

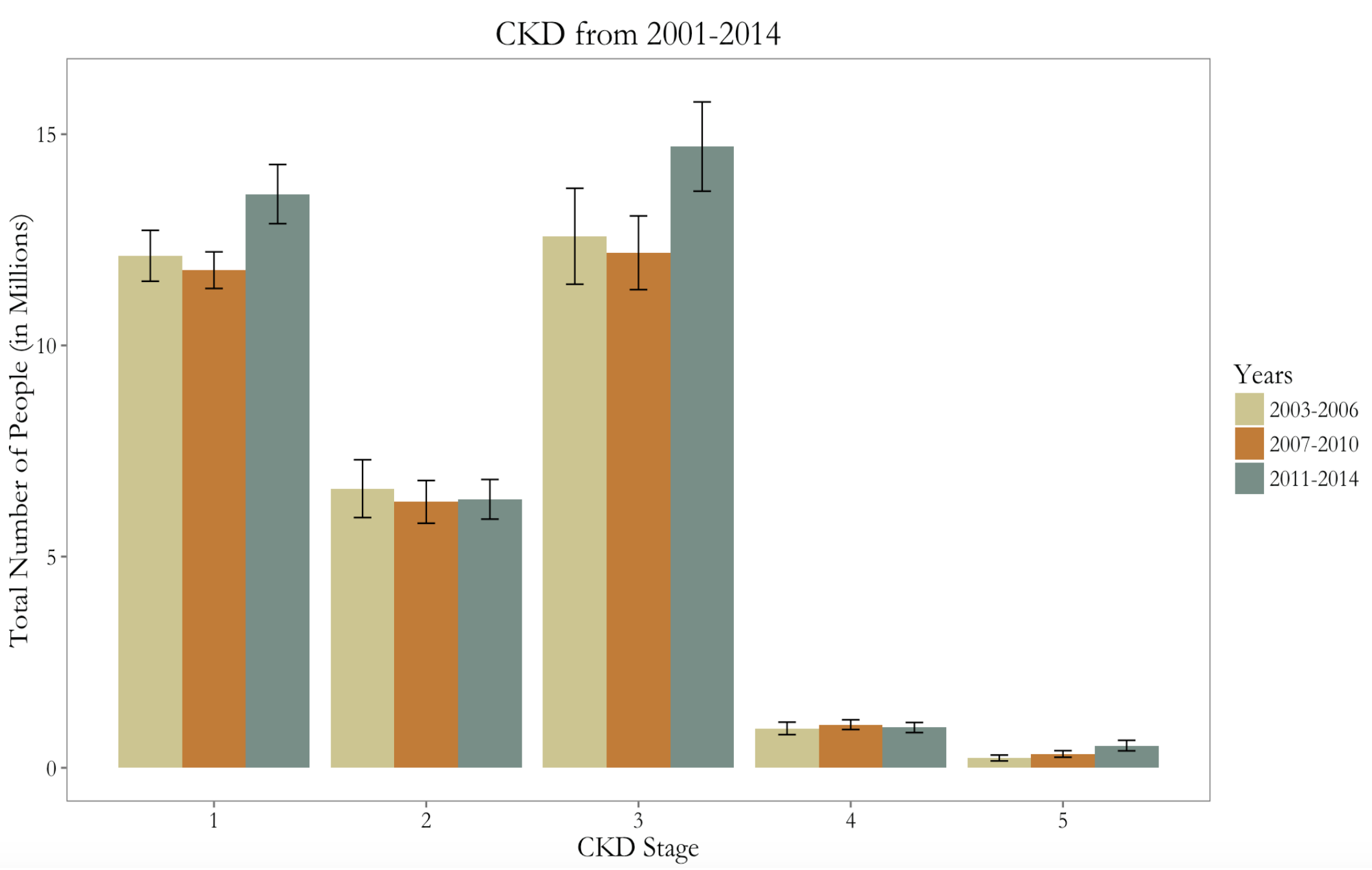
Predicting CKD and Potential Risk Factors with Multiple Linear Regression

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CKD

Chronic kidney disease, or **CKD**, is an emergent epidemic in the United States. While ESRD (end-stage CKD) patients make up less than 1% of Medicare patients, ESRD-related expenditures total in the billions (approx. 7% of total Medicare spending). With the goal of identifying cofactors for this costly disease that greatly decreases quality of life, our research focuses on the association between CKD and other health data. Ultimately, we built a multiple linear regression model that predicts estimated glomerular filtration rate based on one's current state of health, socioeconomic status, and demographic.



NHANES

The data for this study comes from the **National Health and Nutrition Examination Survey** conducted by the CDC every year. Each survey cycle consists of two years and attempts to obtain a representative sample of the United States' population. Our dataset has 78,518 observations, contains 100 different variables, and spans 14 years (2001-2014). Using the 'Survey' package in R, we were able to account for the complex survey design used by the CDC and get a strong sense of what is happening among roughly 320 million people.

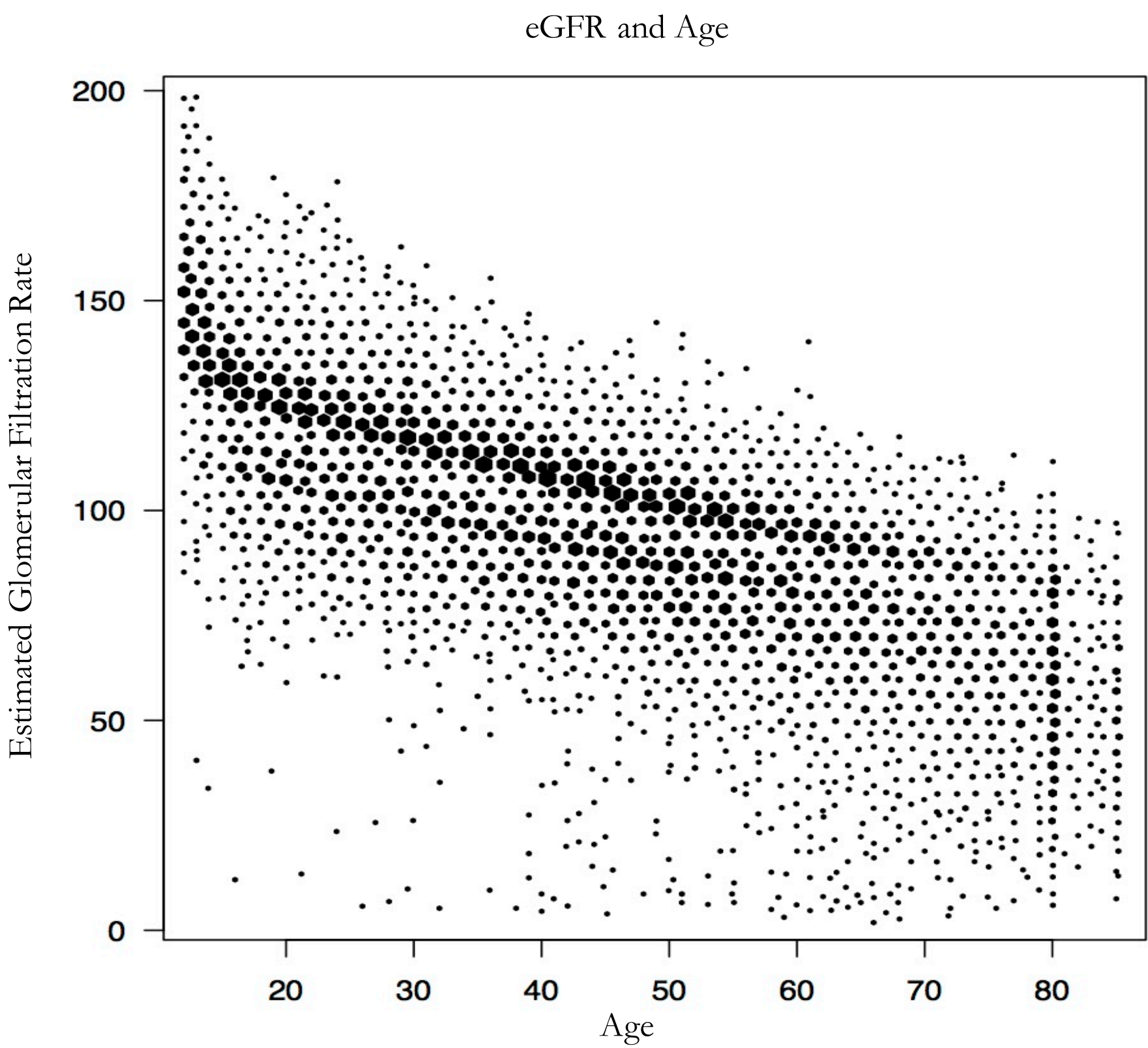
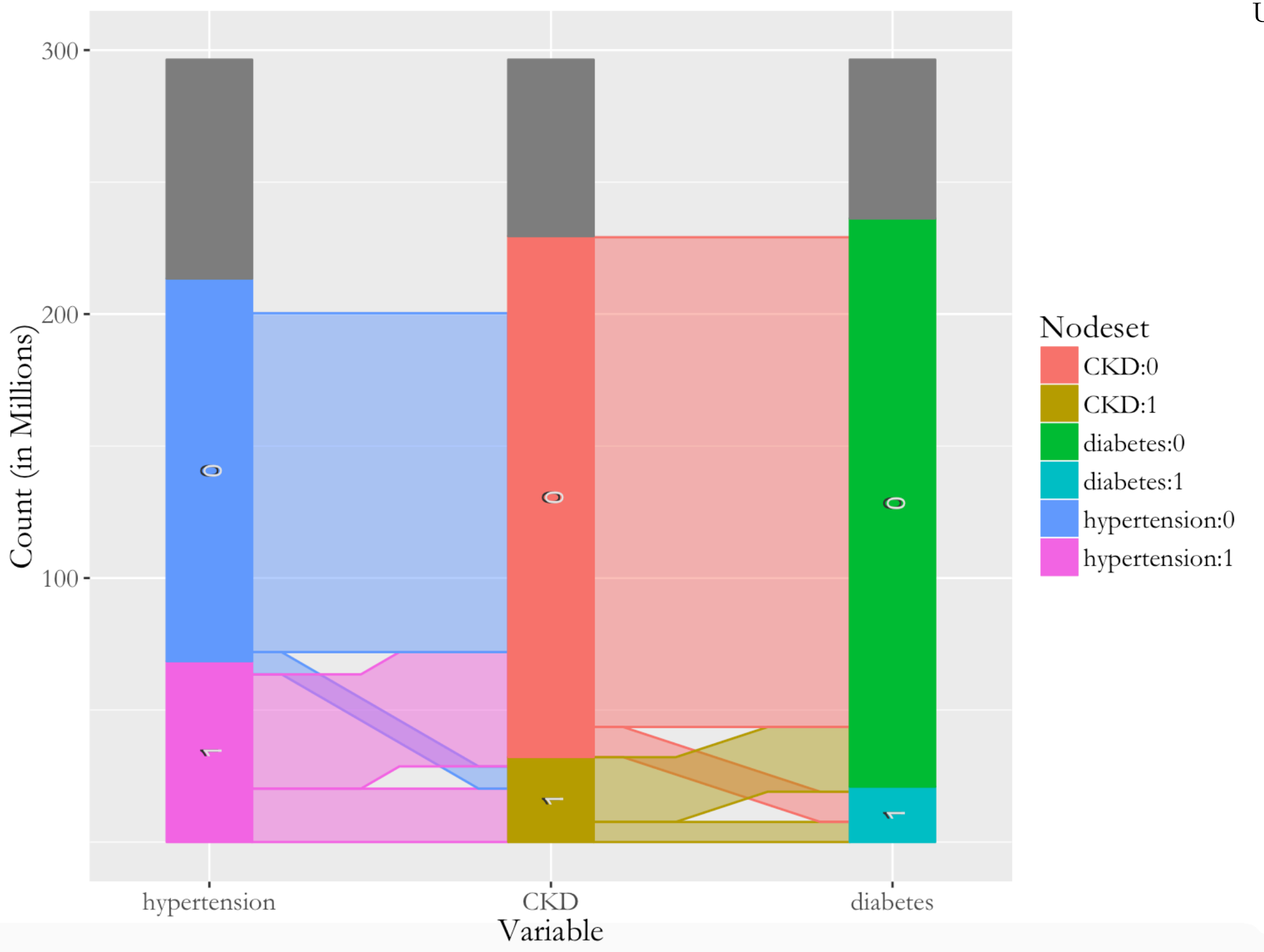
Methods

1. Narrow down variables of interest through literature review, visualizations, and chi-squared tests.

Discard some variables due to a high number of missing values.

Subset the data so that only those older than 18 are included and transform age into a categorical variable.

Parallel sets visualization used to understand relationships between categorical variables in multivariate datasets



Using hexagonal binning, this scatter plot demonstrates strong a linear relationship between age and estimated glomerular filtration rate

2. Use backward selection to get GLMs of the form:
$$\hat{Y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_i x_i + \varepsilon_i$$
with the lowest BIC value.

Test with different initial sets of variables.

3. Perform 10-fold cross validation and bootstrap resampling to find the most accurate multiple linear regression model for predicting estimated glomerular filtration rate (measurement for determining CKD stage).

Penalize errors on higher-weight observations by weighting errors on specific PSUs by corresponding survey weight to maintain internal consistency.

Conclusion and Recommendations for Further Study

For **NHANES**, new individuals are surveyed each year, and geographic location is kept confidential. The inability to track the health of a single person over time prohibited us from performing causation analysis.

Utilizing bootstrap resampling, we found that the coefficients' 95% confidence intervals were generally similar to the experimental values. However, two confidence intervals stood out: the confidence intervals for Non-Hispanic Black, which spanned 0, and diabetes, which was quite wide and had a lower bound very close to 0. Therefore, we are unable to conclusively identify a difference in eGFR for the Non-Hispanic Black group.

After removing all observations that contained a missing value for one or more covariates, only 85% were left for analysis. Adding more covariates reduced this number further and we cannot conclude that the data was missing completely at random. Future studies could explore imputation.

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Citations

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10-fold Cross-Validation Results:

Root Mean Squared Error: **12.902**

Root MSE standard deviation: **0.0771**

Final Multiple Linear Regression Model:

eGFR ~ Hypertension + Gender + Diabetes
+ Race + Age Group

	Coefficient (eGFR)	P-value
Intercept	118.59	0.000
Hypertension	-4.86	0.000
Diabetes	-0.96	0.027
Age 40-59	-15.99	0.000
Age 60+	-34.05	0.000
Male	-1.62	0.000
Non-Mexican Hispanic	-4.42	0.000
Non-Hispanic White	-9.81	0.000
Non-Hispanic Black	-0.63	0.136
Other and Multi-racial	-4.78	0.000