Foundations of Probability Report

University of Strathclyde

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Chapter 1 – Introduction

Maternal health and breastfeeding are critical aspects of early childhood development with far-reaching implications for both the well-being of mothers and infants. The Marmot Review, a landmark analysis of health inequalities in the UK, highlighting the critical role that early life conditions play in shaping physical, intellectual, and emotional development, beginning from prenatal stages. (NHS Tower Hamlets, 2024) This underscores the urgent need for continuous detailed statistical analysis to inform and refine health interventions for mothers and infants.

This study aims to investigate various factors influencing maternal health and breastfeeding practices among new mothers in the Glasgow City Council area of NHS Greater Glasgow and Clyde. The aims of this study are:

1. To determine whether there is any evidence of a significant difference in bump size for those who had a vaginal birth compared to those who had an emergency caesarean.
2. To assess whether there is an association between feeding type (breastfeeding, formula, mixed, or other) and maternal BMI.
3. To explore the distribution of time spent in the hospital after childbirth and identify an appropriate probability distribution model to describe this variable.

By addressing these aims, the study aims to contribute to the existing body of knowledge in maternal and child health, while also providing insights that may aid in the development of targeted interventions and support services for new mothers in the region.

Chapter 2 - Methods

The study utilised data from a simulated dataset based on patterns observed in the "Births in Scotland" and "Infant Feeding" studies, comprising information from 6,150 new mothers in the Glasgow City Council area, collected at two time points: 35 weeks into their pregnancy and during the first visit with their health visitor after childbirth. The dataset encompasses a range of variables, including maternal age, feeding type, breastfeeding initiation, smoking status during pregnancy, type of birth, maternal body mass index (BMI), pulse rate, bump size, iron levels and length of hospital stay after delivery.

The analysis was performed using Minitab software, version 21.1.0. A specific subset of data was generated by initialising a base for random numbers using the student number "202476449" and employing the Bernoulli distribution with a probability of 0.6 for 6150 rows in column C11. Data was filtered to include rows where the value in column C11 was 1, creating a focused dataset for analysis.

Key statistical methods applied included:

- The use of a T-Test to analyse differences in Bump Size between vaginal and emergency caesarean births. This was under the condition the data met the assumptions for the test, meaning the bump size distributions should not deviate significantly from normality. Otherwise, an alternative such as the Mann-Whitney U test would've been warranted.
- Chi-Square Test to explore associations between Feeding Type and Maternal BMI. A data cleansing process was implemented to address several issues within the dataset that could potentially skew the results, including an "Unknown" category within Maternal BMI.
- Probability Distributions Analysis to model the time spent in hospital post birth, using both empirical data analysis and theoretical distribution modelling.

For probability calculations, a combination of Minitab and manual methods were used. These included constructing a probability tree for outcomes relating to smoking and breastfeeding, applying Bayes' Theorem, and employing binomial and gamma distribution to model probabilities and time spent in hospital post-birth.

Chapter 3 – Results

Bump Size Analysis

The T-test was contingent upon the data conforming to relevant statistical assumptions. "Figure 1 - Probability Plot of Bump Size" shows P-values of 1.32 and 0.089 for the "Caesarean – Emergency" and "Vaginal" variables respectively, the results suggest the assumption for conducting a T-test was met. A two-sample T-test was performed in Minitab with the output shown in "Figure 2 - T-Test Output" with a T-value of 0.5, a P-value of 0.612 with the 1633 Degrees of Freedom. This indicates that the mean bump size between the two groups is not significantly different, which suggests the method of delivery (vaginal vs emergency caesarean) does not influence the size of the bump at 35 weeks into pregnancy.

Association Between Feeding Type and Maternal BMI

The Chi-Square Test was conducted to explore the association between feeding type (Breastfeeding, Formula, Mixed) and maternal BMI categories (Underweight, Healthy, Overweight, Obese). The output from Minitab as seen in "Figure 3 - Chi-Square Test Results" showed a Chi-Square statistic of 1.047 with a P-Value of 0.984, indicating no evidence of an association between the feeding type and maternal BMI among the participants. The analysis suggests that maternal BMI does not significantly affect the choice of feeding type for new mothers in this sample.

Time Spent in Hospital After Childbirth

The time mothers spent in hospital after giving birth was analysed to identify an appropriate probability distribution model. The Histogram (as shown in Figure 4) of the time spent indicated a right-skewed distribution, with most mothers staying for a longer duration, this was confirmed with a skewness factor of 1.99. Fitting a selection of plausible probability distributions to the data (as shown in Figure 5 with goodness of fit result in Figure 6) , the Lognormal and Gamma distributions were identified as relatively better fits compared to the Normal and Exponential distributions, despite none of the fits being perfect.

Chapter 4 – Discussion and Conclusion

The bump size revealed no significant difference between the vaginal births and emergency caesarean sections. The finding suggests that the physical characteristic of bump size at 35 weeks is not a predictive method of delivery, challenging any preconceived notions that might exist among expecting mothers and healthcare providers alike. There is little research evidence to support the argument that bump size affects the delivery method, “a big bump is likely to be a reflection of weaker abdominal muscles or shorter stature. It can also be of benign growths in your uterus.” (Pevzner, 2017) This finding across different populations and settings warrants further investigation to confirm its applicability and to explore the underlying factors that contribute to the method of delivery.

The investigation into the relationship between feeding type and maternal BMI found no evidence of this association. This indicates that maternal BMI does not significantly influence the choice of feeding type among new mothers in this study’s context. Some literature such as that by (Amir & Donath, 2007) had suggested that “obese women plan to breastfeed for a shorter period than normal weight women” however, it concluded that “Breastfeeding behaviour is multifactorial, and wide range of socio-cultural and physiological variables impact on a woman’s decision and ability to breastfeed.” (Amir & Donath, 2007)

The distribution of time spent in hospital post-birth was analysed to identify an appropriate probability distribution model. While the Lognormal and Gamma distributions were identified as relatively better fits compared to the Normal and Exponential distributions, neither provided a perfect fit. This indicates variability in recovery times and hospital stay duration that may not be fully captured by these models. (Veazie, Intrator, & Phibbs, 2023) stated that “gamma distribution is commonly used to estimate models of right-skewed variables such as costs, hospital length of stay” validating that the distribution is applicable to recovery time.

The analyses conducted provided insight into several aspects of maternal health and postpartum hospital stay. These results contribute to understanding factors affecting new mothers and their postpartum experiences.

References

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Appendices

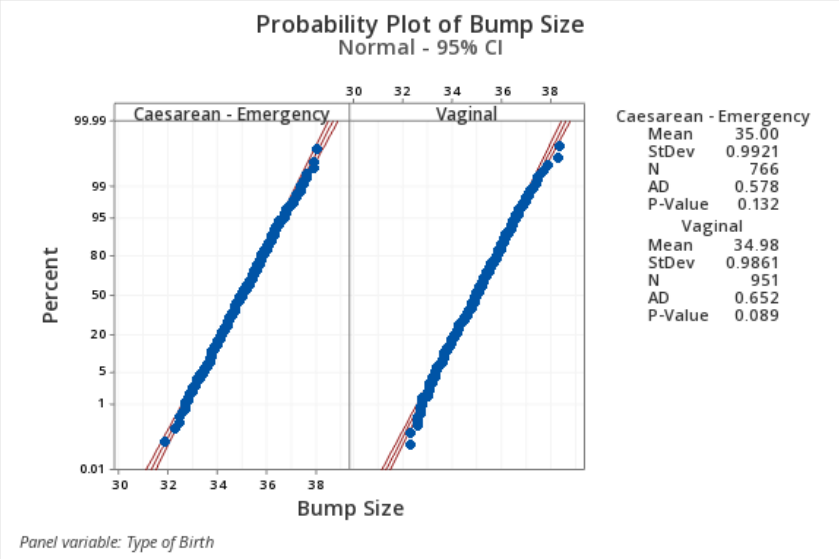

Figure 1 - Probability Plot of Bump Size

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$

Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.51	1633	0.612

Figure 2 - T-Test Output

Chi-Square Test

	Chi-Square	DF	P-Value
Pearson	1.043	6	0.984
Likelihood Ratio	1.047	6	0.984

Figure 3 - Chi-Square Test Results

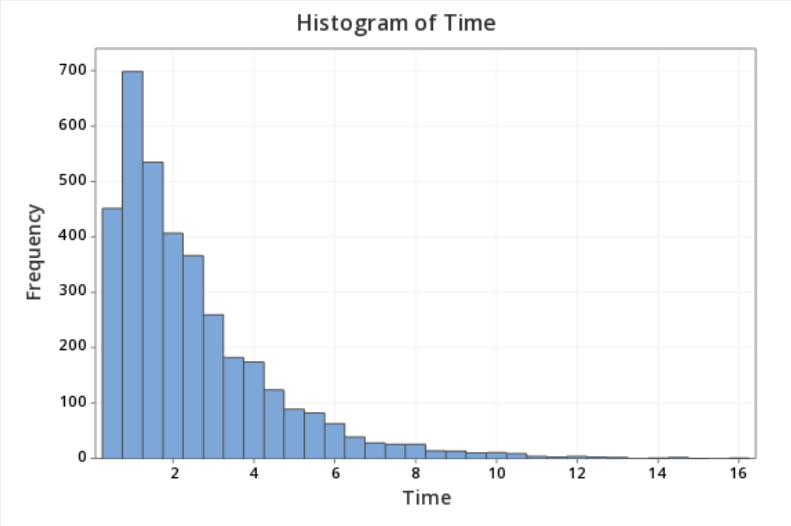

Figure 4 - Histogram of Time Spent in Hospital

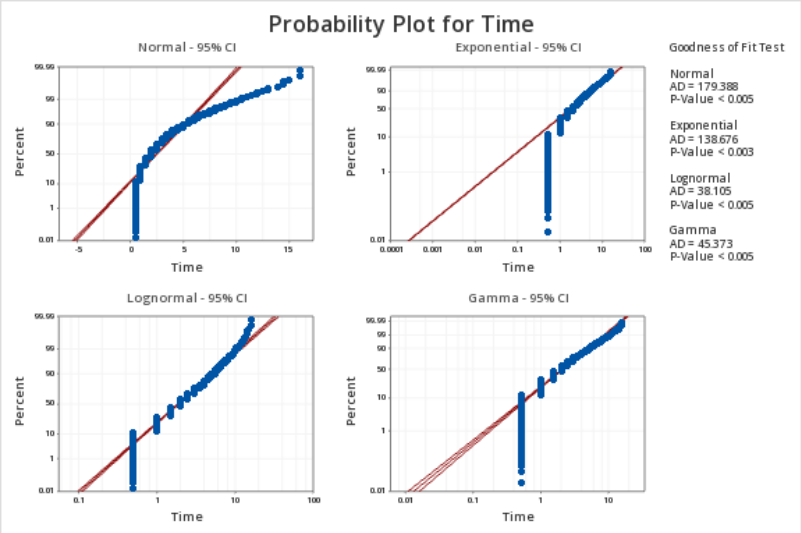

Figure 5 - Probability Plot for Time

Goodness of Fit Test

Distribution	AD	P
Normal	179.388	<0.005
Exponential	138.676	<0.003
Lognormal	38.105	<0.005
Gamma	45.373	<0.005

Figure 6 - Goodness of Fit Test Output