

**School of Mathematics and Statistics**

**MSc Data-Intensive Analysis**

**MSc Applied Statistics and Datamining**

**MT5762 INTRODUCTORY DATA ANALYSIS**

GROUP: DRUNKEN MASTER 2

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**What relationships are there between the measured variables and the birth weight of babies?**

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

Tutor: Dr. Carl Donovan

*“Investigators should, they recommended, assess whether ‘the association between two variables is in fact between the variables investigated and does not merely reflect relationships with a broader group, of which one or the other of the variables forms a part’”*[[1]](#footnote-1).

*“…as concerns grew about the health effects of cigarette smoking, several studies appeared suggesting that smoking mothers were more likely to have babies of lower birthweight compared with nonsmoking mothers”[[2]](#footnote-2).*

*“When looking only at lowbirth weight infants, they found surprisingly that the low birthweight infants of smoking mothers survived considerably better than those of nonsmoking mothers. This appeared highly implausible. ‘It is difficult to visualize a biological mechanism whereby mother’s smoking is the cause for these phenomena—that it exerts a beneficial effect on the infant of ‘low birthweight’ which reduces markedly his risk of early death,’ wrote Yerushalmy. Instead, Yerushalmy suggested that ‘It is not the smoking but the smoker which may offer an explanation for the observed differences’. In other words, the smokers in the study may represent a different group of people whose reproductive experience would have been similar independently of whether or not they smoked. In this case, smoking is not a cause of the difference in birthweight, but is simply correlated with some other factors that are influential”[[3]](#footnote-3).*

*“A prospective study of 2000 women, conducted by Scott Russell and colleagues at the University of Sheffield, had found that in addition to the expected differences in birthweight by smoking status, ‘the percentage of unsuccessful pregnancies (abortion, stillbirth, neonatal death) was higher for smokers’, even when controlling for education, social class, and other factors. This was the first large prospective study to have reported a difference in neonatal mortality. Extrapolating from the data, Russell went on to estimate that one out of every five unsuccessful pregnancies in women who smoked regularly would have been successful if the mother had not smoked during the pregnancy.”[[4]](#footnote-4)*[*14*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4200064/#dyu163-B14)

*The results continue to serve as a case study in causal inference.*

*‘Yerushalmy’s work gained media attention…The evidence appears, therefore, to support the proposition that the incidence of low birth weight infants is due to the smoker and not the smoking.’*[*20*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4200064/#dyu163-B20)*The paper received substantial news coverage, including a column in Family Health Magazine titled ‘In defense of smoking moms’.*[*21*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4200064/#dyu163-B21)

*It wasn’t until 1980, with the report on*The Health Consequences of Smoking for Women*, that a definitive statement appeared in the reports of the Surgeon General regarding the influence of maternal smoking on neonatal mortality.*[*24*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4200064/#dyu163-B24)*By this time, a substantial body of cohort data tracking birth outcomes was available.*

*In a British population cigarette smoking during pregnancy increased the late fetal plus neonatal mortality rate by 28% and reduced birth weight by 170 g, and these differences persist even after allowing for a number of “mediating” maternal and social variables. A change in smoking habit by the end of the fourth month of pregnancy places a mother in the risk category appropriate to her changed habit. This evidence should have important implications for health education aimed at getting pregnant mothers to give up smoking[[5]](#footnote-5).*

**Executive Summary**

The present report is a data analysis project, which focusses mainly on fitting linear models. It intends to determine what relationships are there between the measured variables (Ethnicity, Age, Smoking habits (…)) and the birth weight of babies[[6]](#footnote-6).

In order to do so it is required to produce a model that describes potential drivers of low birth-weight babies.

**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**

MIS

**N**

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

**O**

ORM

**P**

PG

**Q**

QMS

**R**

RQA

**S**

SGBDR

**T**

TIC

**U**

UI

**W**

wt = birth weight in ounces

**X**

XHTML

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# 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 aim of the present report is to produce an analysis 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”[[7]](#footnote-7)*.

It is known that there are many potential drivers of Low-Birth Weight (LBW) babies. According to Kramer (Kramer, M, 1987, p.663), “*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*”[[8]](#footnote-8).

The data set we are analysing in this report contains most of the variables referred above.

“*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[[9]](#footnote-9)*” (Kramer, M, 1987, p.664).

This report was produced using Microsoft Office (Word and Excel)[[10]](#footnote-10) and the Data Frames and its respective manipulation, statistical analysis and plotting were produced in R programming language using the software R-Studio version 3.5.1 available on Apps Anywhere[[11]](#footnote-11).

## Variables in Data File Babies

The variables that were subject to analysis in this report are listed and described in Figure 1: Variables in Data File Babies.

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| Figure 1: Variables in Data File Babies  Source: Adopted from:  <https://github.com/ziqsu/MT5762-Project2/blob/master/description%20of%20babies%20data.txt> |

# METHODS

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

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## Data Cleaning

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).

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| Figure 2: Data-Cleaning Framework  (Illustration: Giovanni Maki)  <https://doi.org/10.1371/journal.pmed.0020267.g001> |

In order to start working and exploring the given data (babies23.data) and to prevent possible errors, the data was checked and cleaned. The data-cleaning framework followed is illustrated in **Figure 2**.

During this process unknown, not clear or not needed, or irrelevant data aspects were cleaned and some existing factor variables were transformed into numeric (Appendix 1 – R code).

## Data Exploration

This part of the report will be dedicated to exploring and determining potential relationships within the data set. The data exploration was produced using R Software.

### Baby Birth Date Weight

A quick exploratory analysis of the histogram (Figure 3) shows that the baby weight values appear to be normally distributed.

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| Figure 3: Density Histogram of Birthday Weight |

### Gestation Period vs. Birth Weight

Exploring the data related with gestation period and birth weight one can observe (Figure 4) that there is an increase in birth weight as gestation period increases. From the correlation point of view this are the variables that present the strongest relationship with Birth Weight.

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| Figure 4: Scatterplot Mother´s Weight against Baby Weight |

### Scatterplot of Mother’s Weight vs. Baby´s Weight

The following scatterplot (Figure 5) does not indicate a strong effect between the variables.

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| Figure 5: Mother´s Weight vs. Baby´s Birth Weight |

### Analysis of wt.1 (mother's weight)

Looking at the scatterplot of mother's weight against baby's weight (Figure 6) it can be seen that it does not indicate a strong effect between the variables.

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| Figure 6: Mother´s Weight and Baby´s Weight |

### Scatterplot of father's weight against baby's weight

The following scatterplot, father´s weight against baby´s weight, also does not indicate a strong relationship between the variables.

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| --- |
| Figure 7: Father´s Weight vs. Baby´s Weight |

### Mother´s Smoking Habits

Although 'smoke' had no correlation with birth weight, common sense says that there would be an effect here between factors of smoking. The boxplots show smaller mean for 'smokes now' but it is still within the interquartile range of the other levels of smoking. Therefore, the effect may not be significant.

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| --- |
| Figure 8: Birth Weight per level of Mother´s Smoking |

## Model Fitting

### Data Model

In this phase we have selected data that does not contain **id** and **date of birth** (due to irrelevance**)**. We will consider that these two factor do not have, in real life, effect on baby birth weight.

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| Figure 9: Histogram of Residuals |

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| Figure 10: Normal Q-Q |

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| Figure 11: Residuals vs Fitted |

#### Fitting a First Order Order Interaction Model

In this phase we will fit out final model – First Order Interaction Model. This process will undergo the following steps:

1. To create a first order interaction for every variable, looking at a high number of variables - circa 200 -300 variables;
2. Then we will proceed, using step function backward selection using AIC score- variable selection with stepwise and best subset approaches. At this stage we have eliminated a high number of variables, being now reduced to some 50 – 60 variables.
3. Here we examine the collinearity of the first order Model. It is observed that there are a considerable number of variable which GVIF number is larger than 10, which prompt us to the following step.
   1. we find the maximum number of GVIF; if it is larger than 10 then we remove it;
   2. Repeat the vif function in order to check the collinearity and get the maximum - repeat the step 1;
4. At this stage we will again proceed using the step function backward selection using AIC. We are now reduced to some 12 variables.
5. We do the above two steps until all the variable's collinearity GVIF is less than 10 and reach a point where we no longer have collinearity problems.

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| Figure 12: Histogram of Residuals |

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| Figure 13: Normal Q-Q |

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| Figure 14: Residuals vs Fitted |

## Check Assumptions

To test for non-constant error variance we use the Breusche-Pagan test (H0: constant error variance) with respect to fitted model. If we have constant error variance then the variation in the residuals should be unrelated to any covariant." null hypothesis is rejected since the p value is less than 0.05.

With the Durbin Watson Test we check upon the correlation of the residuals. If the statistical value is 2 there is no autocorrelation. If the value is between 1.5 and 2.0 we should not concern about it.

# RESULTS

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## Results Bla 1

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## Resultas Bla 3

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### Results 31

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| Figure 4 – bla di bla |

### Results 33

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# DISCUSSION

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## Discussion 1

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### Discussion 11

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#### Discussion 111

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#### Discussion 121

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#### Discussion 122

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## Discussion 2

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| Figure 6 – bla di bla |

### Discussion 21

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| Table 1 – Table *Users*   |  |  | | --- | --- | | Nome | Descrição | | id (Integer, SERIAL PRIMARY KEY) | Número único de um utilizador | | Name (String) | Nome do utilizador | | Email (String, Unique) | Email do utilizador | | HashedPassword (String) | Password codificada | | Role (Admin / Employee) | Papel do utilizador na empresa | |

### Discussion 22

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| Table 2 – Tabela *businessAreas*   |  |  | | --- | --- | | Nome | Descrição | | id (Integer, SERIAL PRIMARY KEY) | Número único de uma área de negócio | | Name (String) | Nome da área de negócio | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tabela 1 – Tabela *businessAreaOption*   |  |  | | --- | --- | | Nome | Descrição | | id (Integer, SERIAL PRIMARY KEY) | Número único de uma opção da área de negócio | | Name (String) | Nome da opção | | BusinessAreaId (Foreign Key) | Chave estrangeira que referência o número único da área de negócio | |

# CONCLUSIONS AND RECOMMENDATIONS/DISCUSSION SUMMARY

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