Effects of Prenatal Drug Exposure on Preschool Development

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Students at the University of Waterloo created this product while being trained in the systematic review methods of Knowledge Impact Strategies. Authors are listed in alphabetical order.
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Take Home Messages

- The majority of the research to date is on methamphetamine and cocaine
- Both methamphetamine and cocaine have subtle effects on development
- Drug effects are typically small when the effects of mediating and moderating variables (e.g. parenting, poverty, health) are statistically accounted for

Overview

This project was completed during the Winter 2014 term by students in an upper-level Psychology course, Community-Based Research, at the University of Waterloo. The students were: Allison Dietrich (Psychology & Social Development Studies), Mariam Rajabali (Psychology), and Megan Smith (Psychology). They were assisted by the course instructor Dr. Kathleen Bloom and teaching assistant Melissa Subnath. The community partner organization for this project was Infant and Child Development Services Peel (ICDSP). Its partnership with the University was coordinated by Angela Lawton, Psychometrist at ICDSP.

ICDSP specializes in the provision of early support services and resources to children who are either at risk of, or are presently displaying, developmental delays or impairments. ICDSP is dedicated to providing family-centered, research-based, and cost effective services. The development of appropriate service pathways is a priority for ICDSP so that individualized support services can be provided in a cost-effective manner.

Children who are prenatally exposed to drugs may be at a heightened risk of developmental delays and impairments. If this is the case, early identification and the implementation of long-term support services may be necessary to help children overcome these difficulties and reach their full potential. ICDSP requires knowledge of the developmental outcomes of children who are prenatally exposed to drugs in order to decide if they should be targeting, following, and providing support services to these children and their families.
What Was Studied?

The precise research question was as follows: “Do preschool children who were prenatally exposed to methamphetamine, oxycodone, heroin, cocaine, or MDMA have developmental impairments?”

How Was It Studied?

A literature search was performed using the Scopus database which compiles peer-reviewed articles from over 19,500 academic journals. The search strategy used was:

(TITLE-ABS-KEY(prenatal AND exposure AND (preschool* OR child*) AND (methamphetamine OR oxycodone OR heroin OR cocaine OR MDMA)) AND NOT TITLE-ABS-KEY(animal* OR nonhuman OR adolescent*)) AND PUBYEAR > 2008 AND (LIMIT-TO(LANGUAGE, "English" ) )

The search was conducted on May 21, 2014. There were 136 hits, one of which was a duplicate, therefore a total of 135 articles were identified.

To ensure the relevance of articles to the research question, articles that met the following criteria were excluded from the review:

- Animal study population
- Adolescent or adult only study population
- Effects of methamphetamine, oxycodone, heroin, cocaine, or MDMA were not studied

Based on the above criteria, 39 articles were deemed to be outliers, leaving 96 articles for further consideration. Further inspection was conducted to identify articles most relevant to the research question. Articles were excluded if they met the following criteria:

- Only assessed the medical/biological effects of prenatal drug exposure
- Did not assess children between the ages of 2.5 and 6 years old

Based on these criteria, a further 66 articles were excluded, leaving a total of 30 articles for inclusion in the final review.

All article inclusion/exclusion and data extraction decisions were reviewed to ensure that there were no discrepancies in the students’ understanding and application of the coding categories. Any discrepancies were resolved through group discussion and consensus, assisted by Dr. Bloom and Melissa Subnath.
Clarifications

1. Some articles studied populations which included children below the age of 2.5 or above the age of 6. These articles were included as long as the children were assessed at some point between 2.5 and 6 years old.

2. Articles were included as long as the mother was taking one or more of the following drugs: methamphetamine, oxycodone, heroin, cocaine and/or MDMA. Information about other substance use such as that of alcohol, marijuana, and cigarettes was not included in the spreadsheet even though comorbid substance use was very common.

3. Some articles may have investigated both developmental and medical outcomes of prenatal drug exposure, but only developmental outcomes were noted in the spreadsheet.

Highlights of Results

- There were no studies on oxycodone or MDMA
- No studies directly compared the effect of prenatal drug exposure to prenatal alcohol exposure
- One research review mentioned the effect of prenatal heroin exposure on neurodevelopment; no studies empirically investigated the effects of prenatal exposure to heroin
- Prenatal exposure to methamphetamine was frequently associated with inattention and impulsivity
- Prenatal exposure to cocaine negatively affected children’s language development and executive functioning
Types of Drugs

- Cocaine: 20
- Methamphetamine: 10
- Heroin: 1

* Some studies studied more than one drug

Research Strategies

- Comparison: 22
- Longitudinal: 11
- Review: 6
- Case Study: 1

* All longitudinal studies were also comparison studies
Survey of Research Articles

Each of the 24 articles outlined in the spreadsheet answered two questions:

- What was studied?
- What was found?

In the spreadsheet, the following features of each article were coded:

- Country: the country in which the data were collected
- Age (years): the age or ages at which the participants were assessed
- Drug: the drug or drugs (methamphetamine, cocaine, heroin) that the mothers were taking during pregnancy
- Method:
  - Longitudinal: a study that tests participants at two or more points in time
  - Review: a report of aggregated findings of one or more previous studies
  - Descriptive: a study that describes features of drug exposed children
  - Comparison: a study that compared drug exposed children to non-drug exposed children
  - Other: case studies of single subjects and editorial articles
- Outcomes: aspects of development that were investigated in the studies
  - Cognitive: intellectual ability and executive functioning (including attention, memory, sensory processing, problem solving and decision making)
- Behavioural: internalizing and externalizing behaviour towards self and others, positive and negative behaviours
- Motor skills: fine and gross motor muscle movements
- Language: articulation, comprehension and overall development
- Social: interactions with family and peers, ability to form attachments
- Disorders: DSM classified disorders such as attention-deficit hyperactivity disorder (ADHD), oppositional defiant disorder (ODD), conduct disorder, and separation anxiety disorder

**Legend**

- ADHD: Attention deficit hyperactivity disorder
- MA: Methamphetamine
- NDE: Non-drug exposed
- PCE: Prenatal cocaine exposure
- PHE: Prenatal heroin exposure
- PMAE: Prenatal methamphetamine exposure
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<th>Age (years)</th>
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<tr>
<td>Abar, B., LaGasse, L. L., DeRauf, C., Newman, E., Shah, R., Smith, L M., . . . Lester, B. M. (2013). Examining the relationships between prenatal methamphetamine exposure, early adversity, and child neurobehavioral disinhibition. <em>Psychology of Addictive Behaviors</em>, 27 (3), 662-673.</td>
<td>• Extent to which PMAE was predictive of childhood neurobehavioral disinhibition problems, as well as the extent to which early adversity mediated this relationship</td>
<td>• PMAE was associated with behavioural and emotional control problems at 5 years • Behavioural and emotional control deficits were associated with deficits in executive functioning at 6.5 years • Children with PMAE were exposed to significantly more overall adversity than NDE children; early adversity significantly mediated the relationship between PMAE and neurobehavioral disinhibition</td>
<td>USA</td>
<td>0 - 6.5</td>
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<td>Ackerman. (2011). A review of the effects of prenatal cocaine exposure among school-age children (Pediatrics 2010) 125, 3 (554-565) DOI: 10.1542/peds.2009-0637). <em>Pediatrics</em>, 128 (3), 593.</td>
<td>• Effect of PCE on growth, cognitive ability, academic achievement, academic functioning, and brain structure and function</td>
<td>• Associations between PCE and growth, intellectual functioning, academic achievement, and language functioning were modest and often explained by social risk factors such as poverty • PCE negatively affected children’s performance on tasks that assessed sustained attention and behavioural self-regulation</td>
<td>NR</td>
<td>&lt; 0.5 - 14</td>
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<td>Acra, C. F., Bono, K. E., Mundy, P. C., &amp; Scott, K. G. (2009). Social competence in children at risk due to prenatal cocaine exposure: Continuity over time and associations with cognitive and language abilities. <em>Social Development</em>, 18 (4), 1002-1014.</td>
<td>• Continuity of social competence between 3 years and first grade in children with PCE and relationship to cognitive and language abilities</td>
<td>• Parent ratings of social competence show continuity over time • Problematic behaviour at age 3 did not predict problematic behaviour in first grade • Early social competence was a significant predictor of first-grade language ability • Impact of early behaviour on later cognitive or language competencies may be stronger for at-risk populations</td>
<td>USA</td>
<td>3 - Grade 1</td>
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<tr>
<td>Bandstra, E. S., Morrow, C. E., Mansoor, E., &amp; Accornero, V. H. (2010). Prenatal drug exposure: Infant and toddler outcomes. <em>Journal of Addictive Diseases</em>, 29 (2), 245-258.</td>
<td>• Effect of PHE on acute and long-term outcomes of infants and toddlers  • Effect of PCE on anthropometric growth, infant neurobehavior, visual and auditory function, and cognitive, motor, and language development</td>
<td>• Prenatal exposure to opioids (including heroin) may increase the child's risk of neurodevelopmental impairment  • PCE was associated with subtle decrements in neurobehavioral, cognitive, and language function  • Caregiving environment may mediate or moderate effects of exposure on development</td>
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<td>0-7</td>
<td>●</td>
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<td>Bono, K. E., &amp; Sheinberg, N. (2009). Effectiveness of early intervention for children prenatally exposed to cocaine: Moderating effects of low birth weight on behavioral outcomes. <em>Early Child Development and Care</em>, 179 (4), 487-501.</td>
<td>• Moderating effect of low birth weight on effectiveness of an early intervention program to improve cognitive, expressive language, and behavioural outcomes for children with PCE, as compared to children with PCE who were assigned to the primary care only comparison group</td>
<td>• Low birth weight was associated with poor cognitive and language outcomes for all children regardless of intervention group  • All children, regardless of birth weight status, had the potential to benefit from the intervention in terms of cognition and language  • Effects of the intervention were more pronounced in reducing negative behaviours and increasing prosocial behaviours for children who had both PCE and low birth weight  • Children who have multiple risk factors, like low birth weight as well as PCE, should be specifically targeted for participation in early interventions</td>
<td>USA</td>
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<td>Carmody, D. P., Bennett, D. S., &amp; Lewis, M. (2011). The effects of prenatal cocaine exposure and gender on inhibitory control and attention. <em>Neurotoxicology and Teratology, 33</em> (1), 61-68.</td>
<td>• Effect of PCE and gender on attention and inhibitory control</td>
<td>• PCE negatively affected the performance of males, but not females  • Heavily exposed males showed deficits in attention and inhibition tasks, significantly more so than lightly or non-exposed males  • A significantly higher proportion of heavily exposed males than non-exposed males or heavily exposed females failed to complete the tasks</td>
<td>USA</td>
<td>6 - 11</td>
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<td>Chaplin, T. M., Fahy, T., Sinha, R., &amp; Mayes, L. C. (2009). Emotional arousal in cocaine exposed toddlers: Prediction of behavior problems. <em>Neurotoxicology and Teratology, 31</em> (5), 275-282.</td>
<td>• Effect of PCE on children’s developing emotional arousal and regulation systems</td>
<td>• Toddlers with PCE showed more agitated emotional arousal  • Higher levels of agitated arousal predicted greater decreases in externalizing behaviour problems from toddlerhood to preschool  • Boys with PCE more frequently approached their caregivers when frustrated, which may reflect an adaptive ability to use caregivers to help them regulate emotion  • Emotional arousal and regulation did not predict trajectory of internalizing behaviour problems through age 5.5</td>
<td>USA</td>
<td>2.5 - 5.5</td>
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<td>Coggins, T. E., &amp; Thorne, J. C. (2010). <em>Substance Abuse and Childhood Language Disorders</em></td>
<td>• Effect of prenatal alcohol exposure and PCE on children’s language and social skills</td>
<td>• Children with prenatal alcohol exposure and PCE may be particularly susceptible to language and social communication deficits  • Dysfunctional postnatal social interactions may further complicate and constrain these children's development</td>
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<td>Derauf, C., Lagasse, L., Smith, L., Newman, E., Shah, R., Arria, A., . . . Lester, B. (2011). Infant temperament and high-risk environment relate to behavior problems and language in toddlers. <em>Journal of Developmental and Behavioral Pediatrics</em>, 32 (2), 125-135.</td>
<td>• Role of easy infant temperament and cumulative environmental risk in predicting cognitive, language, and behavioural outcomes in 3 year old children at high social risk</td>
<td>• Among children with PMAE, higher levels of environmental adversity were associated with increased externalizing and internalizing behavioural problems and compromised language development • Easy infant temperament was associated with reduced externalizing and internalizing behavioural problems in settings of low environmental risk • There were no observable effects of PMAE on 3 year old outcomes</td>
<td>USA</td>
<td>0 - 3</td>
<td>MA</td>
<td>MA</td>
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<td>Derauf, C., Lagasse, L. L., Smith, L. M., Newman, E., Shah, R., Neal, C. R., . . . Lester, B. M. (2012). Prenatal methamphetamine exposure and inhibitory control among young school-age children. <em>Journal of Pediatrics, J61</em> (3), 452-459.</td>
<td>• Association between PMAE and inhibitory control</td>
<td>• PMAE was associated in a dose-response manner with deficits in inhibitory control in early school-age period • Heavy PMAE was related to less accuracy and longer reaction times in a Stroop-like task</td>
<td>USA</td>
<td>5.5</td>
<td>MA</td>
<td>MA</td>
<td>● ● ●</td>
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<td>Eiden, R. D., Godleski, S., Colder, C. R., &amp; Schuetze, P. (2014). Prenatal cocaine exposure: The role of cumulative environmental risk and maternal harshness in the development of child internalizing behavior problems in kindergarten. <em>Neurotoxicology and Teratology, 44</em>, 1-10.</td>
<td>• Association between PCE and child internalizing behaviour problems at kindergarten and mediating/moderating effects of maternal harshness and cumulative environmental risk</td>
<td>• No direct effect of PCE on internalizing behaviour problems at kindergarten age • Maternal harshness was found to have a moderating effect on internalizing behaviour problems • Cumulative environmental risk did not moderate the relationship between PCE and internalizing behaviour problems • High environmental cumulative risk was independently associated with high internalizing behaviour problems</td>
<td>USA</td>
<td>7 months - kindergarten</td>
<td>MA</td>
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ADHD: Attention deficit hyperactivity disorder  | MA: Methamphetamine  | NDE: Non drug exposed  | PCE: Prenatal cocaine exposure  
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<td>Eyler, F. D., Warner, T. D., Behnke, M., Hou, W., Wobie, K., &amp; Garvan, C. W. (2009). Executive functioning at ages 5 and 7 years in children with prenatal cocaine exposure. Developmental Neuroscience, 32 (1-2), 121-136.</td>
<td><em>Effect of PCE on executive functioning</em></td>
<td><em>PCE was indirectly related to executive functioning due to its negative effect on head circumference at birth</em>&lt;br&gt;<em>At 5 years, quality of environment predicted executive functioning</em>&lt;br&gt;<em>At 7 years, caregiver functioning predicted quality of environment which in turn was positively related to executive functioning</em>&lt;br&gt;<em>By age 7, the child’s sex independently predicted executive functioning with females generally performing better</em></td>
<td>USA</td>
<td>5 - 7</td>
<td>MA</td>
<td>Longitudinal</td>
<td>Cognitive, Behavioural, Motor Skills, Language, Social Disorders</td>
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<td>Finger, B., Schuetze, P., &amp; Eiden, R. D. (2014). Behavior problems among cocaine exposed children: Role of physiological regulation and parenting. Neurotoxicology and Teratology, 42, 51-59.</td>
<td><em>Extent to which respiratory sinus arrhythmia (RSA), a natural variation in heart rate which occurs during breathing, at 13 months influences the relationship between PCE and behaviour problems</em></td>
<td><em>PCE predicted low baseline RSA, which in turn predicted fewer behaviour problems</em>&lt;br&gt;<em>PCE may in some cases limit children’s susceptibility to parental negativity</em></td>
<td>USA</td>
<td>3</td>
<td>MA</td>
<td>Longitudinal</td>
<td>Cognitive, Behavioural, Motor Skills, Language, Social Disorders</td>
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<td>Finnegan, L. P. (2010). Introduction to women, children and addiction. Journal of Addictive Diseases, 29(2), 113-116.</td>
<td><em>Impact of in utero drug exposure on mothers' infants and children</em></td>
<td><em>PCE is associated with subtle decrements in neurobehavioral, cognitive, and language function</em>&lt;br&gt;<em>Effects of PCE on behaviour problems and attention, language, and cognitive deficits have been found in older children</em></td>
<td>NR</td>
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• Diagnosed with ADHD with features of oppositional defiant disorder  
• Possible difficulty in forming solid interpersonal relationships  
• Difficulties with motor functioning  
• Nondietary iron deficiency anemia that could contribute to or compound MA-related behavioural problems |
• At 5.5 years children exhibited indicators of risk for ADHD and warranted monitoring |
• PMAE was associated with externalizing and ADHD problems at 5 years of age  
• No effect of PMAE on internalizing behaviour  
• Severity of problems were dependent on the level of exposure |
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<tr>
<td>Lambert, B. L., &amp; Bauer, C. R. (2012). Developmental and behavioral consequences of prenatal cocaine exposure: A review. <em>Journal of Perinatology</em>, 32 (11), 819-828.</td>
<td>Effects of PCE on children's developmental and behavioral outcomes (including intelligence, academic achievement, language, executive functioning, behavioural regulation, and psychopathology)</td>
<td>PCE has not been shown to be directly associated with intelligence or academic performance. Recent studies of children between toddlerhood and elementary school age have reported main effects of PCE on language skills. Independent effects of PCE on executive functioning are subtle, evidence suggests that the caregiving environment may account for the majority for the variance in effects. Associations between PCE and difficulties in behaviour regulation have been observed. PCE has been associated with symptoms of later psychopathology including ADHD, oppositional defiant disorder, depression, and anxiety.</td>
<td>NR</td>
<td>0 - 17</td>
<td>MA</td>
<td>Longitudinal</td>
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<td>Liu, J., Bann, C., Lester, B., Tronick, E., Das, A., Lagasse, L., . . . , Bada, H. (2010). Neonatal neurobehavior predicts medical and behavioral outcome. <em>Pediatrics</em>, 125 (1), e90-e98.</td>
<td>Validity of the NICU Network Neurobehavioural Scale (NNNS) for predicting negative medical and behavioural outcomes of infants with and without prenatal cocaine exposure at 1 month to 4.5 years of age</td>
<td>Children categorized into the most extreme negative profile of the NNNS were more likely to have heavy PCE. Over 40% of the above children had clinically significant behaviour and school readiness problems at 3 and 4 years respectively.</td>
<td>USA</td>
<td>1 month to 4.5 years</td>
<td>PMAE</td>
<td>Longitudinal</td>
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<td>Malek, A. (2012). Prenatal cocaine exposure and the associated adverse on the human pregnancy. <em>Cocaine Abuse: Pharmacology, Treatment and Relapse Prevention</em>, 81-98.</td>
<td>• Effect of PCE on children’s development</td>
<td>• PCE has subtle effects on a number of developmental domains including cognitive, behavioural, motor, and language • Size of effect of PCE on developmental outcomes was typically reduced when conditions that commonly occur with PCE such as alcohol exposure were statistically accounted for</td>
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<td>Mansoor, E., Morrow, C. E., Accornero, V. H., Xue, L., Johnson, A. L., Anthony, J. C., &amp; Bandstra, E. S. (2012). Longitudinal effects of prenatal cocaine use on mother-child interactions at ages 3 and 5 years. <em>Journal of Developmental and Behavioral Pediatrics</em>, 33 (1), 32-41.</td>
<td>• Effect of PCE and recent cocaine use on mother-child interactions</td>
<td>• PCE was associated with poorer overall mother-child interactions • PCE was associated with more maternal intrusiveness and boundary dissolution in 5 year olds • Impact of maternal cocaine use on mother-child interaction may be greatest when the mother uses cocaine during pregnancy and continues drug use into early childhood years</td>
<td>USA</td>
<td>3 - 5</td>
<td>●</td>
<td>●</td>
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<td>Minnes, S., Singer, L. T., Kirchner, H. L., Short, E., Lewis, B., Satayatham, S., &amp; Queh, D. (2010). The effects of prenatal cocaine exposure on problem behavior in children 4- 10years. <em>Neurotoxicology and Teratology</em>, 32 (4), 443-451.</td>
<td>• Comparison of behavioural outcomes of NDE children and children with PCE</td>
<td>• PCE was associated with increased rates of caregiver reported delinquency in females • Children with PCE in foster or adoptive care were rated as having more behaviour problems than those in their relatives’ care</td>
<td>USA</td>
<td>4 - 10</td>
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• PCE was related to higher levels of maternal negative affect, which in turn predicted greater increases in externalizing behaviour problems of the child  
• Children with PCE in high-risk caregiving environments did not experience the decline in externalizing behaviour problems that children normally show beginning at age 3 | USA | 1.5 - 4.5 | • | • | • |
• No increased risk of developing oppositional defiant disorder or separation anxiety disorder | USA | 5 | • | • | • |
| Oei, J. L., Kingsbury, A., Dhawan, A., Burns, L., Feller, J. M., Clewes, S., ... Abdel-Latif, M. E. (2012). Amphetamines, the pregnant woman and her children: A review. *Journal of Perinatology*, 32(10), 737-747. | • Impact of prenatal amphetamine exposure (including PMAE) on the newborn infant and child | • Long term effects of prenatal amphetamine exposure are probably not simple linear relationships between drug exposure and outcome  
• Infants with PMAE are more likely to be affected by complex psychological and environmental problems which may affect developmental outcomes | NR | NR | • | • | • | • |
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<td>Smith, L. M., LaGasse, L. L., Derauf, C., Newman, E., Shah, R., Haning, W., . . . Lester, B. M. (2011). Motor and cognitive outcomes through three years of age in children exposed to prenatal methamphetamine. Neurotoxicology and Teratology, 33(1), 176-184.</td>
<td>• Effects of PMAE on child motor and cognitive outcomes</td>
<td>• PMAE did not affect cognitive outcomes • Children with PMAE (especially those who were heavily exposed) were found to have slightly poorer fine motor skills than NDE children at one year of age • No differences in fine motor skills were observed at three years</td>
<td>USA</td>
<td>1 - 3</td>
<td>Longitudinal Comparison Case Study Cognitive Behavioural Motor Skills Language Social Disorders</td>
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<td>Twomey, J., Lagasse, L., Derauf, C., Newman, E., Shah, R., Smith, L., . . . Lester, B. (2013). Prenatal Methamphetamine Exposure, Home Environment, and Primary Caregiver Risk Factors Predict Child Behavioral Problems at 5 Years. American Journal of Orthopsychiatry, 83(1), 64-72.</td>
<td>• Effect of PMAE on child behavioural problems</td>
<td>• Children with PMAE were twice as likely to exceed the clinical cut-off for externalizing behavioural problems than NDE children • There was no difference between children with PMAE and NDE children regarding internalizing behaviour problems</td>
<td>USA</td>
<td>2.5 - 5</td>
<td>Longitudinal Comparison Case Study Cognitive Behavioural Motor Skills Language Social Disorders</td>
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For more information contact kbloom@kimpact.ca

ADHD: Attention deficit hyperactivity disorder | MA: Methamphetamine | NDE: Non drug exposed | PCE: Prenatal cocaine exposure
PMAE: Prenatal methamphetamine exposure | PHE: Prenatal heroin exposure
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Disclaimer

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Citation


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