frequently (82.5%), followed by anxiety (82.5%), and difficulty sleeping (80.0%).

The 40 children (55.0% males) in the present study ranged in age from 6 - 57 months (M = 22.00 months; SD = 12.11 months) at the time of their developmental assessment. Child welfare was involved with majority of children (87.5%).

Based on maternal report, all children in the current study were exposed to at least one substance *in utero*, with the majority (92.5%) exposed to multiple substances (besides nicotine) and nearly half of the women (42.5%) reported using substances throughout all three trimesters. Children were most commonly exposed to nicotine (82.5%), alcohol (67.5%), cocaine (40%), crack (30%) and prescription drugs (28%).

MEASURES AND PROCEDURES

Cumulative Risk Index

Literature on cumulative risk outcomes has identified the importance of the cumulative occurrence of different types of risk on child cognitive and social-emotional outcomes.

In the current investigation, potential prenatal and postnatal risk factors, previously identified in the research literature in relation to risk due to substance exposure and high-risk environments, were used to create a cumulative risk index.[44-47] Given that a comprehensive, cumulative-risk scale, which would adequately capture the high level of risk in our sample, was unavailable in the current literature, a cumulative risk index was developed using items from previously developed indices. This index included 12 prenatal and 24 postnatal risk items (*see Appendix A*). In line with the calculation of cumulative risk in the literature, each type of risk was coded dichotomously: 0 indicating absence of risk and 1 indicating presence of risk.[46] The presence and absence of risk was based on maternal report obtained from a retrospective file review.

Developmental Function in FASD-Related Neurobehavioral Domains

The Canadian Medical Association Journal (CMAJ 2005) recently published guidelines for the assessment of neurobehavioral function in nine domains following prenatal alcohol exposure.[48] Only seven of these domains are developmentally relevant for infants and very young children:

1) hard and soft neurological signs (including sensory and/or motor difficulties);
2) cognition (IQ);
3) communication;
4) memory;
5) executive function;
6) attention deficit/hyperactivity; and
7) adaptive behavior.

Depending on the age of the child at the time of assessment and the test(s) applicable to that age, functioning in at least 4 out of 7 of these domains was rated for each child. None of the children had data relevant specifically to the memory domain. A list of the measures used in the developmental assessment, the measures' corresponding age ranges and the number of children with scores in each domain is provided in Appendix B. Each domain was coded dichotomously such that a 1 was given if impairment was present, and a 0 was given if impairment was absent. An impaired developmental functioning quotient was then created by summing the number of developmental domains impaired and dividing by the number of domains measured. According to the guidelines set out by the CMAJ, a domain was considered impaired when: 1) scores on standardized tests were 2 standard deviations or more below the mean; and 2) there was a discrepancy of at least 2 standard deviations among subtests on a measure. information, independently rated the level of mother-child relationship functioning in all of the dyads using the PIR-GAS. Inter-rater reliability within one category was high (kappa = .83; $p < .001$). All final category ratings were based on consensus agreement.

Mother-child Relationship Quality

Ratings of mother-child relationship quality were assigned based on retrospective clinical file reviews using the Parent-Infant Relationship Global Assessment Scale from the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood: Revised Edition (PIR-GAS).[49] Ratings were based on the last five clinical case notes written just prior to each child's developmental assessment by parent-infant therapists and/or clinicians. Notes were clinical case records of home visits and group interventions facilitated by parent-infant therapists, as well as observations of the mother-infant relationship made by clinicians. Notes were structured so that the child's emotions and behaviors were described first, then the mother's emotions and behaviors, followed by a description of the mother-child interactions and emotional quality. The focus of all home visiting and group sessions was to promote positive mother-infant relationships, as well as to foster the development of the infant through the relationship with his/her mother.

The PIR-GAS was originally developed as a 100-point, ordinal scale with categories of parent-child functioning ranging from "well adapted" to "grossly impaired", but for ease of ratability the PIR-GAS was used as a 10-category scale in this study. Three components of the mother-child relationship are assessed; behavioral quality of the interaction, affective tone, and psychological involvement. The scale demonstrates both predictive validity to domains such as social-emotional functioning[49,50] as well as concurrent validity with the DSM-IV-TR.[50] Two coders, a clinical psychologist who was familiar with the participants and familiar with the mother-child relationships, and another blind to any clinical

The Emotional Availability (EA) Scale[43] which is used to rate the emotional quality of videotaped-observations of mother-child interactions, was also used with a subset of the sample ($n = 15$) for whom video-recordings were available. This scale assesses parental sensitivity, structuring, non-hostility and non-intrusiveness, as well as child responsiveness and involvement of adult, and is used as a holistic measure of parent-child relationship functioning. This scale was used in addition to PIR-GAS ratings to support PIR-GAS ratings of mother-child relationship quality. All available video recordings were independently coded by two trained researchers, who were clinically unfamiliar with the dyads. Intraclass correlations coefficients (ICC) for inter-rater reliability were calculated using recommended parameters two-way random, absolute agreement, average of coders) and they ranged from .80 to .94 (i.e. high reliability) for all dimensions.[51]

RESULTS

Statistical Analyses

All assumptions underlying the statistical analyses were met and non-parametric analyses were used when appropriate.

Data Analysis Plan

Independent samples t-tests and chi-square tests were used to examine group differences between infants prenatally exposed to alcohol and those exposed to other substances but not alcohol. Pearson product moment correlations and

Spearman's rank correlations were calculated to investigate relations among cumulative risk, mother-child relationship functioning, and neurobehavioral function.

A bootstrapping procedure was used to explore the potential mediating role of mother-child functioning in the relation between cumulative risk and neurobehavioral impairment. Bootstrapping is a nonparametric re-sampling procedure that generates an empirical approximation of the sampling distribution of a statistic from the available data. This is done by considering the original data set as a population of scores, re-sampling with replacement a massive number of times, and computing the indirect effect in the re-sampled data. Point estimates and 95% confidence intervals are estimated for the indirect effects. The point estimates are considered significant at the alpha = .05 level if zero is not contained in the 95% confidence interval. Bootstrapping procedures are gaining favor over the Baron and Kenny (1986)[52] causal steps approach traditionally employed to investigate indirect effects because it is one of the most powerful methods of testing intervening variable effects, especially when dealing with small samples sizes and non-normal data, and because it allows for the investigation of indirect effects even when there is no direct relation between a predictor and outcome variable.[53-55] The current study employed a macro developed by Preacher and Hayes (2004) and 20,000 re-samples.[56]

Cumulative Risk

There were 12 prenatal and 24 postnatal risk domains scored dichotomously, with potential scores ranging from 0 to 36. In this sample, scores on the cumulative risk index ranged from 6 to 24 (*M* = 16.60; *SD* = 5.23; 95% *CI* [14.93, 18.27]).

Prenatal Risk

Seventy-eight percent of the children in this sample experienced one or more prenatal maternal risks other than substance exposure (e.g., maternal transiency, too much/too little weight gain, high blood pressure, teenage pregnancy, minimal prenatal care, history of miscarriages, risk of diabetes, risk of infection, risk of anemia, placenta previa, etc.). The percentage of children exposed to a particular maternal prenatatal risk factor ranged from 2.5% for low weight gain to 55% for history of previous miscarriages. The most frequently reported prenatal risk factors were; history of miscarriages (55%), limited prenatal care (32.5%), risk of anemia (17.5%), and risk of infection (15%).

Developmental Function Outcomes

The developmental functioning quotient was calculated using the aforementioned 7 neurobehavioral domains, where a higher score indicated greater overall impairment. Impairment in each of the neurobehavioral domains for children ranged from 0 to 100. Fifteen children received a score of zero, indicating no evidence of impairment in the domains for which information was available, while two children were impaired in all domains measured. Nearly a third of the children (27.5%) were impaired in half or more of the domains measured. The median impairment score in neurobehavioral domains was 25.0 (interquartile range = 50.0).With regards to IQ, the average composite score for the sample was 98.88 (*SD* = 14.78; 95% *CI* [94.15, 103.61]), and ranged from 64 (1st percentile) to 135 (99th percentile).

Mother-Child Relationship Functioning

Mother-child relationship ratings ranged from 'well adapted' (functioning exceptionally well) to 'grossly impaired' (functioning dangerously disorganized). The frequencies of these mother-child relationship categories are listed in Table 1. The chi-square test did not reveal a significant relation between mother-child relationship quality (high vs. low) and mother-child separations (separated by child welfare vs. not separated by child welfare), $\chi^2(1, n = 38) < 1$, $p = .36$. That is, dyads with less adaptive mother-child relationships were not any more likely than dyads with more adaptive relationships to have experienced a mandated child welfare separation.

The EA scale ratings were found to be highly correlated with the PIR-GAS ratings (e.g. adult sensitivity total: $r_s(14) = .52$, $p < .05$; adult structuring total: $r_s(14) = .62$. $p < .05$; child responsiveness global: $r_s(14) = .51$, $p = .05$; EAS screener: $r_s(14) = .56$, $p < .05$). These findings support the use of the PIR-GAS in rating mother-child relationship quality based on file reviews.

TABLE 1 Frequencies of Mother-Child Relationship Functioning Category Ratings (n= 40)

Category	Description	*n*	%
0	Documented Maltreatment in Relationship	0	0.0
1	Grossly Impaired	2	5.0
2	Severely Disordered	1	2.5
3	Disordered	2	5.0
4	Disturbed	6	15.0
5	Distressed	5	12.5
6	Significantly Perturbed	8	20.0
7	Perturbed	4	10.0
8	Adapted	11	27.5
9	Well Adapted	1	2.5

TABLE 2 Frequencies of children exposed to substance by trimester

	Substance	*n*	%
First Trimester			
	Alcohol[a]	27	67.5
	Crack[a]	12	30.0
	Cocaine[a]	14	37.0
	Nicotine[a]	33	82.5
	Prescription[b]	12	31.5
	Other[b]	18	26
	Multiple[c]	26	70
Second Trimester			
	Alcohol[b]	11	29.0
	Crack[b]	7	18.0
	Cocaine[b]	6	16.0
	Nicotine[c]	22	59.0
	Prescription[b]	10	26
	Other[c]	11	30
	Multiple[c]	11	30
Third Trimester			
	Alcohol[b]	11	29.0
	Crack[b]	2	5.0
	Cocaine[b]	5	13.0
	Nicotine[c]	23	62.0
	Prescription[b]	8	21
	Other[c]	8	21
	Multiple[c]	7	19

[a]n=40; [b] n =38; [c] n=37

Alcohol-Exposed versus Non-Alcohol Exposed

There were 27 children (15 males) with prenatal alcohol exposure and 13 children (7 males) without. Frequency of exposure ranged from daily to occasionally, with 18 children regularly exposed on a daily to weekly basis. Of the children with prenatal alcohol exposure, 11 (29%) were exposed to some extent across all 3 trimesters. Of the 27 children with prenatal exposure, nearly half (46.4%) were exposed to more than 5 drinks per drinking occasion. See Table 2 for a breakdown of the number children exposed to the most common substances by trimester.

Chi-square tests revealed that there was no relation between prenatal alcohol exposure status (exposed vs. not exposed) and gender (male vs. female), $\chi^2(1, n = 40) = .08$, $p = .53$; maternal involvement in clinical services while pregnant (involved vs. not involved), $\chi^2(1, n = 40) = 1.14$, $p = .24$; or maternal custody status (maternal custody vs. non-maternal custody), $\chi^2(1, n = 40) = 3.02$, $p = .56$. In terms of outcomes of interest, independent samples t-tests revealed that the groups did not differ significantly in terms of IQ, and the Mann-Whitney U test revealed that the groups did not differ significantly in terms of mother-child relationship functioning, or neurobehavioral functioning (*see Table 3*). Because the two groups did not differ significantly on the outcome measures of interest the groups were collapsed and subsequent analyses were performed on the entire sample.

TABLE 3 Comparisons of infants/children with prenatal alcohol exposure (n = 28) and without prenatal alcohol exposure (n = 12) on outcome variables

	Children With Exposure		**Children Without Exposure**			
Outcome Variable	*M*	*SD*	*M*	*SD*	*Test statistic*	*n*
Cumulative Risk	18.78	4.01	12.67	4.44	4.28**	40
IQ	98.54	15.05	99.67	14.75	.22	40
Mother-child Relationship Functioning	6 [a]	4 [b]	6 [a]	3 [b]	.29	40
Neurobehavioral Domains	20.16 [a]	.50	21.29 [a]	.25 [b]	.25 [c]	40

Note. Standard deviations appear in parentheses below means.
[a] Mean rank. [b] Inter-quartile range. [c] z score based on Mann-Whitney U test.
**$p < .01$

Correlations between Predictor and Outcome Variables

Consistent with the cumulative risk literature suggesting that overall risk is more predictive of outcomes than any one single factor alone[32], none of the individual risk items related to maternal substance abuse history or relapse were individually related with neurobehavioral functioning (all *r*s(39) <.25, *p* >.05) or IQ (all *r*s(39) <-.24, *p* >.05). However, overall risk was related with neurobehavioral outcomes. Mothers who had lower cumulative risk had children who were impaired in fewer domains. Cumulative risk, on the other hand, was not significantly associated with IQ. Further, adaptive mother-child relationship was also related to neurobehavioral outcomes and IQ, in that more adaptive relationships were associated with fewer neurobehavioral impairments and higher IQ. Correlation coefficients for the relations among cumulative risk, mother-child relationship quality, and neurobehavioral function are shown in Table 4.

TABLE 4 Correlations Between Predictor and Outcome Variables

VARIABLE	1	2	3	4
1) Cumulative Risk	-			
2) Mother-child Relationship Functioning	-.50**	-		
3) IQ, composite score	-.26	.37*	-	
4) Neurobehavioral Domains	.33	-.32*	-.62**	-

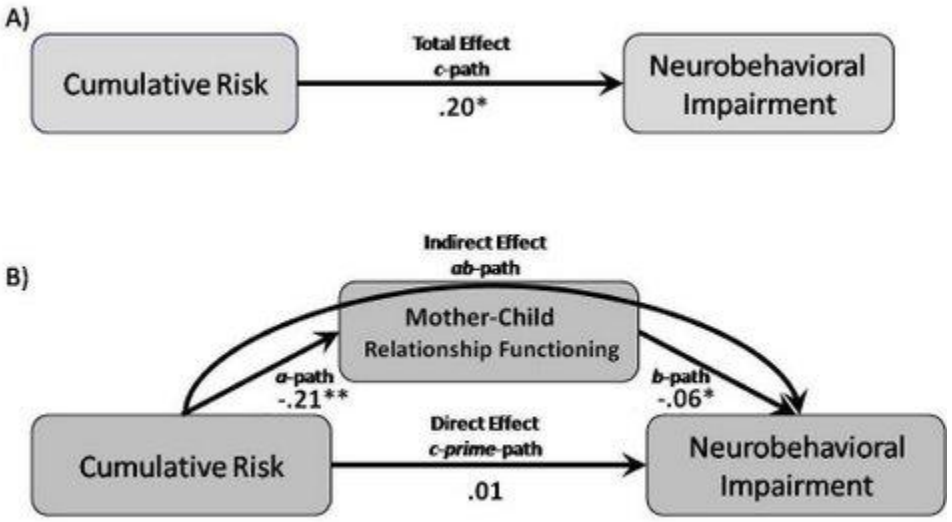
*$p < .05$, **$p < .01$

Bootstrapping Analysis

The regression results indicated that the total effect of cumulative risk on neurobehavioral impairment was significant, total effect (*c*-path) = .02, *p* = .02, (see Figure 1). When the mother-child relationship quality score was included in the model as a mediator, however, the direct effect of cumulative risk was no longer significant, direct effect (*c′*-path) = .008, ns. Furthermore, the bootstrap analyses revealed with 95% confidence that the total indirect effect (i.e., *ab*-path) of cumulative risk on neurobehavioral impairment through the mother-child relationship quality score was significant with a point estimate of .013 and a 95% confidence interval of .002 to .026. Since zero is not contained in the 95% CI, the indirect effect is significantly different from zero at $p < .05$ (two-tailed). A point estimate of .013 for an indirect effect means that as cumulative risk increases by one unit, neurobehavioral impairment increases by .013 units via the effects of cumulative risks on the mother-child relationship quality score, which in turn affects neurobehavioral functioning. Further, 11% of the variance in neurobehavioral functioning is accounted for by the indirect effect through the mother-child relationship quality score (see Figure 1).

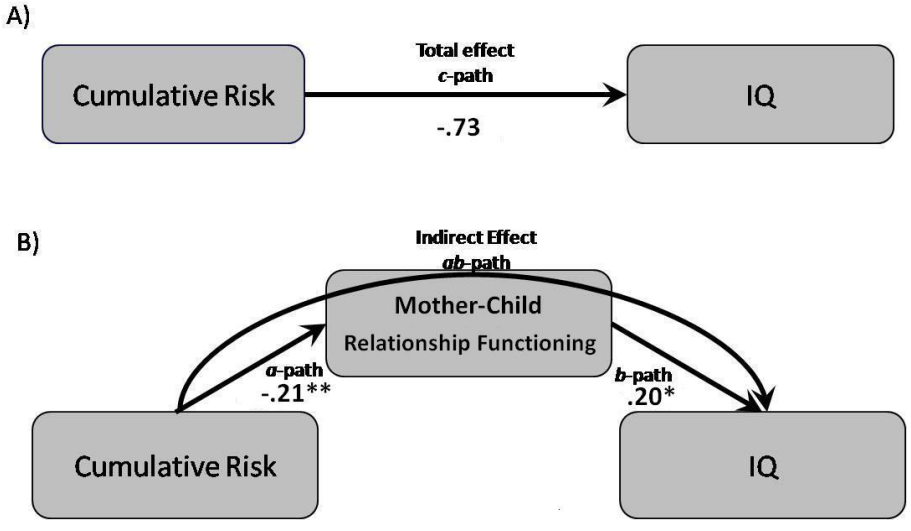
The regression results indicated that the total effect of cumulative risk on IQ is not significant, total effect (c-path) = -1.52, ns, (see Figure 2). When the mother-child relationship quality score was included as a potential intervening variable, however, bootstrap analyses revealed with 95% confidence that the total indirect effect (*ab*-path) of cumulative risk on IQ through the mother-child relationship quality score was significant, with a point estimate of -1.38 and a 95% confidence interval of -2.58 to -.28. Therefore, although IQ was not directly related to cumulative risk, IQ was indirectly related to cumulative risk through the mother-child relationship. As cumulative risk increased by one unit, IQ decreased by 1.38 units via the effects of cumulative risk on the mother-child relationship quality, which in turn affected IQ. Further, 8.3% of the variance in IQ was accounted for by cumulative risk via this indirect path through the mother-child relationship.

FIG. 1



Regression coefficients for (a) the total effect of cumulative risk on neurobehavioral impairment, and (b) the direct and indirect effect of cumulative risk on neurobehavioral impairment when the mother-child relationship functioning score is entered into the model as a mediator. Twenty-thousand bootstrap re-samples revealed that the total indirect effect of cumulative risk on neurobehavioral impairment through the mother-child relationship functioning score was significant at the .05 level, with a point estimate of .013 and a 95% confidence interval of .002 to .026. *p < .05; ** p<.01

FIG. 2



*p < .05; ** p<.01

DISCUSSION

In this sample of mothers with substance-use problems and their infants and young children, findings were consistent with our hypothesis that higher levels of cumulative risk in the larger context of the mother and the child would be associated with poorer developmental outcomes for children. More specifically, cumulative risk was directly related to a global measure of children's neurobehavioral functioning, such that increased risk predicted higher levels of impairment in the domains measured. Because the path from cumulative risk to neurobehavioral impairment became non-significant when the mother-child relationship quality score was included in the model, mother-child relationship quality was found to mediate this relation. In other words, there was a relation between cumulative risk and neurobehavioral outcomes; however, this relation existed through the mother-child relationship. Further, cumulative risk was inversely associated with quality of the mother-child relationship, such that increased risk predicted lower functioning, and conversely, lower cumulative risk scores predicted higher-quality relationships. In turn, the quality of the mother-child relationship was associated with neurobehavioral outcomes such that poorer relationship quality was associated with more difficulties in the neurobehavioral domains, whereas higher quality was associated with fewer impaired neurobehavioral domains.

Providing further support for the intervening role of the mother-child relationship in the effect of cumulative risk on neurodevelopmental outcomes, there was an indirect relation between cumulative risk and IQ, through the mother-child relationship. Counter to our prediction, a direct link between cumulative risk and IQ was not found, although cumulative risk was negatively associated with mother-child relationship quality, which in turn was positively associated with IQ.

Altogether, these findings highlight the important role of the mother-child relationship in neurobehavioral and cognitive outcomes for infants and young children of women with substance-use problems. More than likely these effects are bidirectional to the extent that having a child with fewer neurobehavioral impairments most likely improves the mother-child relationship as these children may be relatively easier to parent.[66,67] These findings are particularly intriguing due to the very young age of our sample. It is possible that early neurodevelopmental function can be affected by high levels of cumulative risk, through the mother-child relationship, if these sources of stress impede mother-child interactions, which serve as the basis for stimulation and learning in early infancy and childhood. Alternatively, if mothers are able to provide a responsive and enduring proximal context, despite high levels of risk in the broader relationship context, these relationship experiences can help nurture healthy emotional development in infants and young children and can modulate the effects of environmental stressors on the neuroendocrine system[57], directly impacting the developing brain and promoting exploratory behaviour.[58] Furthermore, the child's capacity to regulate his/her own emotions emerges from these early emotional exchanges.[59,60] As the capacity for self-regulation matures, so too does the ability to generate strategies such as diverting attention, shifting attention, planning and problem-solving.[61]

This study is part of a growing body of literature showing that the mother-child relationship can act as a buffer against cumulative risk in the distal environment, in early development[41], and is among one of first studies to show a mediating role for the mother-child relationship in the relation between cumulative risk and neurodevelopmental outcomes in a substance-abusing population.

The finding that IQ and overall cumulative risk were not directly related in this sample was unexpected, although the extant literature presents mixed findings regarding the existence of this relation in high-risk samples of infants and young children.[62,63] However, exploratory analyses did reveal a moderate relation between prenatal risk and IQ in this sample, for the alcohol-exposed group (p = .02). This pattern of results suggests that the effect of prenatal alcohol exposure may be more specifically related to overall cognitive functioning, or IQ, whereas cumulative risk measured across both the pre- and post-natal

periods, may relate more strongly with behavioral and adaptive functioning. It may be that prenatal exposure to alcohol acts as a diathesis presenting as a cognitive lag, and that this diathesis, in combination with exposure to ongoing postnatal risk factors, can result in behavioral and adaptive impairments across a wide-range of developmental domains. Future research should consider this possibility more closely.

Alcohol vs. Non-Alcohol Exposure

Based on a substantial body of previous research, we had hypothesized that children with prenatal alcohol exposure would show poorer developmental outcomes across multiple domains.[64] In this sample, children with and without prenatal alcohol exposure did not differ significantly on any of the outcome measures including amount of postnatal risk, IQ or neurobehavioral functioning. Here are several possible reasons why this hypothesis was not supported. First, it is possible that the use of a dichotomous grouping variable for prenatal alcohol exposure may have washed out alcohol effects by including children in the exposed group whose mothers' reported only occasional use. However, this was the case for only 3 children. In fact, 75 % of the children with prenatal alcohol exposure had mothers who drank during at least two trimesters. Also, almost half of the mothers who reported drinking during pregnancy reported drinking more than 5 drinks per occasion. This type of binge drinking pattern has been associated with lower neuropsychological scores.[65] A second possible explanation is that the high percentage of children in this sample with poly-substance exposure may have prevented expected differences between children with and without prenatal alcohol exposure from emerging. Mothers may have also underreported their substance use to varying degrees to prevent stigma regarding their parenting abilities leading to less reliable measures of prenatal exposure. Third, it may be that the effects of prenatal alcohol exposure on developmental outcomes cannot be considered outside the greater context of risk or that the effects of prenatal alcohol exposure on neurodevelopmental outcomes were mitigated in the intervention context. Finally, given that the results of this study have supported hypotheses regarding the importance of mother-child relationship functioning in child outcomes and that there was no difference found in relationship function for exposed and non-exposed children, it is possible that this relationship quality may have concealed/overpowered any difference between these two groups.

Strengths and Limitations

There is an emerging trend to use more powerful bootstrapping techniques for detecting mediation rather than the traditional Baron and Kenny (1986) causal steps approach.[52] This technique was adapted in the current study, allowing potential issues regarding sample size, and assumptions of normal distribution to be circumvented, while affording the power necessary to detect the important mediating role (direct and indirect) of mother-child functioning in the relation between risk and outcomes.

Several methodological limitations should be considered when interpreting these results. Although we did find mediation and the variables included in this study were time-dependent (i.e. prenatal exposure occurred prior to measuring developmental outcomes), we recognize the importance of exercising caution in inferring causation. Because it was impossible to experimentally manipulate cumulative risk, mother-child relationship functioning or prenatal substance exposure, causal inferences about the impact of these variables on the neurobehavioral development and the IQ of infants and children of mothers with substance-use problems should not be expected. To infer causation, one strategy might be to examine these relations longitudinally, in the context of a treatment program designed to enhance the mother-child relationship, and to assess developmental outcomes. Changes in risk over time should also be considered. Also, because all participants were part of an intervention which may have impacted mother-child relationship quality to some extent and because there was no control group, this feature of the methodology may limit generalizability of the results.

Another methodological challenge of the present study was in the mother-child relationship quality rated by PIR-GAS, which had high inter-rater reliability, but was based on clinical case reviews rather than direct observations. However,

given the aforementioned high correlations of PIR-GAS ratings with a standardized, observation-based rating scale, we have provided some support for the use of PIR-GAS with clinical file reviews for measuring the overall quality of mother-child relationship.

This study is among the first to demonstrate that some of the neurobehavioral domains outlined by the CMAJ can be reliably evaluated in infants and young children. Although some domains of neurobehavioral functioning relied heavily on parent report (i.e., executive function and attention), and as such may have been more vulnerable to the effects of mother-child relationship quality (i.e., mothers with more problematic relationships with their child may have rated their child more harshly), scores on this global measure of neurodevelopmental functioning were highly correlated with IQ–a standardized and more precise cognitive index, supporting the validity of this measure. Even in this somewhat homogenous, high-risk sample of very young infants and children, the measure of neurobehavioral functioning impairment was sensitive to variance in developmental abilities. Similarly, despite the challenge of capturing variability in cumulative risk levels given the extremely high-risk nature of this sample, we were able to integrate information from the general cumulative risk literature and to adequately capture the complex range of risks in our sample.

Clinical Implications

The results of this study highlight the importance of focusing on the mother-child relationship in early intervention/infant mental health services. This focus is particularly salient given that many substance-using mothers and their young children experience a complex combination of risk factors that are sometimes difficult to change through interventions. The present research suggests that if high risk families have access to quality, relationship-focused, clinical interventions, the negative impact of cumulative risk on development can be minimized. In addition, these findings speak to the importance of identifying cumulative risk (both pre and postnatal) as an indicator for early intervention services. Developmental outcomes for infants and young children of substance-using women are not necessarily linked to prenatal alcohol use in isolation, but to the entire environmental context, of which the mother-child relationship seems to be a most important element. Therefore, interventions for substance-using women and their young children must be comprehensive with a focus on supporting the child, the caregiving environment (including the mother), and the mother-child relationship in order to optimize developmental outcomes.

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APPENDIX A

Cumulative Risk Index

RISK FACTORS	SCORING
Pre-natal Risk	
More than 3 births	(0) no (1) yes
Drinks 3 or 4 times a week either before or during pregnancy	(0) no (1) yes
Drinks more than 2 drinks per occasion either before or during pregnancy	(0) no (1) yes
Reported drinking more than 5 drinks per occasion before pregnancy	(0) no (1) yes
Reported drinking more than 5 drinks per occasion during pregnancy	(0) no (1) yes
Drinks throughout pregnancy	(0) no (1) yes
Has tried to quit drinking ever	(0) no (1) yes
Reports having had withdrawal symptoms when trying to stop	(0) no (1) yes
Reports ever having had social problems due to drinking	(0) no (1) yes
Has a primary relationship with drinker	(0) no (1) yes
Poly-substance exposure versus single substance exposure during pregnancy	(0) no (1) yes
Continuous exposure over all three trimesters during pregnancy	(0) no (1) yes
Post-natal Risk: Maternal History	
Presence of a diagnosed DSM-IVR mental illness	(0) no (1) yes
Maternal level of education: Has completed high school	(0) no (1) yes
Conviction history	(0) no (1) yes
Mother has history of child abuse	(0) no (1) yes

Post-natal Risk: During Child's Lifespan	
Maternal anxiety symptoms	(0) no (1) yes
Head of household has no more than a semiskilled occupation	(0) no (1) yes
Disadvantaged minority ethnic background	(0) no (1) yes
Mother endorses depressive symptoms	(0) no (1) yes
Mother is engaged in a domestically violent relationship	(0) no (1) yes
Maternal pregnancy	(0) no (1) yes
Child in foster care or kin care	(0) no (1) yes
Medical illness or parent or family member (could include new diagnosis).	(0) no (1) yes
New adult in household (e.g., boyfriend)	(0) no (1) yes
Parental divorce or separation	(0) no (1) yes
Parental substance abuse relapse	(0) no (1) yes
Multiple changes in childcare provider	(0) no (1) yes
Child starting daycare	(0) no (1) yes
Multiple moves (2+)	(0) no (1) yes
Unsafe or overcrowded housing	(0) no (1) yes
Poverty or near poverty (less than $10,000)	(0) no (1) yes
Hospitalization of child	(0) no (1) yes
Parental arrest	(0) no (1) yes
Parental incarceration	(0) no (1) yes
Parent attended treatment	(0) no (1) yes

APPENDIX B

Measures Used to Assess Neurobehavioral Domains, Age Range Applicable to Each Measure in this Sample and Number of Participants Assessed per Domain

DOMAIN	Applicable Age Range (in months)	*n*
Hard/Soft Neurological Signs		40
(a) Sensory Profile Questionnaire	6 – 57	
(b) Bayley Scales of Infant and Toddler Development, 3rd Ed. – Motor domain scales	6 – 57	
Memory		0
(a) NEPSY: A Developmental Neuropsychological Assessment – Memory domain scales	36 – 57	
Adaptive Behavior		40
(b) ABAS-II: The Adaptive Behavior Assessment System-II	6 – 57	
Cognition		40
(a) Bayley Scales of Infant and Toddler Development, 3rd Ed. – Cognitive domain scales	6 – 42	
(b) WPPSI: Wechsler Preschool and Primary Scale of Intelligence – Third Edition: Canadian – Full IQ composite score	30 – 57	
Executive Function		4
(a) BRIEF-P: Behavior Rating Inventory of Executive Function – Preschool Version	24 – 57	

Communication		40
(a) Bayley Scales of Infant and Toddler Development, 3rd Ed. – Language domain scales	6 – 42	
(b) WPPSI: Wechsler Preschool and Primary Scale of Intelligence – Third Edition: Canadian – General Language composite score	30 – 57	
ADD/ ADHD		9
(a) CBCL: Child Behavior Checklist	12 – 57	
(b) CONNERS: Conners' Teacher (Parent) Rating Scale – Revised (S)	36 – 57	

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