Factors Associated with Early Developmental Delay or Disability in Florida’s Children

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Factors Associated with Early Developmental Delay or Disability in Florida’s Children

Prepared by
Maternal Child Health and Education Research and Data Center

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Executive Summary

Factors Associated with on Early Developmental Delay or Disability in Florida’s Children

Background: Improving medical treatment of extremely low birth weight infants over the last 20-30 years resulted in increased survival rates. The developmental sequela of salvaged infants is of great interest to perinatologists. The primary purposes of the current study were to assess the effect of birth weight (BW) on developmental delay or disability in the first three years of life (DDD) and determine whether there is a BW threshold below which all infants should be referred for intervention services.

Methods: Three statewide databases were merged: 1999 Birth Vital Statistics; 1998-99 Medicaid eligibility files; 1999-2002 Children’s Medical Services Early Intervention Program (CMS-EIP) data. Infants who died within the first year of life and plural births were excluded. The final dataset consisted of 171,393 records. A child was determined to have a DDD if a developmental delay, or an established condition, such as sensory impairment, genetic, metabolic, neurological, or severe attachment disorders, was diagnosed through a multidisciplinary evaluation. Logistic regression models were used to relate BW to DDD, controlling for sociodemographic, behavioral, and perinatal variables. Adjusted odds ratios were calculated to describe the effects of BW on DDD.

Results: There was a significant effect of BW on DDD (Adjusted OR = 40.35, 32.12, 15.43, 3.99, 1.46, 1.00, 1.23 for BW categories 450-749, 750-999, 1000-1499, 1500-2499, 2500-2999, 3000-4749, 4750-6050, grams, respectively). 52%, 49%, 34%, 11%, 4%, 3%, and 5% of

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surviving singleton infants in these categories, respectively, suffered a DDD in their first 3 years of life. Four medical and five sociodemographic were significant in addition to birth weight. An equation for predicting the probability of DDD given these factors was obtained and its use exemplified.

**Conclusions:** BW is strongly associated with DDD. Over half (50%) of infants weighing <1000g and about 40% of those weighing <1500g at birth are diagnosed with a DDD before 3 years of age. The probability of DDD for a specific infant also varies by sociodemographic, other perinatal, and behavioral factors.

**Public Health Implications:** The results of this paper suggest that all surviving infants of BW <1000g, and perhaps <1500g, should be offered early intervention services. Consideration also should be given to basing eligibility for services on the estimated probability of DDD, taking additional factors into consideration.
Introduction

Due to increased survival of low and very low birth weight infants since 1970, there has been a dramatic decline in infant mortality rates in the United States \(^1-^3\). There is considerable debate about the effect of this increased survival on childhood morbidity rates and also on the wisdom of salvaging the infants who are marginally viable. A question relevant to this debate concerns the relationship of low and very low birth weights and the risk of developmental delay or disability in early childhood. This issue has been considered previously in the literature but in studies limited by much smaller sample sizes \(^2-^8\) or studies considering only a small number of birth weight groups, not across the entire range of birth weight values \(^3,^6,^8,^9\). In the current paper, we address this issue in the context of a large population-based cohort study with finely defined birth weight categories over the entire range of birth weight values. The goal was to identify a threshold birth weight, below which, the majority of children suffer a developmental delay or disability.

Most studies on developmental morbidity have considered one, two, or sometimes, three birth weight categories \(^3,^6,^8,^9\), but, to the authors’ knowledge, none have looked across the entire range of birth weights in a fine categorization to determine a threshold for automatic referral for services. This paper describes the effect of birth weight on developmental delay or disability in early childhood. A suggestion is made for a cutoff birth weight value under which practitioners should automatically refer infants for intervention services.

The Individuals with Disabilities Education Act (IDEA-Part C: 20 U.S.C. §§ 1400 et seq.) is a federal entitlement program that has been implemented in Florida since 1993 via the state Department of Health Children’s Medical Services’ Early Intervention Program (CMS-EIP). It provides evaluation services for all children, statewide, who are referred by physicians, psychologists, parents, etc., and intervention services for those who are then diagnosed with a developmental delay or disability (DDD) in early childhood (birth – 3 years).
Specific questions considered in this study were: 1) What were the population survival percentages by birth weight (BW)? 2) Given survival, what effect did BW have on the odds that a child would have a DDD? 3) What should the threshold BW value be, if any, for all infants to be automatically referred for intervention services? 4) What effect did certain social demographic, behavioral, and/or perinatal health factors have on a child’s chance of developing a DDD?
Population and Study Sample Description

Three statewide data sets initially were merged to obtain our study population. These data sets were Florida’s Birth Vital Statistics (BVS) for 1999, CMS-EIP data for 1999-2002, and Florida Medicaid eligibility data for 1998-99.

The BVS data set for 1999 contained 196,699 total liveborns. This data set contains demographic and perinatal health factors, as well as a measure of tobacco use, for pregnant women who had children born in the state of Florida in 1999.

The CMS-EIP data system maintains information on children who received evaluation or intervention services from Florida’s statewide, 16-center referral, evaluation, and early intervention program for children less than or equal to 3 years of age. The CMS-EIP program provides evaluation services to all children referred to them. Evaluators, then, determine whether each referred child is eligible for Part C funded intervention services for those diagnosed with a developmental delay or established disability. Within the CMS-EIP data system there were 8,531 children with a diagnosed DDD who were born in 1999.

The Agency for Health Care Administration’s Medicaid data set was used for the period of February 15, 1998 to December 31, 1999, i.e., the period corresponding to the pregnancy window for births in 1999. Medicaid participation was used as an indicator of poverty. The eligibility standard for Medicaid is 185% of the poverty level, so this determines if a family is classified as “low income”.

The three data sets did not contain a common, unique identifier on all records. The BVS data was first merged to the CMS-EIP data and then to the Medicaid data using a deterministic merge strategy developed by Gomatam et al. 10 at the University of Florida. This multi-pass, deterministic merge strategy, with mother’s social security number used on the first pass, had a high merge rate when applied to the current data sets. Details of the application of this merge strategy, and a validation of merged results, were discussed in a previous study 11. The merge
rate exceeded 80%. Any BVS record that did not match to a CMS-EIP record or that matched to a record with no DDD diagnosis was assumed to not have a DDD. The final data set that resulted from these merges was the original BVS data set augmented by two attached variables indicating DDD diagnosis (Y/N) and poverty (Y/N).

Three exclusion criteria were applied to this population-based data set: 1) infant deaths, defined as an infant who died within the first year of life, 2) multiple births, and 3) missing values of birth weight, sociodemographic, behavioral, or perinatal health factors. Infant deaths were excluded because this study was concerned with morbidity outcomes among survivors. Multiple births, resulting from multiple fetuses of a single pregnancy, e.g., twins, and the first of two infants of mothers who gave birth twice in the same year were removed because otherwise assumptions concerning independence between observations would be violated. There were 1505 infant deaths excluded, 5,688 observations excluded for dependency, and 18,117 observations excluded because of missing values. After exclusions there were 171,393 mother-infant pairs (87% of the birth cohort) available for analysis. A description of the population and study sample is given in Table 1.

Methods

DDD was the early childhood morbidity outcome variable studied. It was defined as a Yes/No indicator of whether a child was diagnosed with a developmental delay or disability within the first three years of life. A positive diagnosis was determined if a child followed one of two paths. Some children were referred for Part C evaluation services if suspected to be at high risk for developmental delay. A referral could be made by anyone (e.g., physician, psychologist, parent) and was followed by an EIP multidisciplinary evaluation, which led to a diagnosed or confirmed DDD (i.e., “Yes”), or no diagnosis of developmental delay (i.e., “No”). A child was determined by an EIP team to have a DDD if the child had a developmental delay (including delayed cognition, physical/motor impairment, lack of communication skills, delayed social/emotional development, or lagging adaptive development) or an established condition placing them at high
risk for developmental delay (including sensory impairment, genetic, metabolic, neurological, or severe attachment disorders). Some infants were eligible for evaluation under a different program, i.e., Florida’s Developmental Evaluation and Intervention program (DEI), if they had been cared for in the Neonatal Intensive Care Unit of a designated Florida hospital. These children also were evaluated by an EIP team to determine eligibility for Part C intervention services. If the evaluation team diagnosed a DDD, then a “Yes” was indicated in the variable.

Birth weight, sociodemographic factors, prenatal tobacco use, and perinatal factors were studied to assess their effect on a subsequent early childhood DDD. Thirteen variables were chosen for inclusion based on previous studies of the effect of birth weight or tobacco on developmental or educational outcomes\textsuperscript{12-20}. The perinatal health factors were: birth weight (BW); previous pregnancy experience (PREV); prenatal care (PRECARE); congenital anomalies (CONG); complications of labor or delivery (COMLAB); and interpregnancy interval (IPI). The sociodemographic characteristics included: mother’s education level (MOMEDU), mother’s marital status (MSTAT), poverty (MCAID), mother’s age (MAGE), infant’s race (RACE), and infant’s sex (SEX). The tobacco variable was the number of cigarettes smoked per day during pregnancy (CIGPERDAY). All of the above variables, except IPI and CIGPERDAY, were considered categorical for this study. PRECARE, CONG, COMLAB, MSTAT, and MCAID were all Yes/No indicator variables. MOMEDU was based on the number of years of completed schooling and had categories: less than high school, high school, or greater than high school. PREV had 4 categories: adverse outcome (for women who experienced a previous stillborn or live born that subsequently died or a previous induced or spontaneous abortion), 0 (= no previous births), 1-2, or >2 previous births still living and no previous adverse outcomes. MAGE had 4 categories: 11-17, 18-19, 20-35, and greater than 35 years. The categories for RACE were black, white, and other (consisting primarily of Hispanics), and male and female for SEX. BW categories were 450-749, 750-999, 1000-1499, 1500-2499, 3000-4749, and 4750-6050 grams. IPI was the number of months from the end of the previous pregnancy to the last menstrual period before the current pregnancy. Women with no prior pregnancies were assigned to a separate category coded in such a way as to allow for separate estimation of the effect of first pregnancy on the DDD outcome.
SAS PROC GENMOD was utilized to fit a main effects model involving all independent variables with a segmented linear function of IPI with a change point at 60 months. The change point of 60 months was a rounded value obtained from a previous study. It was determined by fitting a sequence of models with change points at 1, 2, …, 319 months and choosing the one that provided the best fit to the data (i.e., the one with the minimum deviance).

A binomial error distribution was assumed and a logit link was used to fit the model. Adjusted odds ratios, defined as a category’s estimated odds over the estimated odds of the reference category, were calculated from the main effects model for significant effects. Ninety five percent confidence intervals were calculated for these adjusted odds ratios. The following reference categories were used in the calculations: greater than two and an IPI of 60 months for PREV, yes for PRECARE, no for CONG, no for COMLAB, greater than HS for MOMEDU, yes for MSTAT, no for MCAID, 20-35 for MAGE, white for RACE, female for SEX, 0 cigarettes per day for CIGPERDAY and 3000-4749 for BW.
Results

Table 1 shows that the sample for statistical modeling, the population of interest, and the total population had similar profiles with respect to perinatal health factors, sociodemographic characteristics, and birth weight distribution. Also, descriptive statistics in the population of interest (i.e., surviving singletons) were similar to those in the sample after deletion of missing values. Thus, there is no evidence of a selection bias in the sample for statistical modeling. Note that the percentages of DDD are given for the sample for statistical modeling, the population of interest, and the total population for comparison purposes, however, the percentages of DDD among the population of interest are most relevant because they are based on the most information.

Table 1 also shows that survival percentages and percentages of singleton born survivors with early DDD in each of the three BW categories of particular interest which were, respectively, 49.6% and 52.1% in the 450-749 g. category, 85.0% and 48.7 % in the 750-999 g. category, 94.3% and 33.6% in the 1000-1499 g. category, and 99.8% and 3.0% in the reference category (i.e., 3000-4749 g.). Weighted average calculations show that 50% of surviving infants weighing <1000 g. and 40% of those weighing <1500 g. were diagnosed with a DDD in the first three years of life. The fitted main effects model and an example for calculating the model-based estimated probability of DDD are given in the Appendix.

The model-based estimates of the effects of different birth weight categories on developmental morbidity are presented in Table 2 in the form of adjusted odds ratios. It demonstrates a significant increase in morbidity with a decrease in birth weight. The lowest BW group, 450-749 g., had an adjusted odds ratio of 40.35, compared to the reference BW group, 3000-4749 g.

Table 3 summarizes the significant effects of perinatal health factors on early developmental morbidity. Perinatal health factors consisting of prenatal care, complications of labor and delivery, previous pregnancy experience, and congenital anomalies were all statistically related
to DDD. The highest odds ratio (OR) was for congenital anomalies (OR = 5.49, CI = (4.71, 6.40)). Detrimental effects were observed for no prenatal care (OR = 1.64, CI = (1.35, 2.00)) and complications of labor or delivery (OR = 1.21, CI = (1.14, 1.27)). The detrimental effect of being first-born was seen in the odds ratio for the level PREV = 0 (OR = 1.08, CI = (0.95, 1.24)). A first-born infant had higher odds of having a DDD than an infant whose mother had ≥2 previous children and an IPI of 60 months (reference category). Table 3 also summarizes the significant effects of the sociodemographic characteristics or behavioral factor except IPI. IPI is continuous factor so it cannot be presented in the format of Table 3. The significant factors were: male infant (OR = 1.72, CI = (1.63, 1.81)) and maternal poverty (OR = 1.32, CI = (1.24, 1.40)). Both had detrimental effects. There were protective effects for Black race (OR = .81, CI = (.75, .86)) and Other race (OR = .81, CI = (.76, .86)). There were slight protective effects for maternal age 11-17 (OR = .91, CI = (.80, 1.04)) and 18-19 (OR = .92, CI = (.84, 1.02)) and a detrimental effect for maternal age greater than 35 (OR = 1.24, CI = (1.14, 1.35)). There was a slight protective effect for maternal education level equal to HS (OR = .89, CI = (.84, .95)).

For previous pregnancy experience of two or more children and an IPI of less than 60 months, there was a significant protective effect for each unit increase (i.e., one month) in IPI (OR = .995, CI = (.993, .997)).
Discussion

This study found a dramatic increase in developmental delays or disabilities in children less than or equal to three years of age with decreasing birth weight. The high percentages of DDD in the lowest BW categories (52%, 49%, and 34% for 450-749 g., 750-999 g., and 1000-1499 g., respectively) demonstrate that very low BW is a strong predictor of early childhood morbidity. It is unclear why the percentage of DDD in the lowest BW category (52%) is lower than the ones with the previous two years (> 70%). Nevertheless the results of three-year combined suggest a need for further research to assess morbidity rates among these infants at later ages and their quality of life. As advances in medical technology continue to lower the limits of viability, parallel research on morbidity rates among salvaged survivors will produce valuable information for continuing discussions on prudent guidelines for care of marginally viable infants.

The high percentage of low birth weight infants diagnosed with DDD also suggests that the eligibility criteria for EIP or Part C intervention services should be expanded. The current criteria require diagnosis of a developmental delay or an established medical/neurological condition that places the child at high risk for developmental delay. This system is not flawless in catching all children with a DDD. Therefore, there could be a possible underestimation of children with a DDD. The fine gradation of BW categories in this study allowed the identification of a threshold BW to be considered as an additional eligibility criterion. The fact that 50% of all surviving singleton newborns weighing less than 1000 grams were diagnosed with a DDD indicates that this category of low birth weight should be included in the list of established conditions that put children at high risk for DDD. In the next category of low birth weight, 1000-1499 g., 33% were diagnosed with a DDD with a total of 40% of surviving singleton infants <1500 g. having a DDD. Thus, depending on the cutoff percentage for high risk, this group could also be considered to be at risk for DDD. The overall conclusion is that birth weights less than 1000 grams, and possibly less than 1500 grams, is an established condition putting infants at high risk for DDD and therefore automatically should make children eligible for EIP intervention services. The determination of this threshold was possible only because this was a large (n=171,393)

Prepared by the Maternal Child Health and Education Research and Data Center at the University of Florida, a branch of the Lawton and Rhea Chiles Center for Healthy Mothers and Babies at University of South Florida
population-based study using a fine categorization across all BW values. Although the
generalizability of this study’s results cannot be guaranteed, the fact that it is a statewide
population-based study in the countries fourth largest state enhances that likelihood.

The results of the perinatal, behavioral, and sociodemographic factors were largely as expected.
The independent effects of each sociodemographic factor, except for marital status, were
statistically significant and in several instances equaled or exceeded those of some perinatal
health factors. The effects of prenatal tobacco use on early developmental morbidity, however,
turned out to be not significant. The expected findings concerning the perinatal factors are still
useful to practitioners who can further reinforce the importance of these factors to their patients.

The fitted model in the Appendix to this paper could be used to more specifically estimate the
probability of DDD for individual infants, given BW, PREV, PRECARE, CONG, COMLAB,
MOMEDU, MSTAT, MCAID, MAGE, RACE, SEX, IPI, and CIGPERDAY. This estimated
probability could be used with a threshold value to define eligibility criteria for Part C
intervention services in a more precise manor than suggested above using BW alone.

A new finding in this paper is that Black race had a protective effect on early developmental
morbidity. This result is consistent with a similar previous finding of a significant protective
effect of Black race on physical impairment and nearly significant protective effects for sensory
impairment and learning disabilities \(^{21}\) and the fact that cognitive developmental delays are not
evident early, but are acquired with age \(^{19,22}\). The protective effect of Other race (mostly
Hispanic) has been previously documented \(^{23,24}\), but contradicts other findings elsewhere in the
literature where Hispanic ethnicity is thought to have a detrimental effect \(^{4}\). The findings in this
paper concerning Race were, perhaps, evident only when controlling for many potentially
confounding variables. One cannot rule out the possibility that differential referral rates
contributed to the protective effect of Black and Hispanic rates. It would be interesting to
determine in a future study whether White children are referred for EIP evaluation in higher
percentages than Blacks or Hispanics.
Contrary to prevailing perception, there was a significant protective effect of young maternal age on early DDD. This result was consistent with the findings of Gueorguieva et al.\textsuperscript{25} who showed that, although teen age appeared to have a detrimental effect on educational disabilities (i.e., special education placement) in kindergarten when related factors (e.g., maternal education level) were not adjusted, it had a protective effect when potentially confounding variables were controlled.

The findings concerning young maternal age and race highlight the advantages of conducting a multivariable analysis. Statistical modeling, such as that employed in this study, allows the investigation of each factor’s effect, unconfounded by other factors in the model. This technique allows one to assess the independent effects of interrelated risk factors such as race, poverty, maternal age, maternal education, and marital status. In the current study, the odds ratios measuring the effects of each factor were adjusted for the effects of all other factors studied.

When controlling for spacing (IPI), mothers with no previous parenting experience carried an elevated risk of a child having a DDD (OR = 1.08, CI = (0.95, 1.24)), compared to mothers with more than two children who presumably have greater childrearing and parenting experience. This result is contrary to the advantageous outcomes usually reported for first-borns, ignoring spacing of births. We found that increasing spacing of pregnancies has a beneficial effect on children’s development. The benefit of increased spacing may result from the fact that the older the previous child is, the more attention mothers can devote to the newborn, particularly if the older siblings are of school age.

It is noteworthy that previous pregnancy adverse outcome (AO, i.e., stillborn, induced or spontaneous abortion, a liveborn who died) had only a mild effect on the odds of having a DDD child. In previous studies\textsuperscript{26,27} women who had a previous AO were at higher risk for unfavorable infant birth outcomes (i.e., low BW, very low BW, infant mortality, and post-neonatal mortality).

To summarize, a significant association was found between low BW, interpregnancy interval, perinatal health factors, and sociodemographic characteristics and developmental delay or
disability in children less than three years of age. About 40% of very low BW infants (<1500 grams) and half (50%) of extremely low BW infants (<1000 g.) were diagnosed with a DDD before the age of three. It is important to assess the effects of this early identification and intervention through follow-up studies. Additional research on the sequelae of early DDD should continue as these children move through our health and education systems. Studying the impact of early intervention programs on children’s subsequent academic performance is needed. The results of this future research will make important contributions to the ongoing debate on the morbidity, development, and long-term outcome of extremely low, very low, and low birth weight infants. Furthermore, these results have immediate public health implications, as they suggest that extremely low birth weight, and perhaps even very low birth weight, should be made an “established condition” that makes infants immediately eligible for IDEA-Part C intervention services.
References


### Table 1: Comparison of Population and Study Sample

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Table 1: Comparison of Population and Study Sample (cont.)

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<th>Variable</th>
<th>Category</th>
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<th>%</th>
<th>% Survived</th>
<th>% DDD</th>
<th>n</th>
<th>%</th>
<th>% DDD</th>
<th>n</th>
<th>%</th>
<th>% DDD</th>
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<td>Total Population</td>
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<tr>
<td>Population of Interest</td>
<td>(Total population minus IM and plural births)</td>
<td></td>
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<tr>
<td>Sample for Statistical Modeling</td>
<td>(Population of interest minus missing values)</td>
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<td>BW</td>
<td>450-749</td>
<td>801</td>
<td>0.4</td>
<td>49.6</td>
<td>30.1</td>
<td>22.7</td>
<td>328</td>
<td>0.2</td>
<td>52.1</td>
<td>258</td>
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<td></td>
<td>750-999</td>
<td>682</td>
<td>0.4</td>
<td>85.0</td>
<td>42.5</td>
<td>44.4</td>
<td>458</td>
<td>0.2</td>
<td>48.7</td>
<td>376</td>
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<td>1000-1499</td>
<td>1543</td>
<td>0.8</td>
<td>94.3</td>
<td>32.8</td>
<td>62.0</td>
<td>1048</td>
<td>0.6</td>
<td>33.6</td>
<td>839</td>
<td>0.5</td>
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<tr>
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<td>1500-2499</td>
<td>1285</td>
<td>6.6</td>
<td>98.6</td>
<td>11.8</td>
<td>86.9</td>
<td>9944</td>
<td>5.3</td>
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<td>8636</td>
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<td>2500-2999</td>
<td>34214</td>
<td>17.4</td>
<td>99.5</td>
<td>4.3</td>
<td>95.2</td>
<td>32416</td>
<td>17.1</td>
<td>4.2</td>
<td>29131</td>
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<td>3000-4749</td>
<td>14553</td>
<td>74.1</td>
<td>99.8</td>
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<td>96.7</td>
<td>144521</td>
<td>76.3</td>
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<td>131474</td>
<td>76.7</td>
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<td>4750-6050</td>
<td>773</td>
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<td>97.8</td>
<td>4.5</td>
<td>93.4</td>
<td>755</td>
<td>0.4</td>
<td>4.5</td>
<td>679</td>
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<td>IPI</td>
<td>Means</td>
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<td>23.8</td>
<td></td>
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<td></td>
<td>23.8</td>
<td></td>
<td></td>
<td>23.9</td>
</tr>
<tr>
<td>CIGPERDAY</td>
<td>Means</td>
<td></td>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
<td></td>
<td></td>
<td>1.0</td>
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</table>

a. IM = Infant Mortality
b. AO = Previous "Adverse Outcome"
Table 2: Effects of Birth Weight on DDD

<table>
<thead>
<tr>
<th>BW Category</th>
<th>Adjusted Odds Ratio</th>
<th>95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>450-749</td>
<td>40.35</td>
<td>(31.28, 52.03)</td>
</tr>
<tr>
<td>750-999</td>
<td>32.12</td>
<td>(26.01, 39.67)</td>
</tr>
<tr>
<td>1000-1499</td>
<td>15.43</td>
<td>(13.25, 17.96)</td>
</tr>
<tr>
<td>1500-2499</td>
<td>3.99</td>
<td>(3.70, 4.31)</td>
</tr>
<tr>
<td>2500-2999</td>
<td>1.46</td>
<td>(1.36, 1.56)</td>
</tr>
<tr>
<td>3000-4749</td>
<td>1.00</td>
<td>Reference Category</td>
</tr>
<tr>
<td>4750-6000</td>
<td>1.23</td>
<td>(0.85, 1.80)</td>
</tr>
</tbody>
</table>
### Table 3: Effects of Perinatal Health and Sociodemographic Factors on DDD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Reference Category</th>
<th>Adjusted Odds Ratio</th>
<th>95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>PRECARE</td>
<td>No</td>
<td>Yes</td>
<td>1.64</td>
<td>(1.35, 2.00)</td>
</tr>
<tr>
<td>CONG</td>
<td>Yes</td>
<td>No</td>
<td>5.49</td>
<td>(4.71, 6.40)</td>
</tr>
<tr>
<td>COMLAB</td>
<td>Yes</td>
<td>No</td>
<td>1.21</td>
<td>(1.14, 1.27)</td>
</tr>
<tr>
<td>MOMEDU</td>
<td>&lt;HS</td>
<td>&gt;HS</td>
<td>1.12</td>
<td>(1.03, 1.21)</td>
</tr>
<tr>
<td></td>
<td>HS</td>
<td>&gt;HS</td>
<td>0.89</td>
<td>(0.84, 0.95)</td>
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<tr>
<td>MCAID</td>
<td>Yes</td>
<td>No</td>
<td>1.32</td>
<td>(1.24, 1.40)</td>
</tr>
<tr>
<td>RACE</td>
<td>Black</td>
<td>White</td>
<td>0.81</td>
<td>(0.75, 0.86)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>White</td>
<td>0.81</td>
<td>(0.76, 0.86)</td>
</tr>
<tr>
<td>SEX</td>
<td>Male</td>
<td>Female</td>
<td>1.72</td>
<td>(1.63, 1.81)</td>
</tr>
<tr>
<td>MAGE</td>
<td>11-17</td>
<td>20-35</td>
<td>0.91</td>
<td>(0.80, 1.04)</td>
</tr>
<tr>
<td></td>
<td>18-19</td>
<td>20-35</td>
<td>0.92</td>
<td>(0.84, 1.02)</td>
</tr>
<tr>
<td></td>
<td>&gt;35</td>
<td>20-35</td>
<td>1.24</td>
<td>(1.14, 1.35)</td>
</tr>
</tbody>
</table>
Appendix: Formula to Calculate Predicted Probability of DDD from Fitted Model

Fitted Model:

\[
\hat{\Pr}(\text{DDD} \mid \text{explanatory variables}) = \frac{e^{\hat{ip}}}{1 + e^{\hat{ip}}}, \text{ where}
\]

\[
\hat{ip} = -4.0674 - .0343*I(\text{PREV} = AO) + .0798*I(\text{PREV} = 0) + .0013*I(\text{PREV} = 1-2) + .4951*I(\text{PRECARE} = \text{No}) + 1.7029*I(\text{CONG} = \text{Yes}) + .1884*I(\text{COMLAB} = \text{Yes}) + .1092*I(\text{MOMEDU} = <\text{HS}) - .1145*I(\text{MOMEDU} = \text{HS}) - .0304*I(\text{MSTAT} = \text{No}) + .2759*I(\text{MCAID} = \text{Yes}) - .0894*I(\text{MAGE} = 11-17) - .0814*I(\text{MAGE} = 18-19) + .2150*I(\text{MAGE} = >35) - .2146*I(\text{RACE} = B) - .2144*I(\text{RACE} = O) + .5413*I(\text{SEX} = M) + 3.6975*I(\text{BW} = 450-749) + 3.4694*I(\text{BW} = 750-999) + 2.7361*I(\text{BW} = 1000-1499) + 1.3846*I(\text{BW} = 1500-2499) + .3777*I(\text{BW} = 2500-2999) + .2103*I(\text{BW} = 4750-6050) - .0065*(\text{IPI-60})*I(\text{PREV} \neq 0)*I(\text{IPI}<60) + .0084*(\text{IPI-60})*I(\text{PREV} \neq 0)*I(\text{IPI}\geq60) + .0031*\text{CIGPERDAY},
\]

and I(“event”) = 1 if “event” occurred, 0 otherwise. So, for example, I(\text{PREV} = 0) = 1 when a mother has no previous pregnancy experience, 0 otherwise.
Appendix: Formula to Calculate Predicted Probability of DDD from Fitted Model (continued)

Example Calculation:

The predicted probability of DDD given BW = 450-749 g., PREV = 0, PRECARE = Yes, CONG = No, COMLAB = No, MOMEDU = HS, MSTAT = Yes, MCAID = No, MAGE = 11-17, RACE = O, SEX = F, and CIGPERDAY = 60 is calculated as \( \hat{\text{Pr}}(\text{DDD} \mid \text{explanatory variables}) \)

\[
\hat{\text{Pr}} = \frac{e^{\hat{lp}}}{1 + e^{\hat{lp}}}, \text{ where } \hat{lp} \text{ for the given settings of covariates in this example is } \hat{lp} = -4.0674 - .0343*0 + .0798*1 + .0013*0 + .4951*0 + 1.7029*0 + .1884*0 + .1092*0 - .1145*1 - .0343*0 + .2759*0 - .0894*1 - .0814*0 + .2150*0 - .2146*0 - .2144*1 + .5413*0 + 3.6975*1 + 3.4694*0 + 2.7361*0 + 1.3846*0 + .3777*0 + .2103*0 - .0065*(IPI-60)*0 + .0084*(IPI-60)*0 + .0031*60 = -4.0674 + .0798 - .1145 - .0894 - .2144 + 3.6975 + .0031*60 = -.5224.

Thus, for this example \( \hat{\text{Pr}}(\text{DDD} \mid \text{explanatory variables}) = \exp(-.5224) / (1+\exp(-.5224)) = .37. \)