CMPU-250 Project Proposal Group 1

Topic: Analyze the potential bias and discrimination of healthcare prediction algorithms

Intro/Motivation

Machine learning-based algorithms have been widely deployed in the healthcare industry to predict factors like healthcare costs, health insurance claims. While the use of these algorithms often promise efficiency, fairness, and high accuracy, optimized predictive technologies in fact lead to social harms that exacerbate the conditions of marginalized demographics groups (Wang et al., 2023). For example, a study in 2019 has shown how racial bias in an algorithm used to predict potential healthcare needs for patients lead to less amount of resources being spent on African American patients compared to White patients (Obermeyer et al, 2019). Inspired by this phenomenon, our project aims to explore how classical statistical learning algorithms could exhibit such bias while trying to develop potential solutions to mitigate these issues.

Research Questions

The main research question we will focus our analysis on is: Does a model exhibit bias in predicting billing amounts across different demographic (Race, Age, Gender) groups? Specifically, will the model exhibit a higher prediction error for minority groups? Alternatively, we are also eager to develop supervised prediction algorithms that address the question: Which supervised learning algorithms most accurately predict the cost of treatment for a patient given their condition, age, blood type, insurance provider, admission type, medication, test results, and length of stay? For this project we intend to compare Linear Regression, K-Nearest Neighbors, and Neural Networks.

Description of Dataset

The dataset we have selected for this exploration is a mock healthcare dataset. It contains a synthetic data table created using Python's Faker library, and is intended to mirror the attributes of actual healthcare records. Due to privacy and confidentiality reasons, we are unable to utilize actual records, however we believe that this will provide an accurate representation of data found in the real world and even put a unique spin on our project. The healthcare dataset is extremely large, containing just under 50,000 observations across fifteen variables. Due to this scale, we only intend to include a small portion of this data in our exploration. The most noteworthy variables included in this dataset which we intend to work with are Age, Gender, Blood Type, Medical Condition, Date of Admission, Date of Discharge, Insurance Provider, Billing Amount, Admission Type, Medication, and Test Results.

What we expect to find:

Due to the fact that this dataset is synthetic, randomly generated, and extremely large, this means it is unlikely to have any sort of biases naturally. This will have little effect on our second research question, but will absolutely affect the first one. By reducing the size of our dataset significantly we increase the possibility of having noteworthy bias, however we still expect the null hypothesis will be proven true when investigating if a model exhibits bias in predicting billing amounts across different demographics. For our investigation into which algorithms are most efficient at predicting the cost of

treatment, we hypothesize that utilizing Neural Networks will provide the most accurate estimate of cost, due to their strength at modeling predictions with a large number of variables.

Data Analysis plan:

For our data analysis we have divided it into 3 main sections: 1. Data Cleaning 2. Modeling 3. Data Analysis. In terms of data cleaning given our dataset contains roughly 50,000 unique entries we first want to reduce that number down to about 2,000 - 5,000 entries. By filtering patients via a specific date range(e.g February 2024 - May 2024) we can focus our analysis of potential biases to a narrowed time frame. Further, since our dataset consists of synthetic data additional data manipulation will be done to mutate our data to mimic the real world. To achieve this we will assign different demographics to each patient according to real world census data(e.g 65% of patients will be white, 20% African American etc.) under a new column, race, in the dataset. For statistical modeling techniques, our current plan is to create various multiple linear regression models that attempt to normalize factors such as condition, test results, and admission type to focus our analysis on if factors regarding a patient's demographics(i.e race, gender, age) create bias within our models. Finally, to perform our data analysis we will perform hypothesis testing and model comparison to determine if our models display biases in regards to predicting billing amounts for different demographics.

Group Contract:

For this project our group's expectations for each other and in regards to division of labor are as follows. We expect each group member to spend a reasonable amount of time contributing to various portions of the project including but not limited to coding, analysis, general discussion etc.. Additionally we want each group member to make their best efforts at each portion of the project while following the guidelines of the project. In terms of division of labor we think each member should contribute to each portion in some capacity such as coding, analysis, review, and discussion. However, rather than equal division of labor it may be more beneficial for each group member to contribute their efforts to the area they have the most expertise in as long as these efforts balance out by the end of the project. Finally, we will attempt to meet weekly to discuss progress and what each member is currently working on that will progress our project towards completion.

Signature: *Eric Zhang, Luke Rudiak, Aspen Wang*

References:

Angelina Wang, Sayash Kapoor, Solon Barocas, and Arvind Narayanan, "Against Predictive Optimization: On the Legitimacy of Decision-making Algorithms That Optimize Predictive Accuracy," *ACM Journal on Responsible Computing* 1, no. 1 (2024): 1–45, https://doi.org/10.1145/3636509

Ziad Obermeyer, Brian Powers, Christine Vogeli, and Sendhil Mullainathan, "Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations," *Science* 366, no. 6464 (October 25, 2019): 447-453, https://doi.org/10.1126/science.aax2342