Costs of Hospital Stays for Newborns in the United States

An economic overview and analysis of the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) Data

A Preprint

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Abstract

This project examines the costs of hospital stays for newborns (mainly focus on one complicated birth - prematurity) in the United States using the 2014 Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP) data. Infants whose primary payer was private insurance had the highest average costa and lowest mortality. In terms of social-economic status, the groups with the highest median income while not having the highest average expenditure had the lowest mortality. For inequality in health status, this study observed that African American newborns had the highest mortality, average costs and length of stays at hospitals.

Keywords infants · newborns · prematurity · low birth weight · complicated births · preterm birth · hospital costs · HCUP

Contents

1 Introduction

Over the years, considerable research attention has been devoted to childbirth costs in the United States.The cost and expenditure of giving birth vary from country to country. And it is usually considered to be "very expensive" in the United States. According to the National Center for Health Statistics, Centers for Disease Control and Prevention, in the United States, the annual number of births is about 3.8 million. Among all the births, 8.3% are low birth weight infants. For every ten newborns, there is one preterm baby.In 2008, the total national hospital bill in the U.S. was about $1.2 trillion (Wier & Andrews, 2011). Principal diagnoses related to mothers' pregnancy and delivery, and newborn infants accounted for 4.8% and 3.7%, respectively, of the total hospital care bill. The overall national hospital bill to newborn infants was nearly 43 billion dollars, compared with osteoarthritis ($40 billion), acute myocardial infarction ($38 billion), congestive heart failure ($35 billion), pneumonia ($32 billion), and diabetes mellitus with complications ($15 billion). One factor that contributes to the expensive bill to newborn infants is complicated births. Preterm birth/low birth weight, respiratory distress syndrome (a disorder that results in requirements for breathing assistance or extra oxygen supply to infants) and jaundice are the most prevalent complicated birth diagnoses (Fowler et al. 2014). In 2009, newborns with gestational age less than 37 weeks and or birth weight less than 2,500 grams and with respiratory distress syndrome accounted for 23% and 18% of all complicated births, respectively. These two diagnoses accounted for 33% (preterm birth/low birth weight) and 28% (respiratory distress syndrome) of the aggregate cost for complicated births. Altogether, more than 6.5 billion dollars spent on preterm birth/low birth weight and respiratory distress syndrome. This project will mainly focus on preterm infants and analyze the cost and demand for medical care, major determinants of health, and the inequalities in the health of newborns in the United States.

2 Data and Methodology

2.1 Data Source

The data source is the 2014 Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP). The 2014 Nationwide Inpatient Sample (NIS) contains 7,071,762 hospital stays (about 20% of all hospital stays in the U.S.). Each observation includes demographic information (gender, race, median household income national quartile for patient ZIP code), total charges, expected primary payer, length of stay and up to 30 diagnoses and up to 15 procedures.

2.2 Variable Definitions

Hospital stays of newborns were defined using the Neonatal age (first 28 days after birth indicator) in the NIS dataset. There are 794,142 newborn stay observations. Diagnoses and procedures were coded following the International Classification of Diseases, 9th Revision - Clinical Modification (ICD-9-CM). To distinguish groups of preterm/low birth weight infants and "extremely preterm/low birth weight infants," two indicators were generated using (ICD-9-CM) diagnoses codes: 76501-76503, 76514-76518, 76521-76528. Preterm/low birth weight stays were defined by gestational age < 37 weeks and or birth weight < 2,500 grams (Fowler et al. 2014). "Extremely preterm/low birth weight" stays were defined by gestational age < 38 weeks and or birth weight < 1,000 grams (Russell et al. 2007). Respiratory distress syndrome in newborns was identified using (ICD-9-CM) diagnoses code: 769. SAS software (SAS Institute, Cary, NC) and R software (R Core Team, 2020) were used to handle and manipulate the database, to generate a specific data set for following statistical analysis and modelling. For this project, all observations with missing values were removed. Therefore, there were 610,341 valid observations used for the following analysis.

Details concerning of variables are summarized below:

Quantitative Measures:

- Charge: Total Charge ($)
- LOS: Length of Stays (days)
- NPR: Total Number of ICD-9-CM Procedures
- NDX: Total Number of ICD-9-CM Diagnoses

Categorical Factors:

- pt: Preterm Indicator, YES = 1, NO = 0
- RC_NA: Race Indicator Native American, YES = 1, NO = 0

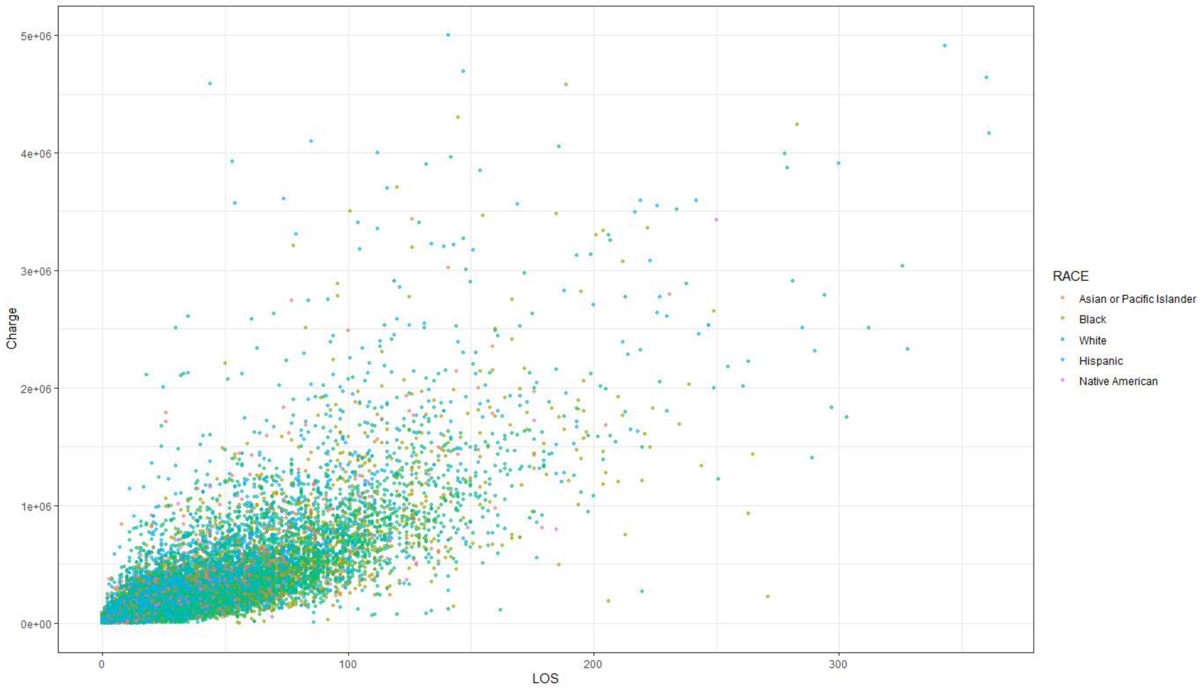

Figure 1: Length of Stay v.s. Charge grouped by RACE

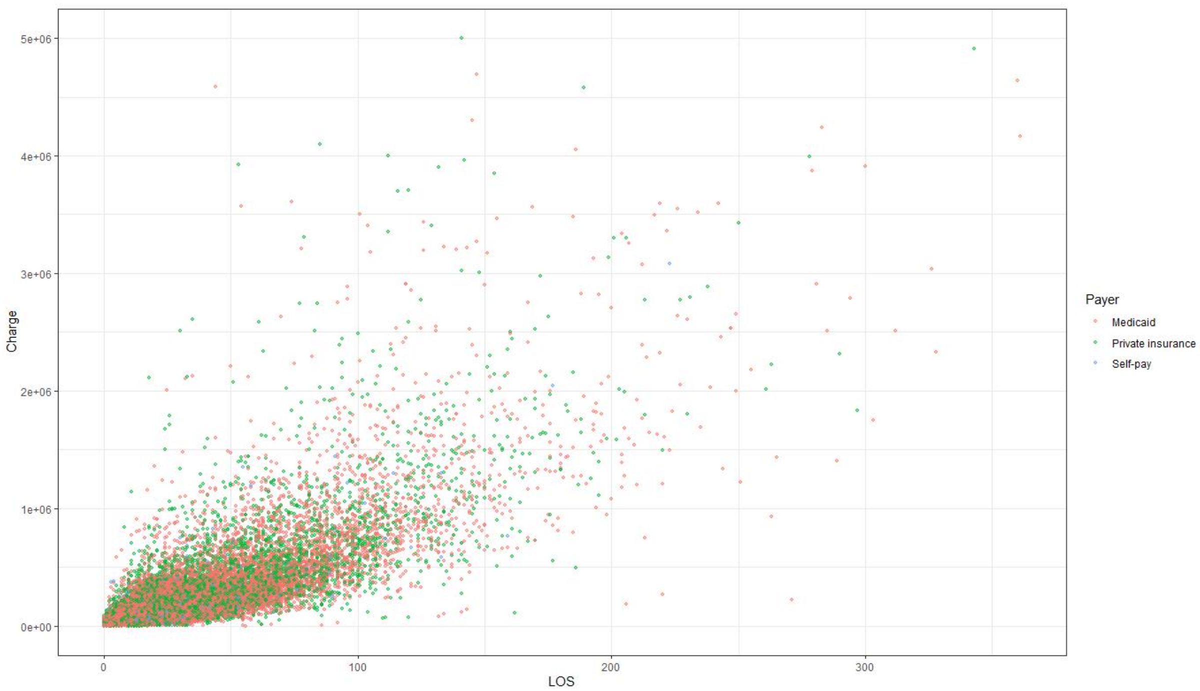

Figure 2: Length of Stay v.s. Charge grouped by Payer

- RC_A: Race Indicator Asian or Pacific Islander, YES = 1, NO = 0
- RC_H: Race Indicator Hispanic, YES = 1, NO = 0
- RC_B: Race Indicator Black, YES = 1, NO = 0
- RC_W: Race Indicator White, YES = 1, NO = 0
- ID_NE: Census Division Indicator New England, YES = 1, NO = 0
- ID_MA: Census Division Indicator Middle Atlantic, YES = 1, NO = 0
- ID_ENC: Census Division Indicator East North Central, YES = 1, NO = 0
- ID_WNC: Census Division Indicator West North Central, YES = 1, NO = 0
- ID_SA: Census Division Indicator South Atlantic, YES = 1, NO = 0
- ID_ESC: Census Division Indicator East South Central, YES = 1, NO = 0
- ID_WSC: Census Division Indicator West South Central, YES = 1, NO = 0
- ID_MT: Census Division Indicator Mountain, YES = 1, NO = 0
- ID_PC: Census Division Indicator Pacific, YES = 1, NO = 0
- RDSI: Respiratory Distress Syndrome Indicator, YES = 1, NO = 0
- PYM: Primary Payer Indicator Medicaid, YES = 1, NO = 0
- PYP: Primary Payer Indicator Private Insurance, YES = 1, NO = 0

2.3 Methodology

2.3.1 Principal Components Analysis

Principal components analysis (PCA) is one of the unsupervised learning techniques that is used to visualize and pre-process data. Many large data set contains multiple variables which might be highly correlated and will lead to multicolinearity in the predictive model. To reduce the complexity of the model, principal components can summarize as much of the variability as possible in the data by using lower-dimensional representation (James et al, 2013). For a data set with n observations and p variables, $X_1, X_2, ..., X_p$, the first component is defined as

$$Z_1 = \phi_{11}X_1 + \phi_{21}X_2 + ... + \phi_{p1}X_p \tag{1}$$

where $\phi_{11}, ..., \phi_{p1}$ are called the loadings of the first principal component. Each principal component is a normalized linear combination because its loadings are constrained and the sum of square of each loading is 1. For a data set with n observations and p features, a $n \times p$ data $\mathbf{X}$. The loadings of the first principal component is computed by solving the object function

$$\underset{\phi_{11},...,\phi_{p1}}{\arg\max} = \left\{ \frac{1}{n} \sum_{i=1}^{n} \left(\sum_{j=1}^{p} \phi_{ji} x_{ij} \right)^2 \right\} \tag{2}$$

subject to $\sum_{j=1}^{p} \phi_{ji}^2 = 1$. The second principal component can be determined after the first principal component has been computed. The second principal component Z_2 is a normalized linear combination uncorrelated with the first principal component Z_1. Using $\phi_k = (\phi_{k1}, \phi_{21}, ..., \phi_{p1})$ to denote the loading vector of the kth principal component, the direction of ϕ_1 is orthogonal to the direction of ϕ_2 (James et al, 2013).

2.3.2 Statistical Tests

This project used the following tests to examine the difference between groups.

- Scheffe's Test
- Kruskal-Wallis Test
- Wilcoxon rank-sum Test
- Pearson's Chi-square Test
- Fisher's Exact Test

Scheffe's test is used to compare multiple groups pairwisely. The Kruskal-Wallis test is a nonparametric method and used when the normality assumption is invalid (Montgomery, 2012). Wilcoxon rank-sum test is the nonparametric alternative to the two-sample t-test. The Pearson Chi-Squared Test for Goodness of Fit is used to test the homogeneity between groups (Ramsey & Schafer, 2012), and the Fisher's exact test is used when the normal approximation to the binomial distribution is invalid (Rosner, 2015).

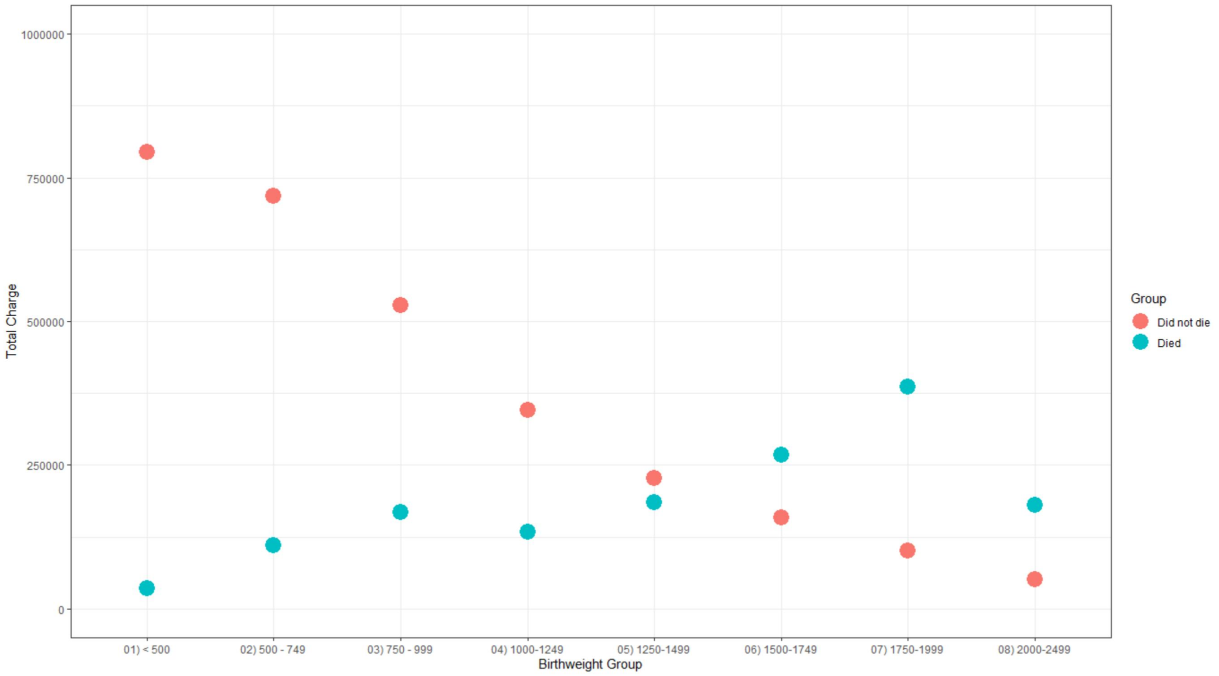

Figure 3: Mean of Total Charge by Birth-weight Group

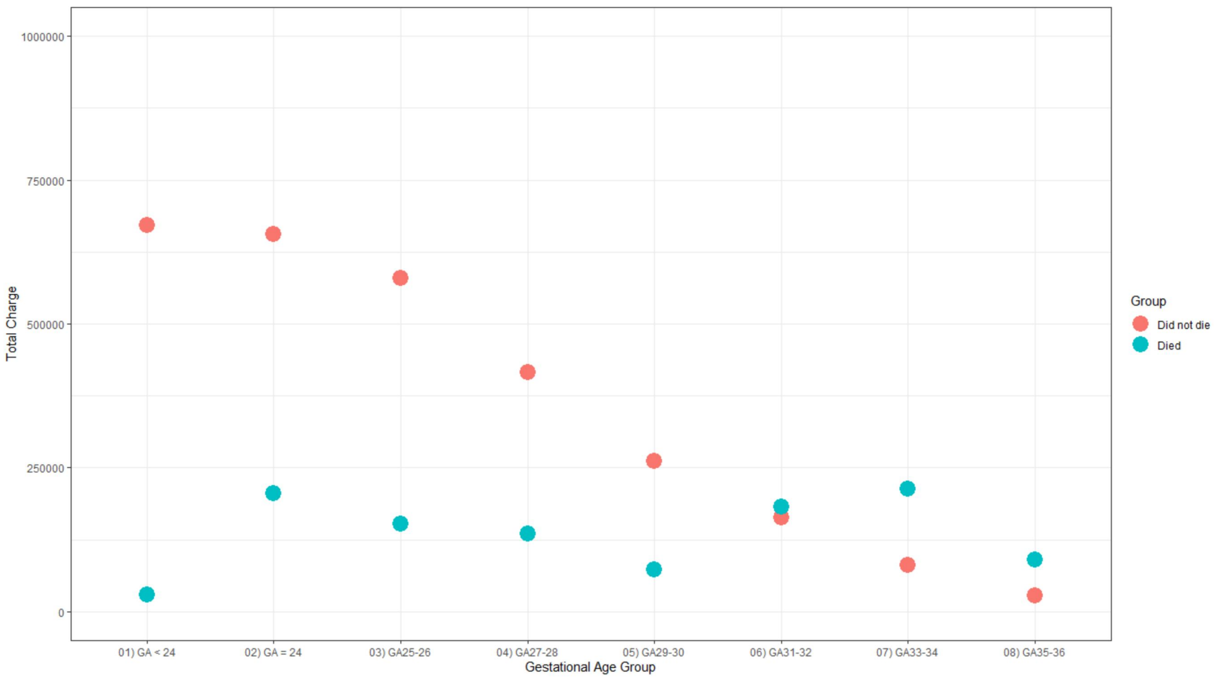

Figure 4: Mean of Total Charge by Gestational Age Group

3 Analysis and Results

Figure 1 presents the scatter plot of length of stay versus total charge, with each payer group being highlighted. Although most of the infants stayed at hospitals for less than ten days and paid a total amount less than \$10,000, there were still many outliers in terms of total charge and length of stay. The highest values observed for length of stay and total charge were about more than 350 days and around \$5,000,000. There was a linear relationship between the charge and length of stay. Nevertheless, the linear association was not strong since we observed many infants who stayed at hospitals less than 50 days and still pay more than \$1,000,000 and infants who stayed at hospitals for more than 50 days while paying less than \$500,000. This less clear pattern implies that, other than the length of stay, other observed and unobserved features might contribute to the total charge. Medicaid and private insurance were the most popular primary payers for the hospital charge, and only a small proportion of newborns were uninsured/self-pay. Figure 2 shows the same scatter plot with racial groups highlighted. Among all observations in the analyzed data, most babies were from the White, Black, or Hispanic groups.

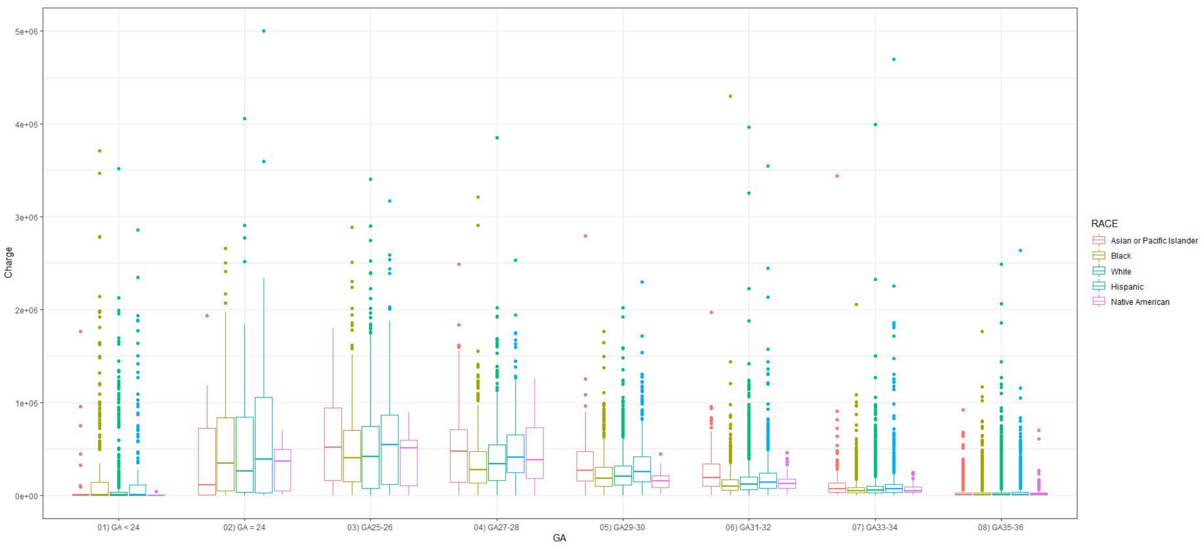

Figure 5: Mean of Total Charge by Birth-weight Group

Figure 3-4 display the relationship between birth-weight/gestational age and total charge. For infants who did not die at the hospitals, the average total cost falls as the birth-weights increases. For newborns who did not survive at the hospitals, the average total charges were relatively low at lower birth-weight (less than 1000 grams) but high at higher birth-weight. A similar pattern also existed for the relationship between gestational age and the average total charge. Figure 5-6 provides more details about the distributions of charge in each birth-weight/gestational age groups by race. In both figures, except for the group with the lowest birth-weight or gestational age, the median cost, for all racial groups, goes down as the birth-weight/gestational age increase. Among all premature babies, those who had birth-weight less than 500 grams or and gestational age less than 24 weeks suffered the highest mortality rate. Also, the numerous outliers in each box plot indicate that there could be other features than birth-weight and gestational age, to influence the total cost.

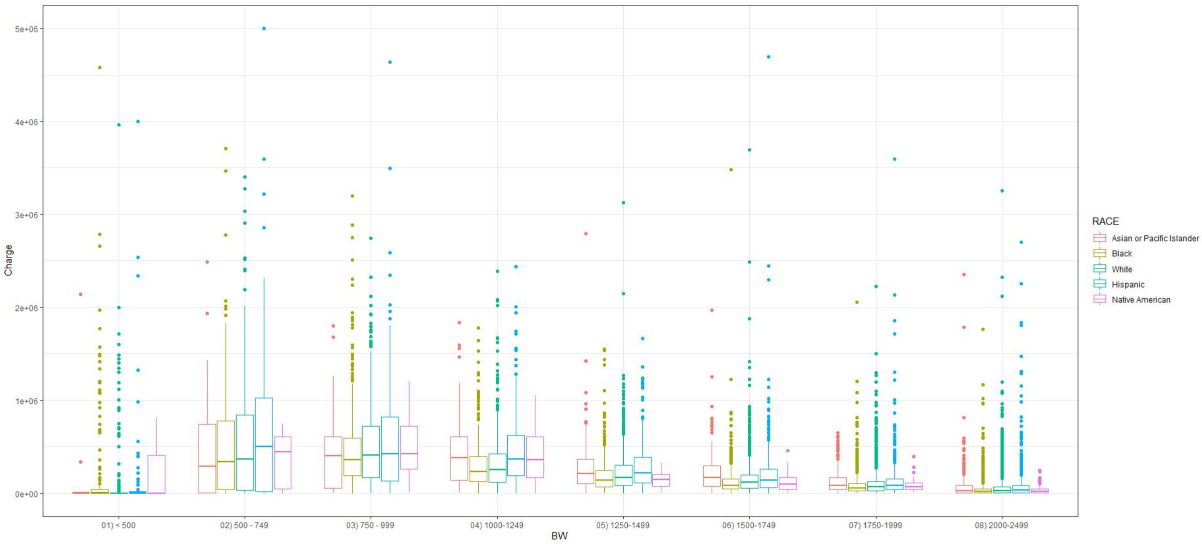

Figure 6: Mean of Total Charge by Birth-weight Group

Figure 7 demonstrates the plot of the first two principal components. Charge, Medicaid, and private insurance are the three most influential features to the first and second principal components. Number of diagnoses, length of stay, number of procedures were positively correlated with the total charge. Preterm and respiratory distress syndrome indicators, while also having positive correlations to the total cost, had less contribution than NDX, LOS, and NPR. Infants in the Middle Atlantic and New England had more expensive hospital bills than those in other hospital divisions. Black and Hispanic groups tended to use Medicaid, and the While group tended to select private insurance. The Black race indicator and the South Atlantic division indicator had a similar direction. Also, both the Hispanic race indicator and the Pacific division indicator had a similar direction. In Figure 8, the correlation between the Black group indicator and the South Atlantic division indicator was 0.19, and the correlation was 0.23 between the Hispanic group and the Pacific division. Similar information was observed in Figure 12, as African Americans comprise more proportion of the population in the South Atlantic division than in other divisions.

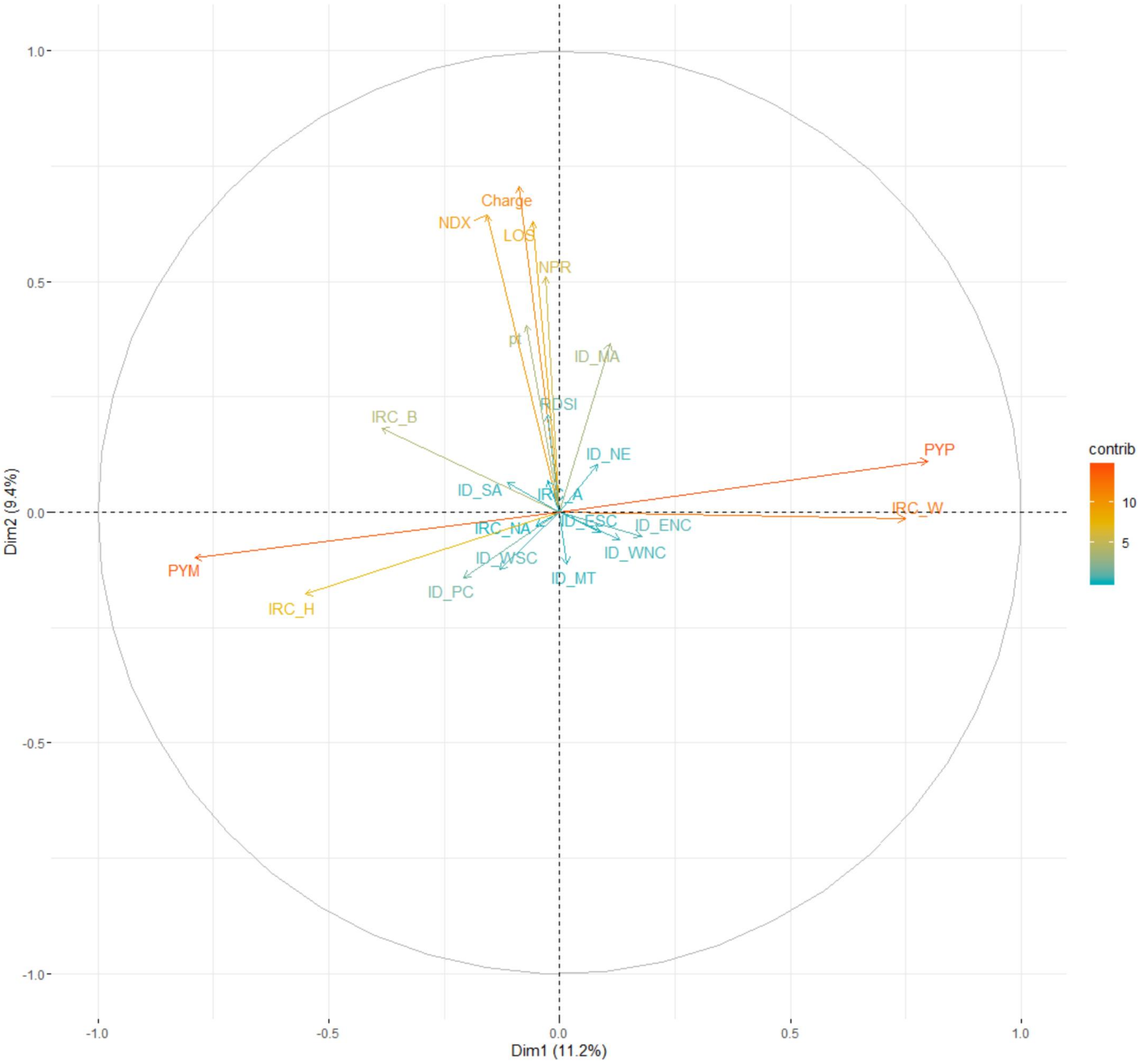

Figure 7: PCA biplot

4 Discussion

4.1 Cost and Demand for Medical Care

The RAND Health Insurance Experiment (HIE) in the 1970s is one of the most important social science experiments in history (Gruber, 2006). This experiment enrolled and randomly assigned

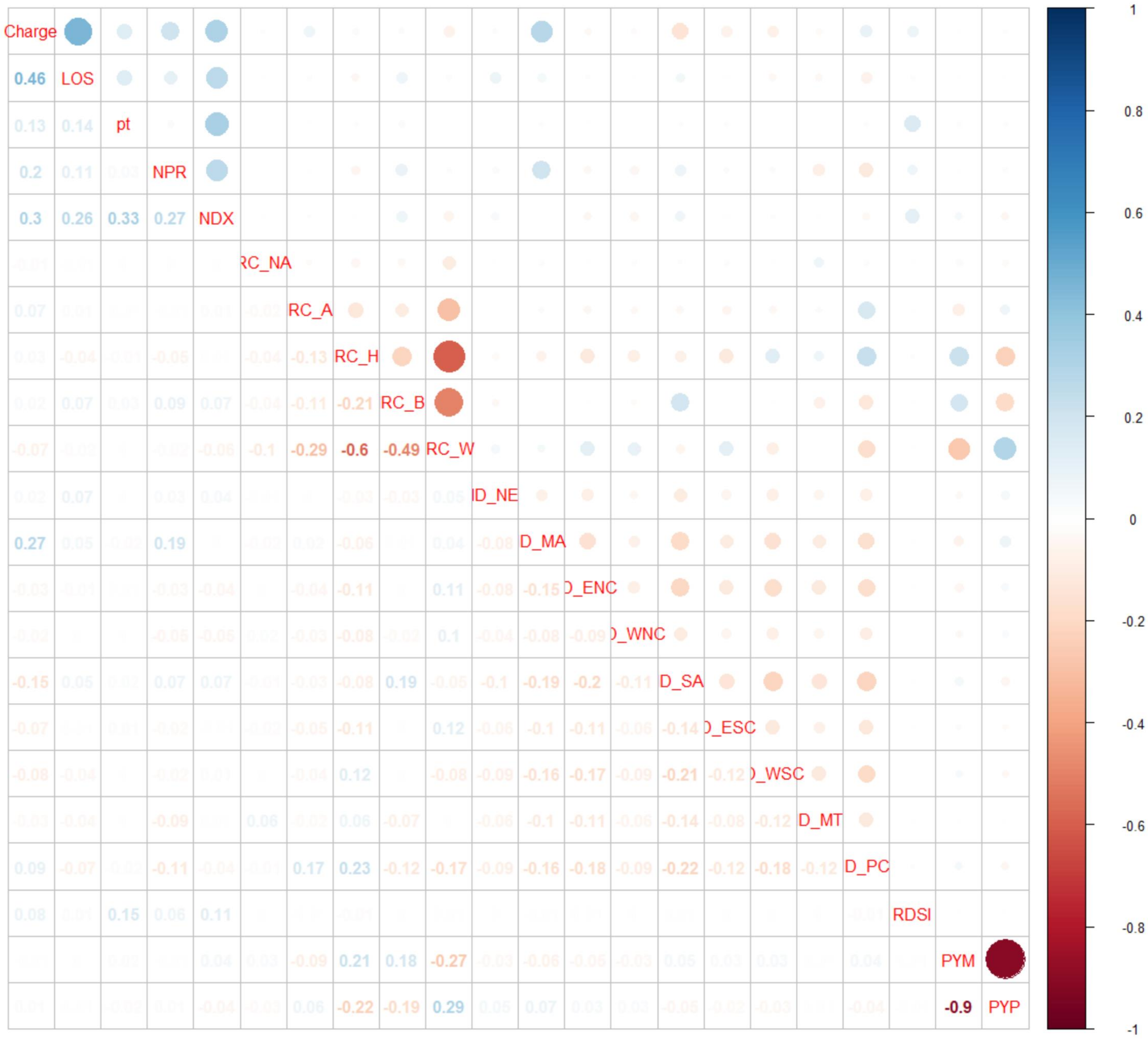

Figure 8: Correlation Plot

different insurance plans to several thousand families from six sites: Dayton, Ohio; Seattle, Washington; Fitchburg, Massachusetts; Franklin Country, Massachusetts; Charleston, South Carolina; and Georgetown County, South Carolina (Manning et al., 1987). Each participating family was designated to one of the four insurance plans with varying level co-insurance rates: free care plan (0 co-insurance), 25% co-insurance plan, 50% co-insurance plan, and 95% co-insurance plan. There is also an upper bound on each family's out-of-pocket health care expenditure per year. The maximum of out-of-pocket spending (the Maximum Dollar Expenditure, MDE) has three levels of (5%, 10%, and 15%) of the annual income of the family. The upper limit of MDE is $1,000. That is to say, regardless of the types of insurance plans, each family would pay at most $1,000 per year on

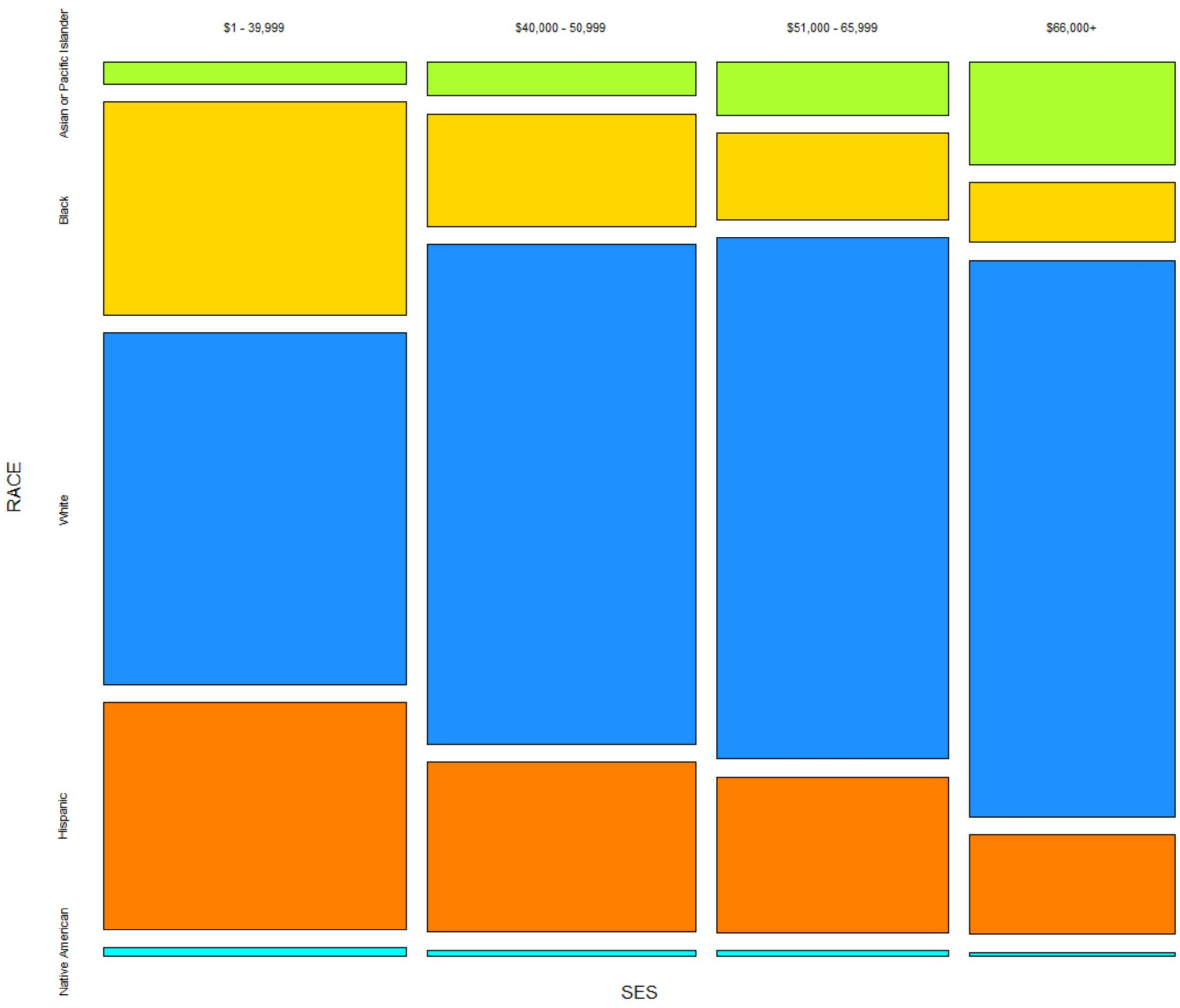

Figure 9: Mosaic Plot: SES v.s. RACE

virtually all medical services. The insurance plan will cover all of the expenses, which are exceeding $1,000.

From Manning et al. (1987), 86.8% of the participants in the free care plan use medical services. This percentage of using any medical services falls as the co-insurance rates increasing. For participants in the 25 percent co-insurance plan and 50 percent co-insurance plan, the probabilities of utilizing any care are 78.8% and 77.2%, respectively. The utilization of medical services is the lowest for the group with the highest (95 percent) co-insurance rate, with only 67.7% of participants used medical services.The number of face-to-face visits and outpatient expenses also falls as co-insurance rates increase. However, no clear pattern was observed between the co-insurance rates and inpatient expenses. The p-value is greater than 0.5 when comparing three groups with co-insurance rates 25%, 50%, and 95%. As Manning et al. (1987) pointed out, the maximum out-of-pocket spending might cause this unclear pattern and non-statistical significance. In this experiment, about seventy percent of the inpatient medical services costed more than the MDE. Therefore the expenditure of hospital stays did not vary much as the maximum costs were $1,000.

In the NIS data, around 5% (30,055) newborns were uninsured/self-pay. This study only considered three types of primary payers: Medicaid, Private insurance, and Self-pay. The average charges for infants used Medicaid was the highest ($19,419.98). For babies whose primary payer is private insurance, the mean cost is $15,262.26, $4,000 less than that of Medicaid. The charges of self-pay/uninsured infants were the lowest, with an average of only $9,015.16. The Scheffe's Test also shows that these three groups were pairwise significantly different. This result might raise an economic question: do the principal-agent problem, and physician-induced demand exist in infant inpatient medical services? As patients were usually less informed about who much services they need exactly, the hospital can provide excessive care and hence charge patients more. Most patients with any insurance only have to pay a small portion of the true expenses, so they are also less elastic to the unnecessary care recommended by the providers. Assuming that the principal-agent problem does exist, three payer groups should receive care of the same quality.

To further investigate the principal-agent problem, each payer group was stratified into two subgroups (preterm and non-preterm). Among all preterm infants using Medicaid or private insurance, the average charges were $110,929.12 and $100,908.86, respectively. For self-pay/uninsured premature babies, the mean cost was $45,495.63, which is less than half of the amount for either Medicaid or private insurance group. However, the mortality of the self-pay/uninsured preterm group was 6.53%, higher than that of Medicaid (2.64%) or private insurance (2.17%) groups. The difference in mortality of three groups might imply that Self-pay/uninsured preterm group received lower-quality medical services.

Among all non-preterm infants using Medicaid or private insurance, the average charges were $9672.78 and $7728.10, respectively. For self-pay/uninsured non-preterm babies, the mean cost was $6081.56. Again, the Scheffe's Test indicates that these three groups were pairwise significantly different. To use mortality as a measurement of the medical service quality, among all non-preterm infants, he private insurance group, which did not have the highest average expenditure, had the lowest mortality rate (0.08%), compared with Medicaid (0.12%) and Self-pay/uninsured (0.14%) groups. The non-inverse proportion between average cost and mortality might be due to the unsymmetrical distribution of hospital charges. The median charges for the three groups are $3493 (Medicaid), $3511 (private insurance), and $3252.5 (self-pay/uninsured). The Kruskal-Wallis test (a non-parametric alternative to ANOVA) was applied in this case where normality assumption is invalid. The p-value is less than 0.00001, and we conclude that the median costs of three non-preterm groups were significantly different. To only compare the median expenditure between non-preterm Medicaid and private insurance groups, Wilcoxon rank-sum test gave p-value = 0.0013. Hence the median between these two groups with health care plans was also significantly different.

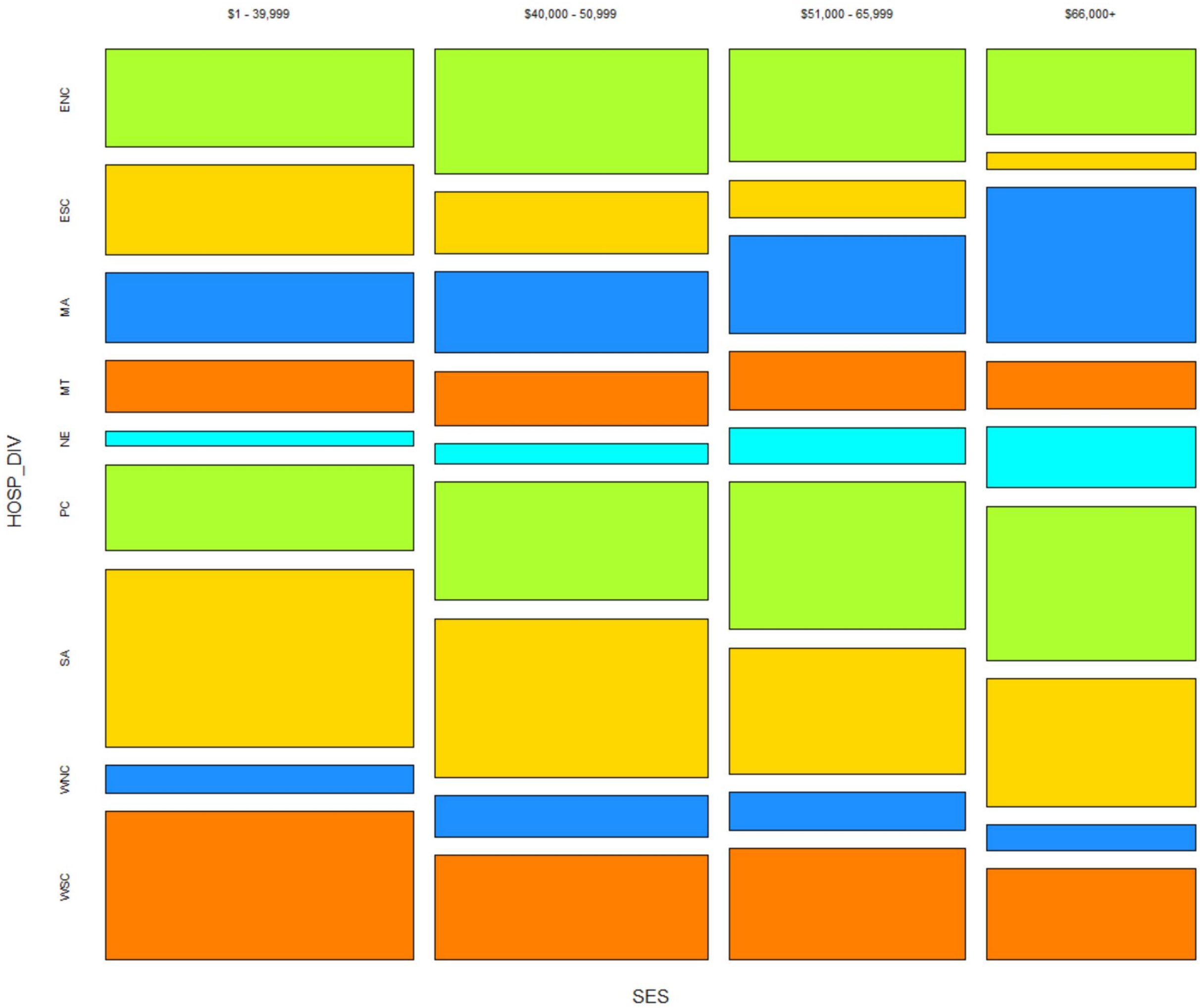

Figure 10: Mosaic Plot: SES v.s. Hospital Division

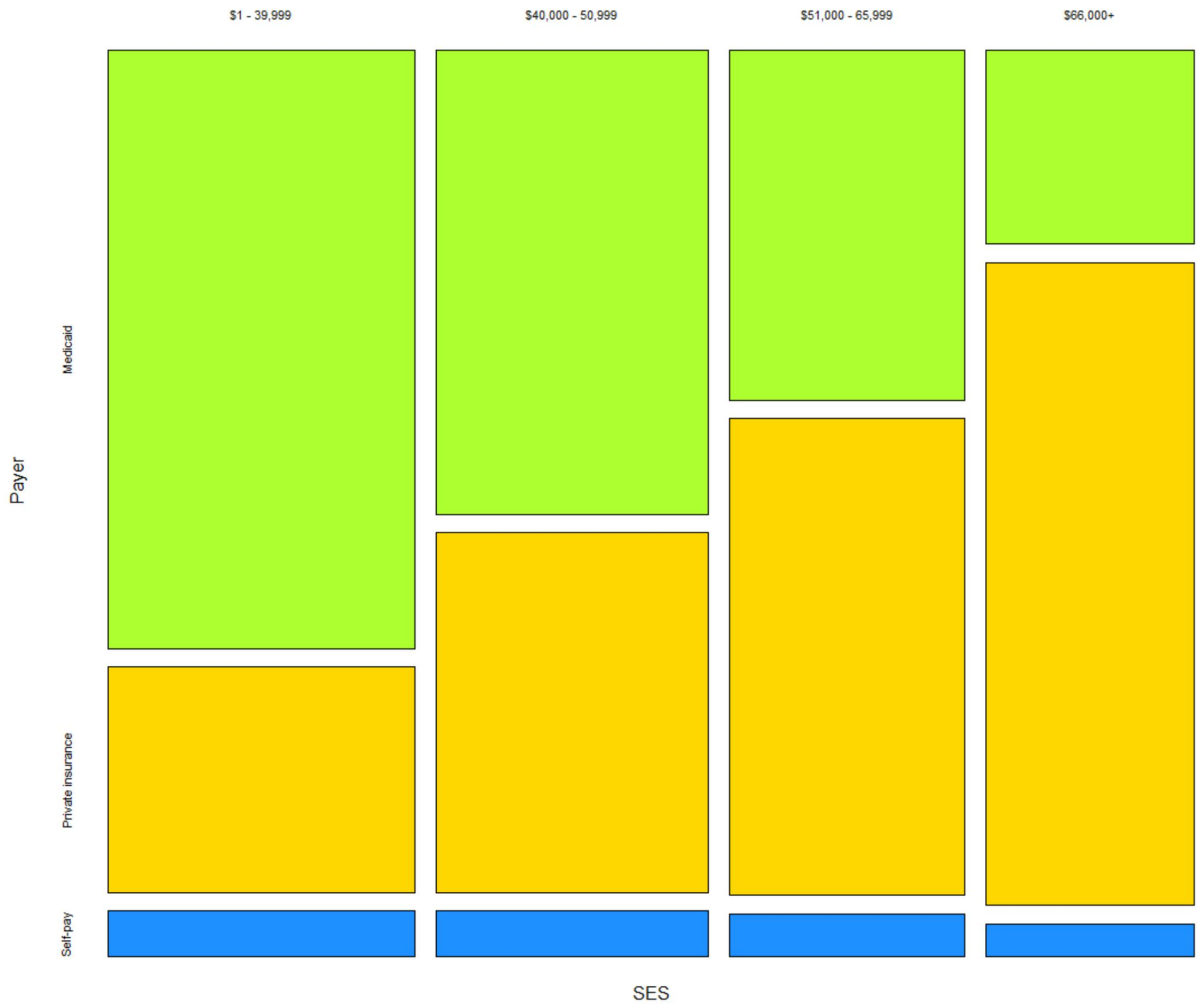

Figure 11: Mosaic Plot: SES v.s. Primary Payer

4.2 Income: A major determinant of newborn health?

Income has always been considered as an essential determinant of health in the health production function for all age-groups. The research of Deaton and Paxson (2001) examined the relationship between income and mortality of two countries (the US and Britain) in the second half of the 20th century and did not observe a clear relationship between infant mortality and incomes. Deaton and Paxson's research focused on the time-series patterns and might not take the development in technology into account since the improvement in medical treatments has been remarkably impacting the mortality for all age-groups. In the NIS data, the median household income for the patient's ZIP Code was recorded for each newborn. This variable is ordinal and can help us to identify the poorest to the wealthiest populations. Group 1 is the population with the lowest median income below $39,999. Group 2 and 3 are the population ranked in the middle, with a median income of $40,000 to $50,999 and $51,000 to $65,999. Group 4 is the wealthiest population with a median income above $ 66,000. For all newborns in the analyzed data, group 1 had the highest mortality (0.41%). The mortality falls as the median income rise (group 2, 0.34%; group 3, 0.29%; and group 4, 0.21%). The p-value of the Pearson's Chi-squared test was less than 0.00001 and indicated the mortality rates were different significantly among four groups.

Each income group was stratified into two subgroups (preterm and non-preterm), to investigate further the role of income as a health determinant. Again for both the preterm and non-preterm populations, mortality goes down as the median income goes up. The mortality rate of the non-preterm group 4 was only 0.07%, which was fifty percent lower than that of non-preterm group 1 (0.14 %). In terms of the cost and expenditure, the non-preterm group 1, while having the highest mortality rate, also had the highest average charge ($ 8866.13), compared with that of non-preterm group 1 ($ 8670.23). The high cost for the group with the lowest median income might be due to the highest average length of stay (2.65 days) and the highest average number of diagnoses (3.05). The Scheffe's Test shows that for all non-preterm babies, both the average length of stay and the average number of diagnoses for group 1 were significantly different from that of the other three groups. This difference might imply that non-preterm babies from the lowest income group tend to be less healthy than non-preterm infants from other wealthier groups. The wealthiest non-preterm group, having the lowest mortality, also had the highest average number of procedures on their records. The Scheffe's Test indicates that the average number of procedures of group 1 was significantly higher than that of the other three groups.

For the preterm population, the average cost of the preterm group 1 was $113,153.53, which was significantly higher than the other three preterm groups based on the results of Scheffe's Test. The median expenditure of the preterm group 1 was also the highest ($4050.0) among all four preterm groups, compared with group 3 ($3483.0), group 2 ($3284.0), and group 1 ($3357.0). The Wilcoxon rank-sum test gave a p-value = 0.0003586 and concluded that the median cost of preterm group 1 was significantly higher than group 3 (the second-highest median cost group). The richest preterm group, while not having the lowest average number of diagnoses, had the lowest average length of stay at the hospital and the highest average number of procedures. Based on the Scheffe's Test, the average length of stay were not significantly different among preterm group 2-4. The average number of procedures for preterm group 1 was significantly different from that of preterm group 2 and 3, but not significantly different from preterm group 1.

Several factors might contribute to this insignificant difference among preterm groups. First, the parents' actual income level might not be accurate because this variable is based on the ZIP Code instead of interviewing or surveying the parents. Parents who were supposed to be in the wealthiest group were living in the region with lower income or vice versa. Second, information, such as occupation and education level, regarding the parents' socioeconomic status were not given by the NIS data. For instance, a parent whose occupation is a dietitian and or has a Master of Public Health might contribute positively to the baby's health status, regardless of the actual income. Last, there were other unobserved characteristics of the parents, which could be strongly correlated with an infant's birth weight. For example, there is a strong negative correlation between maternal smoking and infants' birth weight (Huxley,2013). If a mother smoked in pregnancy was not recorded in the NIS data. Even if the maternal smoking status was provided, the smoking status of other family members (e.g. father, brothers/sisters) might also impact the birth weight of an infant negatively due to exposure to second-hand smoke. It is a challenging undertaking to measure various potential determinants of premature babies, such as maternal mental health, lifestyle. For instance, how well a new immigrant mother to adapt her life in the new environment might affect the birth weight of the baby.

4.3 Inequalities in Health

Considerable amount of efforts have been made to reduce the inequalities in health among different ethnic groups. For instance, the difference in life expectancy between African Americans and the white was 3.7 years in 2016, compared with 8.3 years in 1950 (Williams and Cooper, 2019). However, the racial gap still exists. In the NIS data, there were five racial groups: Asian or Pacific Islander, Black, Hispanic, Native American, and White. Among all infants, the black group had the highest average charge ($21,625) and mortality rate (0.58%). Pearson's Chi-square test shows that the mortality rates of all groups were different significantly. To only compare the mortality rates between the black group and Hispanic groups (second highest mortality), Fisher's Exact Test gave a p-value < 0.00001 and concluded that the mortality rate of the black group was the significantly highest. Regarding the overall cost, the black group was significantly higher than the other four

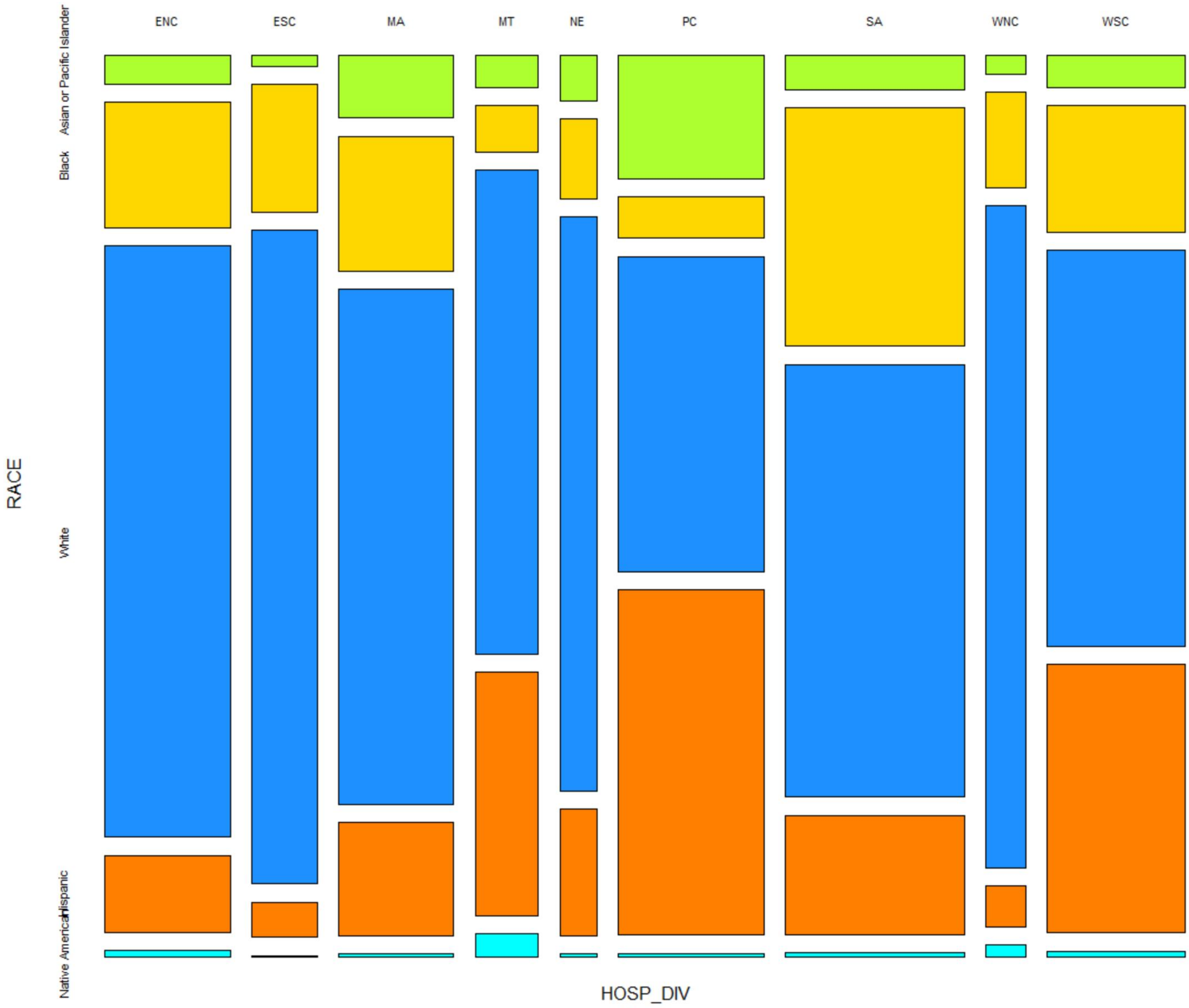

Figure 12: Mosaic Plot: Hospital Division v.s. RACE

groups, and the average expenditure was not significantly different among Asian or Pacific Islander, Native American, and White groups by Scheffe's Test. The black groups also had the significantly highest average length of stay at hospitals, while the average length of stay for Asian or Pacific Islander group was 3.33 days, being significantly lowest among all five groups.

The analyzed population was divided into two strata: preterm and non-preterm groups. Among all non-preterm infants, the Hispanic and Black groups had the top two highest average expenditure ($9,504.90 and $9,144.65). The non-preterm Black group, while not having the highest average expenses, suffered the highest mortality rate (0.15%), length of stay (2.77 days), and the average number of procedures (1.11). The non-preterm Asian or Pacific Islander group had the highest median cost ($4418.5) and the lowest mortality rate (0.06%). The non-preterm White group and the Hispanic group had the lowest average number of diagnoses (2.89) and the lowest average number of procedures (0.84) on record. For the preterm population, The preterm Hispanic and Asian or Pacific Islander groups had paid the most expensive bills, on average of $122,642.69 and $115,801.68, respectively. The preterm White group, however, spent only $93,272.49 on average, which was significantly lower than the Asian or Pacific Islander, Hispanic, and Black groups by Scheffe test. The preterm Hispanic group, while paying the most expensive hospital bills, did not have the lowest mortality rate. Its mortality rate was 2.68%, higher than those of the Asian or Pacific Islander (2.12%), White (2.21%) and Native American (2.20%). The preterm Black group had the highest mortality rate (3.71%), and length of stay at hospitals (18.43 days). Its average length of stay was significantly higher than those of the Asian or Pacific Islander, Hispanic, and White groups.

The health status pattern of the Black group was clear, regardless of the presence of premature conditions. The Asian or Pacific Islander group and the Hispanic group, however, demonstrated less apparent patterns. Within these two populations, a large proportion was immigrants from other countries. The research of Williams and Cooper (2019) suggested that immigrants have a positive impact on the health profiles of the Asian or Pacific Islander and Hispanic populations. The mortality rates of immigrants, regardless of the racial groups, are lower than their native-born compatriots, although this advantage in health status will diminish in the long run. The NIS data did not provide the indicator of being an immigrant or a "recent" immigrant for each record.

Previous researches have found that inequalities in health between racial groups can be reduced effectively with proper interventions (Williams and Cooper,2019). Perry Preschool Program (PPP) was a randomized controlled trial with 37 years of follow-up in neighbourhoods of Ypsilanti, Michigan, to examine the impact of early childhood intervention to life-long health status (Muennig et al., 2009). The PPP targeted preschool African American kids from low-income households. This experiment recruited 123 kids, who were randomized to receive daily academic assistance and home visits or to be in the control group with no intervention. All the instructors who participated in this program had postgraduate degrees and completed related training. Although the intervention group, at age 10, did not have advantages in IQ scores, the treatment group was found to have better academic achievement due to better motivation of study (Heckman, 2006). Dramatic positive impacts on the treatment group, at age 40, were observed as they had higher income, homeownership rates and fewer criminal records than the control groups. The intervention group also received less welfare assistance than the control groups, which might imply that the control group had better insurance coverage. The Abecedarian project based in North Carolina is another experiment of the life-time impact of childhood interventions. This program, initiated in 1972, recruited 111 newborns (98% African American) who were assigned to either the control group or the early educational intervention group (Compbell, 2008). This study found that, at age 21, the intervention group had higher four-year college completion rates, employment rates, skilled job rates and a lower percentage of being a teen parent (< 19 years) than the control group. In terms of lifestyle and behaviour, the young adults in the intervention group were more likely to be living in an active lifestyle and to use seat-belts, meanwhile had less likely to smoke and use marijuana. Early childhood intervention was also proved to reduce the probability of having mental health problems at age 21 (McLaughlin et al., 2007).

5 Conclusion

From the previous studies and the statistical analysis of the NIS data, we observed that costs associated with premature conditions place a significant economic burden on the United States. There was still about five percent of newborns were not covered by the current insurance system. Potential inequalities in the newborns' health status were also observed from the NIS data. Proper intervention (e.g. education to parents) might be necessary to improve both the health status of infants, meanwhile reducing the economic burden, in the future.

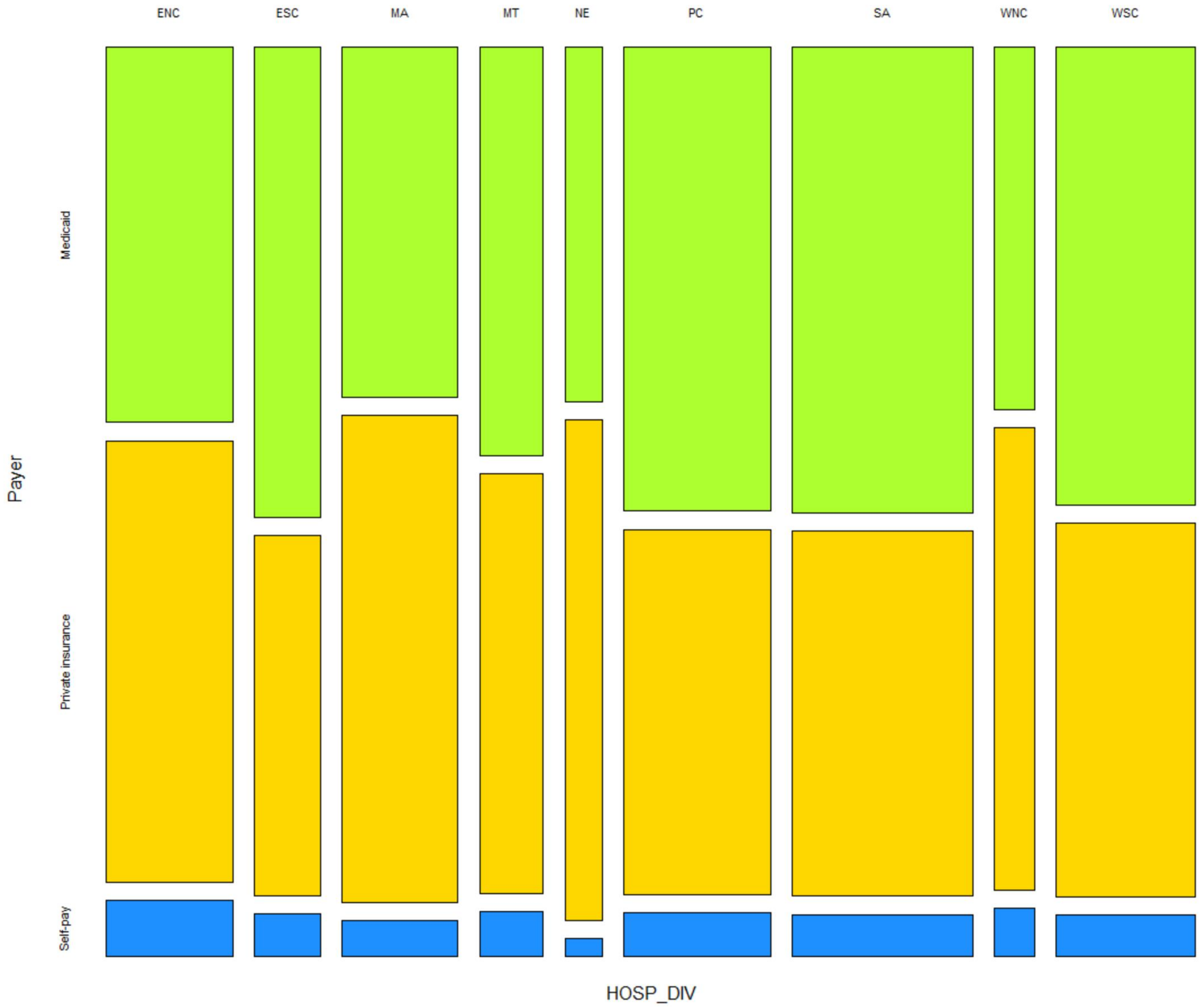

Figure 13: Mosaic Plot: Hospital Division v.s. Primary Payer

References

[1] Wier, L., & Andrews, M. (2011) The National Hospitall Bill: The Most Expensive Conditions by Payer, *HCUP Statistical Brief #107*, Agency for Healthcare Research and Quality

[2] Fowler, T., Fairbrother, G., Owens, P., Garro, N., Pellegrini, C., & Simpson, L. (2014) Trends In Complicated Newborn Hospital Stays & Costs, 2002-2009: Implications For The Future, *Medicare & Medicaid Research Review*, 4(4)

[3] Russell, R., Green, N., Owens, P., Steiner, C., Meikle, S., Howse, J., Poschman, K., Dias, T., Potetz, L., Davidoff, M., Damus, K.,& Petrini, J. (2007) Cost of Hospitalization for Preterm and Low Birth Weight Infants in the United States, *PEDIATRICS*, 120(1)

[4] James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013) An Introduction to Statistical Learning with Applications in R, *Springer*

[5] Gruber, J. (2006) The Role of Consumer Copayments for Health Care: Lesson from the RAND Health Insurance Experiment and Beyond, *The Henry J. Kaiser Family Foundation*

[6] Manning, W., Newhouse, J., Duan, N., Keeler, E., & Arleen, L. (1987) Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment, *The American Economic Review* 77(3), 251-277

[7] Deaton, A., & Paxson, C. (2001) Mortality, Income, And Income Inequality Over Time In Britain And The United States, (Working Paper No. 8534), National Bureau Of Economic Research

[8] Huxley, R. (2013) Smoking, birthweight, and mortality across generations, *European Heart Journal* 34(44), 3398-3399

[9] Williams, D., & Cooper, L. (2019) Reducing Racial Inequalities in Health: Using What We Already Know to Take Action, *International Journal of Environmental Research and Public Health* 16(4), 606

[10] Muennig, P., Schweinhart, L., Montie, J.,& Neidell, M. (2009) Effects of a Prekindergarten Educational Intervention on Adult Health:37-Year Follow-Up Results of a Randomized Controlled Trial, *American Journal of Public Health* 99(8), 1431-1437

[11] Heckman, J. (2006) Skill Formation and the Economics of Investing in Disadvantaged Children, *Science* 312(5782), 1900-1902

[12] Campell, F., Wasik, B., Pungello, E., Burchinal, M., Barbarin, O., Kainz, K., Sparling, J.,& Ramey, C. (2008) Young adult outcomes of the Abecedarian and CARE early childhood educational interventions, *Early Childhood Research Quarterly* 23(4), 452-466

[13] McLaughlin, A., Campbell, F., Pungello, E.,& Skinner, M. (2007) Depressive Symptoms in Young Adults: The Influences of the Early Home Environment and Early Educational Child Care, *Child Development* 78(3), 746-756

[14] Montgomery, D. (2012) Design and Analysis of Experiments, *Wiley*

[15] Ramsey, F., & Schafer, D. (2015) Fundamentals of Biostatistics, *Brooks Cole*

[16] Rosner, B. (2012) Design and Analysis of Experiments, *Brooks Cole*