ESTIMATING THE NEUROCOGNITIVE EFFECTS OF AN EARLY INTERVENTION PROGRAM FOR CHILDREN WITH PRENATAL ALCOHOL EXPOSURE

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ABSTRACT

Background
Animal studies suggest that early intervention in pups exposed heavily to ethanol *in utero* can mitigate their neurocognitive damage. No human studies on this promising mechanism exists.

Methods
Breaking the Cycle is an early intervention program for drug-and alcohol addicted mothers and their young children. We compared BSID-III scores between infants heavily exposed to ethanol and a group exposed only to drugs of abuse, mainly cocaine. Both groups benefited from all aspects of our early intervention program.

Results
The two groups did not differ in any aspect of the BSID-III. These data are in contradistinction to the damage seen in heavily ethanol- exposed infants not benefiting from early intervention.

Conclusions
This pilot suggests that early intervention may mitigate some of the well described damages caused by heavy *in utero* alcohol exposure.

Heavy maternal alcohol use in pregnancy is associated with serious adverse effects in the offspring, including the different features of the Fetal Alcohol Spectrum Disorder. The life-long sequallae of these effects include a pervasive pattern of neurocognitive and behavioral handicaps.[1] Mattson and colleagues have documented that high levels of prenatal alcohol exposure are related to an increased risk for deficits in intellectual functioning.[2] At age 6 to 7 years, Bailey and colleagues have found that children exposed to binge drinking were 1.7 times more likely to have IQ in the mentally retarded range.[3] Willford and colleagues have shown in a longitudinal study up to the age of 10 years, a significant relation between alcohol exposure during the first and second trimesters and the composite score of the Stanford-Binet for African American Children.[4]

Recently, the plasticity of the neonatal brain has been shown in experimental animal models, leading to dramatic recovery from intrauterine insults, including hypoxia and ethanol exposure, secondary to stimulation programs for the offspring.[5] This has led to the question of whether early intervention may be able to attenuate some of the *in utero* risks of ethanol in humans.

Testa and colleagues[6] completed a meta-analysis of nine independent investigations published between 1973 and 2000 which examined the developmental scores of ethanol-exposed children and compared the scores to control groups using earlier versions of the Bayley Scales of Infant Development (BSID-I and II).

The authors reported that of the three age groups which were examined (6-8 months, 12-13 months, 18-26 months) that only the 12-13 months ethanol-exposed children had lower Mental Development Index (MDI) scores than their control group counterparts; however, these results were reduced when the effect sizes were statistically adjusted using relevant covariates e.g., psychosocial factors. The authors suggested three potential explanations for the results of their investigation:

1. The pattern of findings is not so much related to age as to the fact that the BSID-I and II are more heavily weighted to

measure attention and short-term memory at 12-13 months while at 6-8 months, it primarily measures social and motor skills, and at 18-26 months, it is more weighted to measure expressive language skills.
2. The impact of the psychosocial factors of children living in an impoverished environment may similarly impact the development of the ethanol-exposed and non-ethanol-exposed children.
3. The previous research is neither large nor conclusive enough to demonstrate relevant impacts.

The present preliminary investigation attempted to account for previously identified challenges by; first, limiting analyses to children assessed using the BSID-III[7] which parses out aspects of mental development by the use of cognitive, language and social scales, as opposed to an overall mental index. Second, this exploration occurred within the context of an early intervention program which addresses many of the significant psychosocial risk factors that pervade the lives of the identified families.

The optimizing impact of early intervention programs on children's development and behaviour has been well documented in the literature.[8-13] The Zero to Three National Center for Infants, Toddler's and Families has presented compelling evidence for the promotion of early intervention services for infants and toddlers, particularly those at-risk for poor developmental outcomes.

The basis for this advocacy includes:

1. Early experience, coupled with the influence of genes, literally shape the architecture of the brain.
2. Early experiences take place in relationships.
3. All domains of development are interdependent.
4. Development is cumulative, so early experiences lay the foundation for all that follows.
5. Because early experiences matter, we must intervene with young children who are at risk.
6. Early experiences are a proven investment in our future.[14]

In regards to parenting interventions for substance-involved mothers, there is a paucity of systematically evaluated research in this area, primary due to the challenges of engaging families who have such an unstable and chaotic life.[15] In regards to developmental outcomes related to these early intervention programs, one investigation reported intervention/control group differences at 6-, 12-, and 18-months. A second study found significant differences in developmental scores at 12-months between treatment and non-treatment groups; a third investigation found both groups of 36-month old children (intervention and no intervention) showing scores below clinical norms. Conclusions from these reviewed investigations often included the fact that interventions for substance-involved mothers and children need to be comprehensive and multiperspective to meet the needs of the complex lives of these high risk families.[14]

Breaking the Cycle is a Toronto-based program that serves drug and alcohol-dependent women and their young children.[16] Established in 1995, the program follows a holistic approach which includes addiction counseling, parenting programs, early childhood intervention, and a variety of other interventions described in Table 1. Breaking the Cycle (BTC) is one of Canada's first early identification and prevention programs for pregnant women and mothers who are using alcohol or other substances, and their young children. In addition to substance-use and exposure, women and children served at BTC experience a host of complex conditions of risk including mental health problems, domestic violence, homelessness, poverty, health/medical vulnerabilities and maltreatment/trauma. These conditions are exacerbated by the families' alienation from health and social supports.

Since 1995, BTC has developed a comprehensive, cross-sectoral, relationship-based range of integrated services through a single-access model, with home visitation and outreach components. BTC operates through the efforts of a partnership including Mothercraft, Motherisk-Hospital for Sick Children, Children's Aid Society of Toronto, Catholic Children's Aid Society, Toronto Public Health, St. Joseph's Health Centre, St, Michael's Hospital, and the Ministry of Community Safety and Correctional Services. BTC offers individual and group

addiction treatment, parenting programs, child care, child developmental services (including screening, assessment and intervention), health/medical services, FASD Diagnostic Clinic, mental health counseling, case management, parent-infant therapy, home visitation, pregnancy outreach, and support around instrumental needs (including food, clothing and transportation).

To estimate the potential effects of this intensive and comprehensive early intervention and stimulation program on neurocognitive achievements of children exposed *in utero* to large doses of ethanol, we compared them to a similar cohort of BTC children exposed *in utero* to other drugs of abuse, not known to affect neurocognitive development.

The results of this analysis were also compared to findings in the scientific literature on the effects of heavy *in utero* ethanol exposure on neurocognitive development. In the present investigation, we expect that there will not be any significant differences between the cognitive development scores of children exposed to alcohol and other substances in the prenatal period and children who were not exposed to alcohol but whose mother engaged in misuse of other substances during pregnancy. Additionally we expect that the cognitive scores of both groups will be within the average range (no more than one standard deviation from the mean).

METHODS

Over the years BTC has utilized several psychological tools to estimate cognitive development of children. For the purpose of this pilot study we have used archival data from 2006-2009 when the BSID-III cognitive, language and motor composite scores have been used, as well as the WPPSI-III[20] verbal, performance and full composite scores.

Our study sample was dichotomized into 2 groups; mother-child dyads where the primary intrauterine exposure was to ethanol at levels of problem drinking (n=28), and mother-child pairs where no alcohol use during pregnancy was reported (n=15). Both groups reported misuse of other drugs during the prenatal period, primarily cocaine. Although women within the ethanol group reported different patterns of alcohol consumption, in all cases they were using alcohol in a problematic way, with significant impacts on their health and psychosocial lives. As part of holistic nature of BTC intervention, all of the mothers and children in both groups took part in multiple interventions summarized in Table 1.

Maternal variables (educational attainment and monthly income) and child variables (age at assessment, gestational age, birth weight, and developmental testing scores) were compared using the Student's t-test for unpaired data or Mann Whitney U test, as appropriate.

TABLE 1 BTC Programs and Services

PROGRAMS & SERVICES	DELIVERED BY:
BTC Pregnancy Outreach Program	Breaking the Cycle, St. Joseph's Health Centre (TCUP) & Women's Own Withdrawal Management Centre
ADDICTIONS	
Relapse Prevention Group	Breaking the Cycle & Mothercraft
Recovery Group	Breaking the Cycle & Mothercraft
Life Skills Groups	Breaking the Cycle & Mothercraft
Individual Counselling	Breaking the Cycle & Mothercraft
Connections	Breaking the Cycle
PARENTING	
New Moms' Support Group	Toronto Public Health & Mothercraft
Nobody's Perfect Parenting Program	Toronto Public Health & Mothercraft
Cooking Healthy Together	Toronto Public Health, Mothercraft & Breaking the Cycle
Parent-Child Mother Goose Program	Breaking the Cycle
Parent-Child Counselling	Breaking the Cycle
Hanen "You Make the Difference" Group	Breaking the Cycle

Mothercraft "Learning Through Play" Group	Breaking the Cycle
Child Welfare Access Visits	Children's Aid Society of Toronto/Catholic Children's Aid Society of Toronto & Breaking the Cycle
MENTAL HEALTH COUNSELLING	Mothercraft
CHILD CARE	Breaking the Cycle & Mothercraft
DEVELOPMENTAL CLINIC	
Developmental Screening and Assessment	Mothercraft & Breaking the Cycle
Early Intervention through Homes Visitation	Mothercraft
FASD DIAGNOSTIC CLINIC	
Individual Pre-Postnatal Counselling	Motherisk, Mothercraft & Breaking the Cycle
HEALTH/MEDICAL SERVICES	Motherisk, Toronto Public Health, Individual Pre-Postnatal Counselling - Breaking the Cycle, St. Joseph's Health Centre (TCUP)
BASIC NEEDS SUPPORT	
Clothing Exchange	Breaking the Cycle
Daily Breakfast & Lunch	Second Harvest
Transportation	Breaking the Cycle
PROBATION AND PAROLE SERVICES	Ministry of Community Safety and Corrections

RESULTS

Both groups of mothers (ethanol or non-ethanol) were of extremely low socioeconomic status, with low levels of educational attainment (Table 2). All children in the ethanol group were exposed to alcohol in the first trimester of gestation, 15 of these were also exposed in the second trimester and 13 were also exposed in the third trimester.

Most of the children were born at term. Children in both groups had evidence of mild intrauterine growth retardation, evidenced by slightly low birth weight at term with no significant differences between the groups (Table 2). Psychological testing most often took place between the ages of 2-3 years for both groups. Based on the cut-off age of 36 months, children were tested on either the BSID-III or WPPSI-III assessment tool.

As shown in Table 3, the ethanol-exposed children's achievements were similar to the other drug-exposed children, regardless of the test or subtest used. The mean standardized developmental scores for both groups, regardless of assessment instrument, were within the normal range.

TABLE 2 Comparison of Characteristics between Ethanol-exposed and Non-exposed Groups

Characteristic	Group	N	Mean	SD	P
Age of child at assessment (months)	Non-ethanol	15	28.8	19.9	0.27
	Ethanol	25	35.8	18.7	
Gestational age (weeks)	Non-ethanol	15	39.3	1.7	0.70
	Ethanol	28	39.0	2.5	
Birth weight (pounds)	Non-ethanol	15	3.2	0.7	0.80
	Ethanol	29	3.1	0.6	

Highest Grade Completed	Non-ethanol	15	2.8	1.1	0.90
1=elementary school	Ethanol	28	2.8	1.1	
2= some secondary school					
3= completed secondary school					
4= some post secondary school					
5= completed post secondary school					
Monthly Income (dollars)	Non-ethanol	13	1035.7	549.2	0.80
	Ethanol	26	1075.7	812.8	

TABLE 3 Comparison of IQ between Ethanol-exposed and Non-exposed by Test Battery used

Test	Group	N	Mean	SD	P
BSID-III Cognitive	Non-ethanol	11	100.5	15.4	0.62
Composite Score	Ethanol	17	100.0	10.1	
BSID-III Language	Non-ethanol	11	101.0	15.3	0.52
Composite Score	Ethanol	16	104.2	11.8	
BSID-III Motor	Non-ethanol	11	100.4	14.1	0.42
Composite Score	Ethanol	15	104.4	10.5	
WPPSI-III Verbal	Non-ethanol	4	105.2	8.3	0.63
Composite Score	Ethanol	11	100.3	19.4	
WPPSI-III Performance	Non-ethanol	4	93.0	14.1	0.82
Composite Score	Ethanol	11	91.4	17.4	
WPPSI-III Full	Non-ethanol	4	98.0	14.2	0.8
Composite Score	Ethanol	11	94.5	20.7	

DISCUSSION

Our small pilot study suggests that children attending BTC after intrauterine exposure to ethanol by alcohol-dependent mothers did not achieve cognitively lower than those exposed to other drugs of abuse, most often cocaine. The secondary hypothesis was supported, as the mean scores for both groups of children were within the average range (one standard deviation from the average score) for both the BSID-III and the WPPSI-III.

The reliability of maternal reports of their drug and/or alcohol abuse at BTC is very high, as corroborated in some cases by hair and meconium testing for alcohol and drug abuse.[17] Moreover, maternal motivation for change is a key component of retention in the BTC program whereby women may be able to give very detailed accounts of drug and alcohol abuse. For ethical reasons, BTC cannot randomize mother-child pairs not to receive the standard treatment, and, hence our study does not have an internal control group of untreated mother-child pairs.

These results can be interpreted as suggesting that the intensive and comprehensive early intervention services by BTC may attenuate the cognitive achievement in the children, consistent

with the experimental animal studies.[5] The results of the present investigation are consistent with those reported in Testa et al., who found no significant differences between the MDI of ethanol-exposed and control group children. The results are also consistent with 2 of 3 previous studies which used the BSID to examine the impact of early intervention programs for substances exposed mothers and children.[15] Interestingly, the intervention study that demonstrated a difference between treatment and non-treatment groups may have been affected by the same measurement bias that was reported in the non-intervention studies, where the BSID was assessing constructs at 12-months which are more likely to be impacted by ethanol-exposure and were reduced once psychosocial factors were statistically controlled.[15]

Previous investigations of ethanol-exposed children have demonstrated an effect on the cognitive development of children; however, many of these studies have been conducted when children were older[2-4]and had longer periods of time to be impacted by co-occurring psychosocial risk factors. The question then becomes, at what point in time do we begin to see the impact of prenatal alcohol exposure and can continued support from intensive and comprehensive early intervention programs attenuate this effect. The fact that the children whose families have received services through BTC are between 0- and 6-years of age and are still following within a normal developmental trajectory based on measurement through standardized tools is encouraging.

A previous study from BTC has shown that families successfully enrolled and retained in the Program achieved favorable outcomes in being able to demonstrate positive parenting, despite BTC mothers having statistically more severe psychosocial problems prior to enrollment.[16] Specifically, the findings confirmed:

1. significant increases on measures of postnatal attachment and quality of attachment;
2. significant improvement on mothers' sense of parenting competence; and,
3. significant decrease in parenting stress over time.[16]

These previous results support the present findings, and suggest that a more favorable psychosocial environment for ethanol-exposed babies facilitates stimulatory effect and, hence, possibly attenuating adverse CNS effects caused by ethanol.[16]

It may also be hypothesized that the findings could reflect other factors that are addressed through the comprehensive early intervention model at BTC, including:

- Early assessment and developmental monitoring of children with confirmed prenatal alcohol exposure.
- Access to intensive and individualized early intervention based on developmental assessment.
- Improvements in maternal health and well-being.
- Improvements in parenting functioning.
- Improvements in levels of social support and access to services.[16]

Our study is limited by its relatively small sample size, by the fact that only IQ was utilized, and by the fact that the children were under the age of three years. Future research should address the question whether BTC early intervention has a positive long-term impact on the different pervasive alcohol-associated behavioral deficits.

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