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Perinatal Risk Factors for Mild Motor Disability

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The aetiology of mild motor disability (MMD) is a complex issue and as yet is poorly understood. The aim of this study was to identify the prevalence of perinatal risk factors in a cohort of 10-year-old boys and girls with (n = 362) and without (n = 1193) MMD. Among the males with MMD there was a higher prevalence of postpartum haemorrhage, caesarean section, low birth weight and stressful first year of life. Among the females with MMD, there was a higher prevalence of essential hypertension, anaemia, and threatened pre-term. Multivariable logistic regression revealed gender (male), anaemia, threatened pre-term birth (if female), and hypertension (if female) weakly explained MMD at 10 years. These results underscore the importance of considering gender differences in order to better understand the multiple influences on motor development.

Keywords: Developmental Coordination Disorder; Gender differences; Motor disability; Maternal; Perinatal; Risk factors

Introduction

Mild motor disability (MMD) is a condition in which impairment in motor coordination cannot be explained by any known physical disorder or other diagnosed condition. The prevalence of this condition ranges from 6% to 22% depending on the terminology and assessment criteria used (for review see Cermak, Gubbay, & Larkin, 2002). The consequences of poor motor development have been well documented (Cantell, Crawford, & Doyle-Baker, 2008; Summers, Larkin, & Dewey, 2008); however, less is understood about the early risk factors for this condition and whether

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they differ between boys and girls. Brain damage, heredity or genetic disposition, neurological impairment or a suboptimal environment have been implicated (Gubbay, 1975; Larkin & Hoare, 1991), although it is likely that more than one factor may contribute. Of interest to this article is the contribution of an infant's in-utero and early life experiences to their later motor development. A detailed examination of early childhood risk factors of MMD remains a distinctive gap in the literature, although the notion that some maternal and perinatal factors have the potential to contribute to suboptimal motor outcomes is not new.

A higher incidence of birth-related factors such as prolonged labour, abnormal delivery, caesarean section, or use of forceps (Gubbay, 1975; Hoare, 1991) or child-related factors such as toxaemia, jaundice, intrauterine growth restriction (IUGR), preterm or overdue birth dates, or need for ventilation (Davis, Ford, Anderson, & Doyle, 2007; Hoare, 1991; Johnston, Short, & Crawford, 1987; Jongmans, Henderson, de Vries, & Dubowitz, 1993; Michelsson & Lindahl, 1993) have been noted among MMD children. As early as 1947, Gesell and Amatruda reported a higher incidence of birth injuries among children with motor difficulties. More recently, Hadders-Algra (2002) found that combinations of pre- and perinatal stressors, such as preterm birth or intrauterine growth restriction, resulted in differing levels of minor neurological dysfunction.

Less is understood about maternal factors affecting the quality of the intrauterine environment on an infant's motor development. Evidence of fetal programming and its role on health outcomes in humans is growing (Phillips & Jones, 2006). Animal studies have confirmed that the health of the prenatal environment has long term consequences on the health of the baby. Among rats, under-nutrition in the mother leads to obesity, hypertension, and hyperphagia in the offspring, and also

affects their sedentary behaviour and physical activity levels (Vickers, Breier, Cutfield, Hofman, & Gluckman, 2000; Vickers, Breier, McCarthy, & Gluckman, 2003). Barker and colleagues proposed a link between early life factors and adult health, particularly cardiovascular disease and diabetes (Barker, 1998). However, the effect of specific maternal stressors in the neonatal and infancy periods on later motor development is, as yet, poorly understood. It is probable that a mother's hypertension, smoking, excessive drug or alcohol use, or high levels of anxiety and stress (Magann et al., 2007) could affect the integrity of the infant's developing brain and nervous system. As a consequence, neonatal vulnerability to further external stressors such as trauma, illness, feeding difficulties or poor parenting practices or other suboptimal living conditions is therefore increased. Poor motor outcomes are a distinct possibility. Few researchers have noted gender differences in the prevalence of these factors, although Davis and colleagues (2007) found that male sex increased the likelihood of motor difficulties among very low birth weight infants. Male sex alone is considered by some to be a significant risk factor for the development of motor difficulties (Hadders-Algra, 2002).

Motor competence is an emergent characteristic that is refined over time in response to many interacting constraints or enablers. Where motor development measures have been tracked over time, only moderate correlations have been observed (Johnston et al., 1987; Michelsson & Lindahl, 1993; Silva & Ross, 1980). Silva and Ross (1980) found that correlations between different motor skill measures lessened with time, from a high of .74 between 3 and 4 years of age to .37 between 3 and 6 years of age. In that sample of 879 New Zealand children, only 10 of the 31 children diagnosed with motor delays at 3 years of age were still in the same category at 5 years of age. Similarly, Michelsson and Lindahl (1993) found that less than 40% of

children with poor motor scores at 5 years still had poor scores at 9 years of age. Parker and colleagues (2007) noted gender differences when tracking motor performance across time with the Raine cohort. They found that there was an increase in the number of girls with motor difficulties when tracked over 3 years, while the incidence among boys decreased. It is feasible that some perinatal risk factors may have a greater impact on motor competence during one phase of childhood than another.

To date, few studies have had access to a comprehensive list of maternal and perinatal variables, and motor competence measures at a later age for a large sample of children. The longitudinal Western Australian Pregnancy Cohort (Raine) Study provides a unique opportunity to examine perinatal risk factors for MMD and to identify whether they differ by sex. This article compares the prevalence of certain maternal and perinatal variables in a cohort of ten-year-old boys and girls with and without MMD and looks at the overall effect of these variables on motor competence.

Method

Participants

The participants are from the Western Australian Pregnancy Cohort (Raine) Study. This longitudinal study, which started in 1989 recruited 2,900 women at or before the 18th week of gestation from the antenatal booking clinic at a tertiary level obstetric hospital in Perth, Western Australia (Newnham, Evans, Michael, Stanley, & Landau, 1993). The cohort is considered to be representative of the Western Australian population (Li et al., 2008). The study was approved by the ethics committees of Princess Margaret Hospital for Children and King Edward Memorial Hospital for Women and informed consent was obtained from all participants. At 10 years of age,

2047 children participated in the follow up data collection. Of these, 1617 (79%) participated in the physical assessments including motor competence (males = 839, females = 778). They were then allocated to one of two groups according to their Neuromuscular Development Index (NDI) (M = 100, SD = 15). This Index is derived from scores on the McCarron Assessment of Neuromuscular Development (MAND) (McCarron, 1997). Those with an NDI of > 85 were considered to have average or above average motor competence and those with an NDI of ≤ 85 were considered to have mild (71-85), moderate (70-55) or severe (below 55) motor disability. This test has been validated as an identification tool for motor impairment (Tan, Parker, & Larkin, 2001; for a review see Barnett, 2008). Those with an NDI of ≤ 85 and a diagnosed disability (n = 62) were removed from further analyses, resulting in a final sample size of 1555.

Measures

Mother. Comprehensive data on social and demographic factors, medical and obstetric history and exposure to potential toxins (alcohol, illicit drugs, medications and smoking) were obtained from each parent at enrolment and, in the mother's case, updated during the 34th week of pregnancy. The women delivered at the obstetric hospital.

Child. The babies were examined at 2 days of age by a paediatrician or midwife. Questions were asked about sociodemographic and psychosocial characteristics of the child and the family including the child's sex and race; child's birth weight and gestational age; child's plurality; child's health (ICD-9), child's weight and height; total gross family income; maternal age; parental education; parental occupation; family structure; number of siblings; parental smoking; parental

use of alcohol and drugs; parental physical health; parental mental health; frequency of residential move; and residential postcode. Examination included anthropometric assessment, routine physical examination, check for dysmorphology, and developmental assessment. Of interest to this article are data collected at birth, at 1 year of age and the motor competence measure collected at 10 years of age.

Independent variables. Based on the literature regarding possible early risk factors, variables covering four broad domains were included in the study; pregnancy, birth, child, and sociodemographic factors. Most measures were based on medical records or maternal reports and they are self-explanatory. Those variables that do require explanation are listed below.

Stressful pregnancy. Mothers were asked if any of ten events, such as "pregnancy problems", "separation or divorce", or "money problems", have happened to them in the past year. The number of events were added to derive a total life stress score (Tennant & Andrews, 1976). A family reported to have three or more "major life events" occur in the last year was considered to have significant stress.

Regular alcohol use. Mothers who reported that they drank alcohol "daily", several times a week" or "engaged in binge drinking" since becoming pregnant, were regarded as having regular alcohol use.

Regular or occasional drug use. Mothers who reported that they used recreational drugs "regularly" or "occasionally" since becoming pregnant, were regarded as having regular or occasional drug use.

Smoking. Mother's smoking status at the 34th week of pregnancy was classified as never smoked, smoked before this pregnancy only, smoked in the first trimester of this pregnancy only, smoked during and after the first trimester of this pregnancy, and

a variable summarised each mother's report of smoking at any stage of the pregnancy (no, yes).

Long time to respond. Children who took longer than two minutes to breath spontaneously following birth were deemed to take a long time to respond.

IUGR. An algorithm developed by Blair (1996), incorporating measures of sex, birth weight, gestational age, parity and mother's height, was used to derive a measure of intrauterine growth restriction. Children less then 85 per cent expected birth weight were regarded as "intrauterine growth restricted".

Preterm. A gestational age of less than 37 weeks.

All potential risk factors were dichotomised. A major advantage of working with dichotomised variables is that comprehensive risk factor information can be analysed in a comparable manner.

Motor Competence. Motor competence was first assessed at 10 years of age with the MAND which is a reliable and valid test of neuromuscular development (McCarron, 1997). The MAND provides information on fine, gross and global motor competence for ages 3½ to adult and includes five fine motor and five gross motor test items. Results are standardised to create the NDI which has a mean of 100 and a SD of 15.

Statistical Analyses

All analyses were conducted using SPSS, Version 15 (SPSS Inc, Chicago ILL) [AU: Reference needed here]. The dependent variable was motor competence which was dichotomised using a cut point of an NDI of 85 in order to create two groups within the sample, those with and those without MMD. All explanatory, or risk factor variables were dichotomous. The difference in prevalence of each factor between

motor competence groups was examined using Chi-square tests for males and females independently. A binary logistic regression model was developed using all significant variables to identify predictors of MMD. Sex was included as a main effect and as an interaction effect. Probability values of $p \leq .05$ were used to determine significance.

Results

Table 1 describes key demographics for the study cohort by sex. The prevalence of each risk factor in the group with and without MMD is shown for males and females separately (Table 2). There were few variables that were significantly more prevalent among children with MMD compared to those without although some interesting sex differences emerged. Among the females, pregnancy risk factors were more likely to be significantly different between the two groups. Proportionately more mothers of female children with MMD experienced hypertension and anaemia than mothers of typically developing female children. In addition, more mothers of female children with MMD experienced a threatened premature labour than mothers of female children without MMD. Among the males with MMD, birth difficulties and a stressful first year were more prevalent. As shown in Table 2, more males with MMD experienced an elective or emergency caesarean birth than those without MMD. A significantly higher proportion of males with MMD had a birth weight of < 2000 g than those without MMD; however, a reverse picture emerged among the female cohort. More males with MMD experienced three or more stressful events during the first year of their life than those males without movement difficulties.

[t] Insert Table 1 near here/[t]

[t] Insert Table 2 near here/[t]

All significant explanatory variables were analysed in a multivariable logistic regression model (Table 3). The sample for this calculation was reduced to 1410 (37 MMD, 108 non MMD) due to missing data for some participants. A test of the full model with all variables, as well as sex and sex as an interaction with each variable was statistically significant [χ^2 (15, N = 1410) = 72.1, p = **.000] [AU: please provide exact p value here]** indicating that the variables, as a set, distinguished between participants with and without MMD. Nevertheless, the proportion of variance explained was low (R^2 = .07). According to the Wald statistics, sex (male), anaemia, threatened pre-term birth (if female), and hypertension (if female) were significant risk factors for MMD at 10 years. The odds ratios showed that being male increased the likelihood of MMD by 67% compared to girls. If the mother had hypertension and preeclampsia or experienced a threatened preterm birth and was carrying a female baby the risk of MMD increased 11 times and 5.6 times respectively.

[t] Insert Table 3 near here/[t]

Discussion

The purpose of this study was to identify antenatal and perinatal risk factors for low motor competence, and in particular MMD in 10-year-old children. While the overall predictive significance of early adverse developmental factors was weak for MMD and motor competence in general, interesting gender differences emerged.

Gender Difference

MMD was partly explained by adverse maternal health in females and difficult birth or early life factors among the boys. Few studies have noted gender differences in the incidence of maternal and perinatal risk factors among children with motor difficulties

(Davis et al., 2007), although the incidence of boys diagnosed with MMD is often reported as higher than for girls. In this study cohort, a higher percentage of the males (25.9%) than the females (18.6%) were in the MMD category. Boys, in general, have a higher risk for many adverse neonatal outcomes such as urinary tract infections and pulmonary difficulties (Stevenson et al., 2000; Whitaker et al., 2006), although, with age these outcomes may reverse. For example, gender differences favouring boys have been observed in motor-related constructs such as physical activity, physical fitness and motor ability (Armstrong, McManus, Welsman, & Kirby, 1996; Baquet, Twisk, Kemper, Praagh, & Berthoin, 2006; Hands & Larkin, 2001; Michaud, Narring, Cauderay, & Cavadin, 1999), even within the MMD population (Hands & Larkin, 2006).

The observed gender differences could be explained by several emerging bodies of knowledge. Evidence is accumulating that sex hormones, in particular testosterone, causes the male brain to develop differently than the female brain during childhood and into adolescence (de Bellis et al., 2001; Speck et al., 2000). Prenatal and neonatal exposure to testosterone may play a causal role in sexual dimorphism or be a risk factor for conditions that are observed more frequently in one sex, such as autism (Knickmeyer & Baron-Cohen, 2006). Animal studies have found that adverse conditions will affect male and females differently according to sex specific developmental windows during both fetal and neonatal periods (Zambrano et al., 2005). Even gene expression in somatic tissues is dramatically different between male and female mice with near identical genome sequences (Yang et al., 2006). The intra- and extra-uterine environments are therefore acting on differently developed brains in boys and girls and some factors may have a greater impact on one sex depending on its timing in relation to the infant's phase of development. Researchers investigating

the developmental origins of health and disease consistently find and report marked differences in males and females outcomes across a wide variety of factors in animal and humans (see for example Feldt et al., 2007; Lie, Muhlhausler, Duffield, Morrison, & McMillen, 2007).

Pregnancy Factors

Essential hypertension and anaemia were significant risk factors for the females but not the males. Few studies have reported on the effect of maternal hypertension on infant outcomes for males and females independently. A greater risk of cerebral palsy has been observed, although Withagen, Wallenburg, Steegers, Hop, and Visser (2005) found a possible protective effect of hypertension in preterm infants. Preeclampsia alone was not a risk factor for motor development, this is consistent with other studies. For example, Kirsten and colleagues (2000) reported that gross motor outcome was not affected in infants aged 24 to 48 months of age if severe pre-eclampsia had developed before 34 weeks gestation.

There is limited evidence that maternal iron deficiency during pregnancy may negatively impact on a child's neurological system (Rioux, Lindmark, & Hernell, 2006) or risk of still birth (Watson-Jones et al., 2007). Lower psychomotor scores were observed in five-year-old children who had low serum ferritin (Tamura et al., 2002), although the link to maternal iron levels was unclear. In the present study, maternal anaemia was more prevalent among the females with MMD. No studies were identified that reported gender differences. A similar, and possibly related trend, was evident in this study for diabetic mothers who delivered female children with motor difficulties. A higher percentage of the female MMD cohort had mothers with

diabetes than the cohort without MMD. Diabetes is thought to cause an increased fetal iron requirement (Rioux et al., 2006).

Birth Factors

In this study, a caesarean birth was identified as a risk factor for both MMD and low motor competence in general for males. We found few studies reporting on long term outcomes for infants born by caesarean section, although two studies found intellectual outcomes were lower for babies born by elective caesarean (Ounsted, Moar, Cockburn, & Redman, 1984; Pauc & Young, 2006).

Child Factors

In this study, low birth weight was a predictor for MMD among the boys only. In this cohort, the highest prevalence of low birth weight was among the females with high motor competence, the reverse picture to the males where there was a higher prevalence in the MMD males. Low birth weight is consistently associated with a higher incidence of motor and sensory neurodevelopment problems in children (Eriksson, Katz-Salamon, & Carlberg, 2006; Holsti, Grunau, & Whitfield, 2002; Marlow, Roberts, & Cooke, 1989; Schmidhauser et al., 2006). In a cohort of extremely low birth weight children, Holsti and colleagues (2002) found a higher incidence of MMD, a lower Performance IQ, and more learning difficulties in arithmetic. In an earlier study Marlow and others (1989) investigated 53 children at six years of age who weighed less than 1251g at birth and a control group matched for age, sex and school. Motor impairment testing revealed that the low birth weight children had significantly more motor difficulties than the control group. In addition, the index group exhibited more adverse behavioural traits and lower intelligence quotients than the controls. On the other hand, Erikson and colleagues (2006) tracked

the motor performance of a cohort of 165 very low birth weight infants from 5 months of age until over five years. They found that while the majority of the children's motor skills were inferior to the control group, they were within the normal range. The researchers noted the unstable nature of motor skill over time. The higher incidence of low birth weight (< 2000 g) among the males with MMD in this study is consistent with Jones and colleagues (2005, 2006) who identified a gender difference in the relationship between low birth weight and responses to stress independent of other potentially confounding factors such as socioeconomic status or weight. At 7 to 9 years of age boys with low birth weight were more likely than girls to have raised arterial pressure and vascular resistance following a stress test.

Similar findings of adverse neurodevelopmental outcomes have been reported for infants born preterm (< 30 weeks) when compared to term infants (Thompson et al., 2007). Brain development during the last trimester varies between regions, therefore an early birth would mean some regions would be more likely to be affected than others given the reduced time in the intrauterine environment (Peterson, 2003; Thompson et al., 2007). Thompson and colleagues (2007) identified region-specific differences in brain volumes between male and female preterm babies (p = .002). Greater volumes for the males were identified within the inferior occipital and cerebellum regions and may be the result of hormonal influences. In this study there was a greater proportion of children with MMD born preterm, but the differences for both males and females were not statistically significant. Similarly, contrary to expectation, there was not a higher incidence of infants born with intra-uterine growth restriction (IUGR) in the group with MMD. In other studies, children with IUGR were found to be more likely to have more allergies (Hesselmar, Dahlgren, Wennergren, Aberg, & Albertsson-Wikland, 2002), learning, language and social

interaction difficulties and motor coordination impairment than their full-term counterparts (Cooke & Foulder-Hughes, 2003; Hadders-Algra, 2002).

Socio Demographic Factors

In this study, few lifestyle or socio demographic factors were significant risk factors. Prenatal exposure to narcotic and non-narcotic drugs (Lewis, Misra, Johnson, & Rosen, 2004; Schiller & Allen, 2005) and maternal smoking (Taylor & Rogers, 2005) increased the risk of poor behavioural and physiological outcomes for an infant, however these factors were not more prevalent in the MMD cohort in this study. Surprisingly, daughters of mothers who used drugs on an occasional or regular basis during pregnancy had significantly higher motor competence at age 10 years than daughters of non-drug users.

Infants whose mother reported a stressful pregnancy were not more likely to have motor difficulties. This is also surprising given the number of studies that have reported reliable links between maternal stress and pregnancy outcomes (Talge, Neal, & Glover, 2007); however, it may indicate that a more specific relationship exists between the nature of the stressful experience and the outcome of interest. Stressful events during the first year of life, such as divorce or death, did have an adverse effect on motor outcomes for the males. This may be a more critical developmental window for males then females.

Limitations

A limitation of the study is that it was retrospective, so we were limited by the variables collected in the earlier years. While the database is rich, it certainly does not include all variables that might be predictive of later motor development.

While not ideal in all circumstances, the practice of dichotomising information is common in epidemiology and it continues to play a key role in much epidemiological research. An advantage of working with dichotomised variables is that the statistical power of the available exposure data is maximised. Stratification inevitably reduces the amount of data at each level, thereby reducing the possibility of finding a statistically significant difference between groups with differing levels of exposure. An important disadvantage is that information is lost when continuously distributed data are dichotomised.

Conclusion

Overall, the predictive significance of early adverse developmental factors was low for MMD. Motor competence is an emergent characteristic that is the outcome of many interacting factors that refine the neuromuscular system from childhood to adulthood to old age. MRI studies show the human brain continues to develop well into early adulthood (Sowell, Trauner, Gamst, & Jernigan, 2002). While some antenatal and perinatal events or conditions may compromise the early development of the infant motor system, it is likely that an enriched movement context with supportive psychosocial and relevant environmental experiences during childhood may ameliorate the potential long term adverse consequences.

These findings have shown gender differences in risk factors for compromised motor outcomes at 10 years of age. The aetiology of MMD is a complex issue and to date is poorly understood. Further research is needed to better understand the nature of MMD as there are many potential interacting variables apart from, or in addition to, the perinatal factors considered in this article. Further studies considering the severity,

timing and duration of risk factors during pregnancy and immediately post birth are also required.

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Table 1

Characteristics of the Study Cohort (*N* = 1555)

	Total *N* = 1555				Males n = 801				Females n = 754			
	Mean (*SD*)		Count (%)		Mean (*SD*)		Count (%)		Mean (*SD*)		Count (%)	
Age (mths)	126.5	(2.27)			126.7	(2.5)			126.4	(2.0)		
Maternal age (yr)	29.2	(5.7)			29.3	(5.6)			29.1	(5.8)		
Gestational age (wk)	38.8	(2.2)			39.9	(2.0)			38.6	(2.3)		
Race												
Caucasian			1320	(84.9)			685	(85.5)			635	(84.2)
Aboriginal			32	(2.1)			20	(2.4)			12	(1.6)
Other			188	(12.1)			88	(11.0)			100	(13.3)
Not available			15	(0.01)			8	(0.01)			7	(0.01)
Birth weight (gms)												
All	3325.6	(599.4)			3401.8	(587.6)			3244.7	(601.5)		
> 85 NDI	3342.9	(569.7)	1193	(76.7)	3429.2	(551.4)	584	(72.9)	3260.2	(575.2)	609	(80.8)
≤ 85 NDI	3268.5	(685.8)	362	(23.3)	3328.0	(671.3)	217	(27.1)	3179.4	(699.8)	145	(19.2)
NDI												
All	95.0	(13.34)			93.8	(13.8)			96.2	(12.74)		
> 85	100.3	(9.6)	1193	(76.7)	100.1	(9.8)	584	(69.6)	100.6	(9.5)	609	(78.3)
≤ 85	77.2	(6.8)	362	(23.3)	76.8	(6.8)	217	(25.9)	77.9	(6.9)	145	(18.6)

Table 2

Prevalence of Risk Factors for Males and Females with DCD (≤ 85 NDI) and without MDD (> 85 NDI) at 10 Years of Age

	Males				Females			
	Total	> 85 NDI n = 584 *n* (%)	≤ 85 NDI n = 217 *n* (%)	*p*	Total	> 85 NDI n = 609 *n* (%)	≤ 85 NDI n = 145 *n* (%)	*p*
Pregnancy factors								
Essential hypertension	801	23 (3.9)	10 (4.6)	.82	754	20 (3.3)	14 (9.7)	**.002**
Preeclampsia	801	133 (22.8)	61 (28.1)	.14	754	128 (21.0)	39 (26.9)	.15
Threatened abortion	800	35 (6.0)	17 (7.8)	.44	754	43 (7.1)	11 (7.6)	.97
Renal tract infection	801	22 (3.8)	8 (3.7)	.99	754	26 (4.3)	10 (6.9)	.26
Anaemia	800	140 (24.0)	51 (23.5)	.95	754	167 (27.4)	57 (39.3)	**.007**
Diabetes	800	44 (5.8)	10 (4.6)	.48	754	32 (5.2)	10 (6.8)	.20
Stressful pregnancy	801	72 (12.3)	28 (12.9)	.92	754	78 (12.8)	21 (14.5)	.69
Regular alcohol use	801	33 (5.7)	9 (4.1)	.50	754	45 (7.4)	4 (2.8)	.06
Regular or occasional drug use	801	31 (5.4)	16 (7.4)	.52	754	50 (8.2)	6 (4.1)	.17
Smoking	755	161 (29.1)	66 (32.7)	.39	694	204 (36.2)	51 (38.9)	.63
Birth factors								
Threatened preterm labour	800	21 (3.6)	7 (3.2)	.96	754	18 (3.0)	15 (10.3)	**.000**
Ante partum haemorrhage	801	37 (6.3)	17 (7.8)	.55	57	49 (8.0)	8 (5.5)	.39
Post partum haemorrhage	800	91 (15.6)	50 (23.0)	**.02**	754	126 (20.7)	38 (26.2)	.18
Elective or emergency caesarean	801	114 (19.5)	58 (26.7)	**.03**	753	125 (20.6)	37 (25.5)	.23
Child factors								
Fetal distress	801	48 (8.2)	14 (6.5)	.49	754	40 (6.6)	14 (9.7)	.26
Long time to respond	797	60 (10.3)	24 (11.2)	.81	748	48 (8.0)	16 (11.0)	.31
Twin/triplet	801	14 (2.4)	8 (3.7)	.45	754	29 (4.8)	10 (6.9)	.40
First born	754	264 (48.0)	99 (48.5)	.99	704	272 (47.6)	64 (48.5)	.98
Low birth weight								
<2500 g	801	53 (9.1)	24 (11.1)	.47	754	49 (8.0)	19 (13.1)	.08
<2000 g		9 (1.5)	10 (4.6)	**.02**		19 (7.6)	11 (3.1)	**.02**
Pre term	801	51 (8.7)	22 (10.1)	.63	754	73 (12.0)	21 (14.5)	.24
IUGR	801	102 (17.5)	43 (19.8)	.51	754	110 (18.1)	31 (21.4)	.42
Breast fed < 3 months	764	134 (24.0)	52 25.4)	.26	711	137 (23.8)	41 (30.4)	.15
Breast fed > 3 months		383 (68.5)	131 (63.9)			382 (66.3)	80 (59.3)	
Bottle fed		42 (7.5)	22 (10.7)			57 (9.9)	14 (10.4)	
Socio demographic factors								
Young mother	799	36 (6.2)	11 (5.1)	.68	753	41 (6.7)	10 (6.9)	1.0
Low level maternal education	801	199 (34.1)	86 (39.6)	.17	754	210 (34.5)	55 (37.9)	.49
Low SES	785	104 (18.2)	45 (21.2)	.38	741	112 (18.8)	31 (21.5)	.52
Father not at home	801	54 (9.2)	22 (10.1)	.81	754	58 (9.5)	21 (14.5)	.11
Mother doesn't work	728	341 (64.3)	129 (65.2)	.91	684	379 (68.0)	92 (72.4)	.39
Low income	769	152 (27.1)	57 (27.3)	.52	708	131 (22.9)	39 (28.7)	.19
Race	793			.09	747			.43
Caucasian		492 (85.0)	193 (90.2)			510 (84.3)	125 (88.0)	
Aboriginal		18 (3.1)	2 (0.9)			11 (1.8)	1 (0.7)	
Other		69 (11.9)	19 (8.9)			84 (13.9)	16 (11.3)	
Stressful first year of life	728	115 (21.7)	62 (31.3)	**.009**	684	127 (22.8)	28 (22.0)	.95

Note. IUGR Intrauterine Growth Restriction. *p* values in bold are significant.

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Table 3

Multivariable Logistic Regression for Predictors of MMD (n =1410)

Risk Factors	*B*	Odds ratio	95% CI for Odds ratio	
Sex (male)	**.52**	1.68	1.12,	2.49
Essential hypertension	**2.49**	12.10	3.11,	47.07
Anaemia	**.47**	1.60	1.05,	2.41
Threatened preterm labour	**1.22**	3.40	1.53,	7.6
Low birth weight < 2000g	.24	1.28	.48,	3.38
Caesarean section	.15	1.17	.72,	1.90
Post partum haemorrhage	.10	1.11	.68,	1.79
Stressful first year	-.01	.99	.62,	1.60
Sex* Essential hypertension	**-2.41**	.09	.01,	.64
Sex* Anaemia	-.44	.64	.36,	1.13
Sex* Threatened preterm labour	**-1.72**	.18	.05,	.68
Sex* Low birth weight < 2000g	1.10	3.00	.71,	12.75
Sex* Caesarean section	.11	1.11	.59,	2.1
Sex* Post partum haemorrhage	.44	1.56	.17,	1.56
Sex* Stressful first year	.51	1.66	.91,	3.05
Model χ^2				72.1 (p =.000)
Pseudo R^2				.075
N (df)				1410 (15)

Note. Results in bold are statistically significant