

**School of Mathematics and Statistics**

**MSc Data-Intensive Analysis**

**MSc Applied Statistics and Datamining**

**MT5762 INTRODUCTORY DATA ANALYSIS**

GROUP: DRUNKEN MASTER 2

ID Numbers: 180012191; 180025784; 110013122; 180029941, 180024795

**An Examination of the Influences on Low Birth-Weight Babies**

*Producing a model that describes potential drivers of low birth-weight babies.*

Tutor: Dr. Carl Donovan

**Executive Summary**

The present report focuses on fitting linear models to determine the effect of different variables on the birth weight of babies.

**INDEX**

**Content**

[1 INTRODUCTION 1](#_Toc528907488)

[1.1 Variables in Data File Babies 3](#_Toc528907489)

[2 METHODS 4](#_Toc528907490)

[2.1 Data Cleaning 4](#_Toc528907491)

[2.2 Data Exploration 5](#_Toc528907492)

[2.2.1 Baby Birth Date Weight 5](#_Toc528907493)

[2.2.2 Gestation Period vs. Birth Weight 5](#_Toc528907494)

[2.2.3 Scatterplot of Mother’s Weight vs. Baby´s Weight 6](#_Toc528907495)

[2.2.4 Analysis of wt.1 (mother's weight) 7](#_Toc528907496)

[2.2.5 Scatterplot of father's weight against baby's weight 7](#_Toc528907497)

[2.2.6 Mother´s Smoking Habits 8](#_Toc528907498)

[2.3 Model Fitting 8](#_Toc528907499)

[2.3.1 Data Model 8](#_Toc528907500)

[2.3.2 Fitting a First Order Interaction Model 10](#_Toc528907501)

[2.4 Check Assumptions 13](#_Toc528907502)

[2.5 Other Tested Models 13](#_Toc528907503)

[3 FIVE-FOLD CROSS VALIDATION (Final Model) 14](#_Toc528907504)

[3.1.1 Results bla 11 14](#_Toc528907505)

[3.2 Results Bla 2 15](#_Toc528907506)

[3.3 Resultas Bla 3 15](#_Toc528907507)

[3.3.1 Results 31 16](#_Toc528907508)

[3.3.2 Results 32 16](#_Toc528907509)

[3.3.3 Results 33 16](#_Toc528907510)

[4 DISCUSSION 17](#_Toc528907511)

[4.1 Discussion 1 17](#_Toc528907512)

[4.1.1 Discussion 11 17](#_Toc528907513)

[4.1.1.1 Discussion 111 18](#_Toc528907514)

[4.1.2 Discussion 12 18](#_Toc528907515)

[4.1.2.1 Discussion 121 18](#_Toc528907516)

[4.1.2.2 Discussion 122 19](#_Toc528907517)

[4.2 Discussion 2 19](#_Toc528907518)

[4.2.1 Discussion 21 20](#_Toc528907519)

[4.2.2 Discussion 22 20](#_Toc528907520)

[5 CONCLUSIONS AND RECOMMENDATIONS/DISCUSSION SUMMARY 21](#_Toc528907521)

[6 BIBLIOGRAPHY 22](#_Toc528907522)

# INTRODUCTION

As anyone ever said “life is a gamble” to you? Such a statement reflects the feeling that our lives are surrounded by unpredictable, or “random”, events (Wild & Seber, 2000, p.1).

The present report analyses and discuss some results that can answer the question “what relationships are there between the measured variables and the birth weight of babies?”

The data used in this report is part of a larger group of studies from the Child Health and Development Studies (CHDS), which *“are prospective longitudinal studies on medical and social aspects of pregnancies and on the health and development of children”[[1]](#footnote-1)*.

Previous studies indicate that there are many potential drivers of low birth-weight (LBW) babies. According to Kramer (1987), “*factors with well-established direct causal impacts on intrauterine growth*” and consequently LBW, “*include infant sex, racial/ethnic origin, maternal height, pre-pregnancy weight, paternal weight and height, maternal birth weight, parity, history of prior low-birth-weight infants, gestational weight gain and caloric intake, general morbidity and episodic illness, malaria, cigarette smoking, alcohol consumption, and tobacco chewing*”[[2]](#footnote-2).

The data set we are analysing in this report contains most of the variables mentioned by Kramer above and will be discussed later.

“*Of the 127 million infants born in the world in 1982, 20 million (16%) were estimated to weigh less than 2500g., and over 90% of these infants were born in developing countries, a function not only of the higher birth rate in these countries but also of their LBW[[3]](#footnote-3)*” (Kramer, M, 1987, p.664).

Data cleaning, analysis and plotting were produced in the R programming language using the software R-Studio version 3.5.1 (R Core Team, 2018).

# METHODS

## Data Cleaning

The data were cleaned to remove unknown values that were being presented as numerical within the data set. All variables had been classified as integers within the programming software so the numerical ones were changed to numerical to allow analyses to be performed on them.

## Data Exploration

Exploratory analyses were performed on the data to investigate the potential for the existence of relationships between the variables and birth weight. Correlation values were obtained and used to select which variables to explore. These variables were visualised with scatterplots, giving an indication of the strength of the relationship. The categorical variable of mother’s smoking habits was plotted as a boxplot.

## Model Fitting

Linear models were fitted using linear regression, analysis of variance (ANOVA) and the Akaike Information Criterion (AIC). Nominal variables were removed from the data before fitting to ensure they did not affect the result (ID number, for example). Assumptions of the models were checked. Normality was assessed by plotting the residuals along a quantile-quantile (QQ) plot and by plotting a histogram. A Shapiro-Wilk normality test was also performed. Independence was assessed through a scatterplot of the residuals against the fitted values. Constant variance was tested by performing a Breusch-Pagan test and a Durbin-Watson test was performed to test for autocorrelation.

# RESULTS

“All models are wrong, but some models are better than others.” (Crawley, 2015, p.4)

Data cleaning deals with data problems once they have occurred. Error-prevention strategies can reduce many problems but cannot eliminate them. We present data cleaning as a three-stage process, involving repeated cycles of screening, diagnosing, and editing of suspected data abnormalities (Van den Broeck, Argeseanu Cunningham, Eeckles, & Herbst, 2005).

## Data Exploration

### Correlation of All Variables with Birth Weight

To investigate which variables were likely to effect birth weight, the correlation values were calculated. The strongest correlations were gestation period, mother’s height, mother’s weight and father’s weight. None of the correlations are particularly strong but they indicate that relationships may exist. Further exploratory analysis was performed on these variables. The correlation calculation did not include categorical variables, so relationships may exist that are not found here. The correlation values are shown in Figure.

|  |  |
| --- | --- |
|  | **Correlation** |
| **Gestation Period** | 0.40 |
| **Mother’s Height** | 0.22 |
| **Mother’s Weight** | 0.17 |
| **Father’s Weight** | 0.15 |

**Figure: Correlations between variables and birth weight**

### Gestation Period

A scatterplot of gestation period and birthweight was created to visualise the relationship. As can be seen in Figure, there birth weight appears to increase as gestation period gets longer. This is in line with the correlation value of 0.40 that was found.

|  |
| --- |
| Figure 4: Scatterplot of gestation period against baby weight |

### Mother’s Height

The second-strongest correlation with birth weight was seen with mother’s height (correlation of 0.22). Figure represents this as a scatterplot but does not indicate a strong relationship between the variables.

|  |
| --- |
| Figure 5: Scatterplot of Mother´s Height vs. Birth Weight |

### Mother’s Weight

Figure shows a scatterplot of mother's weight against birth weight. There does not appear to be a strong relationship between the variables. This was expected as the correlation between the variables was 0.17.

|  |
| --- |
| Figure 6: Scatterplot of mother´s weight and birth weight |

### Father’s Weight

The final variable visualised was father’s weight. Its correlation with birth weight was 0.15 so a clear relationship through visualisation was not expected. Figure shows the relationship as a scatterplot and does not indicate a large effect.

|  |
| --- |
| Figure 7: A scatterplot of father’s weight against birth weight |

### Mother´s Smoking Habits

Exploratory analysis was performed on mother’s smoking habits. This was a categorical variable with factors: never smoked, smokes now, smoked until pregnancy, and once smoked (long before pregnancy). Previous studies have suggested that maternal smoking during pregnancy causes low birth-weight in babies (Perez da Silva Pereira et al, 2017). Therefore, the relationship between mother’s smoking habits and birth weight were explored and visualised using boxplots (Figure). These show a smaller median for birth weight of babies whose mothers currently smoke but it is still within the interquartile range of the other levels of smoking. Therefore, the effect may not be significant.

|  |
| --- |
| Figure 8: Birth weight per level of mother´s smoking habits |

## Model Fitting

### Model with all variables

A model was fitted using all variables except ID and data. The stepwise AIC backwards selection method was chosen. This calculated the AIC score using all variables then removed the variable which caused the largest decrease in AIC score. This was repeated until removing any of the variables caused an increase in the AIC score. The final AIC score was 3359.82, providing a model with the following variables (Table).

|  |  |
| --- | --- |
| Variable | Coefficient |
| **(Intercept)** | -98.99311 |
| **Gestation period** | 0.454 |
| **Mother’s Previous Pregnancies** | 0.74966 |
| **Mother’s Height** | 1.26968 |
| **Father’s Race** | -0.56526 |
| **Father’s Weight** | 0.07689 |
| **Mother’s Smoking Habits** | 2.15663 |
| **No. of Cigarettes Smoked by Mother** | -2.16762 |

Table: **Coefficients of the variables in the model**

An ANOVA was performed to check whether the variables have contributed to the predictive ability of the model. The p-values were all < 0.05, which suggests that the variables selected for the model contribute to the model’s predictive ability.

The assumptions of the model were checked. For normality, a Shapiro-Wilk normality test was performed and returned a p-value of 0.09. As this is greater than 0.05, the null hypothesis (that the data are normally distributed) is not rejected. From the QQ plot of residuals of the model (Figure) and Shapiro-Wilks normality test, we could conclude that the residuals of the model come from a normal distribution.

To test for linearity, the residuals have been plotted against the fitted values (Figure). Although the graph is not perfect, it shows the linearity of the model.

For heteroskedasticity, a Breusch-Pagan test was performed. Its null hypothesis is that there is constant error variance. The p-value is < 0.05 so the null hypothesis is rejected. This indicates that heteroskedasticity exists. It can also be seen from the graph of residuals against fitted data (Figure).

To test for autocorrelation, a Durbin-Watson test was performed. The null hypothesis states that the residuals are uncorrelated. This returned a p value of 0.54, so we fail to reject the null hypothesis in this case. Also, a DW statistic close to 2 indicates that the residuals are uncorrelated. For this model, the test returned a statistic of 1.84.

Collinearity was tested by using variance inflation factors. Since all of the variance inflation factors were less than 10, collinearity is not considered to be an issue.

|  |
| --- |
| Figure 9: Histogram of Residuals |

|  |
| --- |
| Figure 10: Normal Q-Q |

|  |
| --- |
| Figure 11: Residuals vs Fitted |

### Fitting a First-Order Interaction Model

In this model, first-order interactions between two variables were examined. All variables were used and first-order interactions between every pair of variables in the data were calculated. This created over 200 variables. Stepwise AIC backward selection was performed which reduced the variables to between 50 and 60. The collinearity of this model was then examined. It was observed that there were a considerable number of variables which GVIF number was larger than 10. The variable with the largest VIF value was removed and the test was performed again. This was repeated until all values were below 10.

AIC backwards selection was performed again since many of the previous variables had been removed. After model selection, 12 variables remained and the AIC score of the model was 3358.58. The collinearity was checked again and all VIF values were less than 10. The coefficients of the model are shown in (Table).

|  |  |
| --- | --- |
| Variable | Coefficient |
| **(Intercept)** | -83.21759 |
| **Gestation period** | 0.44988 |
| **Mother’s Height** | 1.04438 |
| **Father’s Education** | -1.33282 |
| **Father’s Weight** | 0.07541 |
| **Family Yearly Income** | -0.50323 |
| **Time Since Mother Quit Smoking** | 1.99309 |
| **No. of Cigarettes Smoked by Mother** | -2.02635 |
| **Family Yearly Income:Mother’s Previous Pregnancies** | 0.15018 |
| **Mother’s Weight:Mother’s Education** | 0.01692 |
| **Mother’s Education:Father’s Race** | -0.20793 |
| **Time Since Mother Quit Smoking:Mother’s Education** | -0.64961 |
| **Father’s Education:Mother’s Smoking Habits** | 0.61855 |

Table: **Coefficients of the variables in the first-order interaction model**

The assumptions of the model were assessed in the same way as the previous model. For normality, the Shapiro-Wilks normality test returned a p-value of 0.22, so the null hypothesis is not rejected. From the QQ plot of the residuals of the model (Figure) and Shapiro-Wilks test, it cannot be concluded that the data come from a normal distribution. Figure shows the linearity of the model by plotting the residuals against the fitted values. For heteroskedasticity, we use Breusch-Pagan test returned a p value of 0.16 so the null hypothesis is not rejected.

The p-value of the Durbin-Watson test was 0.08, suggesting that there is no correlation of the residuals. It also returned a DW statistic of 1.83. Therefore, the model passed all assumptions.

|  |
| --- |
| Figure 12: Histogram of Residuals |

|  |
| --- |
| Figure 13: Normal Q-Q |

|  |
| --- |
| Figure 14: Residuals vs Fitted |

## Check Assumptions

## Other Tested Models

# FIVE-FOLD CROSS VALIDATION (Final Model)

We have, so far, looked upon various models in order to find a better performing one. However, it can be difficult to determine if these improvements in scores result from the captures of better relationships within our model or if we are just overfitting the model. In order to clarify this aspect we use validation techniques such as Five-Fold Cross Validation.

### Results bla 11

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

## Results Bla 2

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

* Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis.
* Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis.
* Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis.

## Resultas Bla 3

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Results 31

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Results 32

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Results 33

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

# DISCUSSION

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

## Discussion 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Discussion 11

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

#### Discussion 111

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Discussion 12

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

#### Discussion 121

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

#### Discussion 122

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

## Discussion 2

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Discussion 21

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

### Discussion 22

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

# CONCLUSIONS AND RECOMMENDATIONS/DISCUSSION SUMMARY

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut varius laoreet consectetur. Nulla in vulputate lacus. In et volutpat ante. In ultrices turpis neque, id dictum erat auctor ac. Pellentesque mattis, magna rutrum rutrum placerat, orci augue molestie nunc, vel porttitor risus tellus non dui. Vivamus id convallis odio. Duis ut nulla id nulla gravida vulputate a condimentum tellus. Ut purus justo, tempus sed iaculis at, accumsan id sapien. Etiam eu massa vehicula, accumsan urna sed, varius magna. Maecenas dapibus arcu leo, et tempus leo tincidunt id.

# BIBLIOGRAPHY

Crawley, M. J. (2015). *Statistics - An Introduction Using R*. ( lda John Wiley & Sons, Ed.) (Second Edi). Sussex.

Kramer, M, S. (1987). Determinants of low birth weight: methodological assessment and meta-analysis. *Bulletin of the World Health Organization, 65 (5): 663-737 (1987)*. Obtido de https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2491072/?page=1

Van den Broeck, J., Argeseanu Cunningham, S., Eeckles, R., & Herbst, K. (2005). Data Cleaning: Detecting, Diagnosing, and Editing Data Abnormalities. Obtido de https://doi.org/10.1371/journal.pmed.0020267

Wild, C. J., & Seber, G. A. F. (2000). *Chance Encounters - A first Course in Data Analysis and Inference*. (J. W. & Son, Ed.) (1st ed.). USA: John Wiley & Son, Inc.

**APPENDIX**

Appendix 1 – Abbreviations

**Abbreviations**

**A**

AIC = Akaike´s Information Criterion

**D**

drace = father’s race, coding same as mother´s race

dage = father´s age, coding same as mothers age

ded = father´s education, coding same as mother´s education

dht = father´s height, coding same as mothers height

dwt = father´s weight, coding same as mothers weight

**E**

ed = mother´s education

**G**

GVIF – Variance Inflation Factor

**H**

ht = mother´s height in inches to the last completed inch

**I**

id = identification number

inc = family yearly income in $2500 increments

**L**

LBW = Low Birth Weigh

**M**

**N**

number = number of cigarettes smoked per day for past and current smokers

**O**

**P**

**Q**

**R**

**S**

**T**

**U**

**W**

wt = birth weight in ounces

**X**

1. <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-3016.1988.tb00218.x> [↑](#footnote-ref-1)
2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2491072/?page=1> [↑](#footnote-ref-2)
3. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2491072/?page=2> [↑](#footnote-ref-3)