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**COGS516 LITERATURE REVIEW**

**Health Insurances: Gender Rating & Regional Effect on  
Insurance Prices**

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# Introduction

After the industrial revolution, with the increase of big cities and fast population growth, civilizations passed on a new generation of humane issues to be upheld<sup>[1]</sup>; some of these particular issues are held by private entrepreneurs with the rise of the United States. These entrepreneurs started insurance companies for certain humane matters that the government should provide by following specific government regulations and procedures that protect the consumer from the abuse of the private company. Later on, in the EU/EEA, new, more humane insurance policies and systems models were initiated<sup>[1]</sup>. Insurance, specifically health insurance, after the mid-20th century, initialized with its new model for newly emerging economic areas<sup>[1]</sup>. Countries such as Switzerland had a 100-year programmed system that continuously updated to the new age of the 21<sup>st</sup> century, and it is suggested in the Orlu et al.<sup>[1]</sup> to be adopted by Turkey due to this research to be concluded, which is gender-based insurance policies. Furthermore, another interesting pricing procedure is held in the US for people living in different states and even in different counties of a specific state, whether it is urban or rural<sup>[2]</sup>. Moreover, whether there is more than one insurance company that is giving service to the area is also effective in the current holding system in the US<sup>[2]</sup>.

American Center for Disease Control and Prevention Center (CDC) suggests that particular disability and risk factors can be used like the following price policy and coverage procedure for insurances, and they can be named; Alcohol usage, Illicit Drug usage, body measurements (height, size, etc.), mandatory diet, Certain disabilities, and physical or mental function issues, Exercise or physical activity capacity, Obesity/BMI, Smoking<sup>[3]</sup>. Even to date, many private and social health insurance companies still use other parameters, such as gender or age, to calculate the insurance price per year. Even today, they include different premiums for different age groups that are specially tailored to the consumer group of the specific age groups<sup>[4]</sup>. On the contrary, in recent years, gender-rating-based pricing is started to diminish by banning done by Obama legislation and European Commission, but still, many countries use both gender and age-based and other factors to calculate the insurance price<sup>[4][5]</sup>. For the US, before the ACA, which stands for the Affordable Care Act, Montana was the first to prohibit the usage of gender as an insurance price factor<sup>[5][6]</sup>. Intrinsically ACA, which was initiated and immediately put into effect in early 2010, was expected to give equal pricing and premiums for all but did not give equal pricing for all; it was missing age, income, and, most important, region<sup>[6]</sup>.

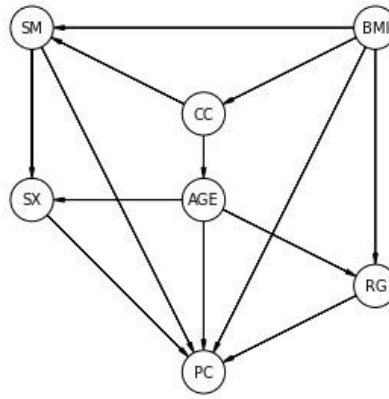
Affordable Care Act started a chain-reaction in the health insurance pricing with the new regulations it came with, such that giving more potential to see the effects of the other not forbidden pricing indexes, one of which is region-based pricing<sup>[6]</sup>. Other than that, ACA did not prevent private insurance companies from switching from age to some other feature to measure their pricing for regions due to it did not forbid the usage of age<sup>[6]</sup>. With that, companies in the US started to give more importance to the region and age, even though, in recent years, there were some movements against age and income-based health insurance pricing. Furthermore, companies after the ACA even started to give numbers as ratings to the states and their counties for pricing and give different pricing for rural and urban areas in specific states according to their new policies<sup>[6][7]</sup>.

In this project, the total and direct gender effect also total and direct region effect on the price will be excerpted to understand the importance and whether it is needed to be a significant factor in health insurance pricing policies. For the analysis, a data set called *Medical Cost Personal Dataset - Health Insurance Cost Prediction (Insurance) data* by Amy Aguirre is used with ~ 1300 samples<sup>[8]</sup>. Moreover, in the analysis, the dataset used, which is *Medical Cost Personal Dataset - Health Insurance Cost Prediction (Insurance) data*, may not be a data that is taken from the United States due to its regular descriptions of the features in the metadata given by Amy Aguirre are not in English rather Spanish, also since the Affordable Care Act, gender is no more used in the pricing or held in the data storages for the pricing reasons, so it is assumed that the data is taken from a country that not started to use regulation such as in the US case<sup>[8]</sup>.

# Approach

In the project, it is planned to use the following approach to attack the problem of whether gender also the region individually have a tremendous effect on the prices of health insurance and also to see whether they are individually crucial indicators that should be used in the determination of price by making a directed acyclic graph of dependencies and pulling out the gender as the independent factor to affect the cost of insurance.

In the *Medical Cost Personal Dataset - Health Insurance Cost Prediction (Insurance) data*<sup>[8]</sup>, there exist precisely 1338 data with a slightly imbalanced gender ratio of consumers given with a balance of 51:49 (male: female)<sup>[8]</sup>. Furthermore, according to the CIA World Factbook, the world has a 1.01:1.00 male to the female ratio, which gives the fact that the imbalance is rather insignificant when compared with the total population, so the dataset has no a bias toward gender in the light of the total population information is known<sup>[9]</sup>. The features of the data-set can be provided as; age, sex(gender), BMI, children count of the person, whether the person smokes or not, their region, and the price for the total of 6 features given<sup>[8]</sup>.



(Figure 1 - Directed Acyclic Graph of Medical Cost Personal Dataset - Health Insurance Cost Prediction (Insurance) data<sup>[8]</sup> for model to be used in the project)

The dataset that is going to be used, as mentioned above, has 6 features and 1 outcome, which is the cost of the health insurance. Health insurance prices are affected by several measures, and two of them are the region and gender of the individual that is going to purchase the insurance. These two features that affect the price have an inferential domain in their system, as can be seen in *figure 1*. In some regions of a country, one can assume by their prior knowledge that in some regions there exist many elderly and in some others, many young people are living for various reasons, such as university location. Also, regions can also affect the population if small regions are picked. Technical (STEM-focused) universities and the regions near the university will have gender differences due to the lack of women in STEM fields worldwide<sup>[10]</sup>. Dataset also shows that age can also indicate gender, and it is due to the fact that natural death age imbalance of genders for people who live in equal ecosystems<sup>[11]</sup>. therefore age also has an effect on gender, and that leads to different pricing for insurance<sup>[11]</sup>. Even though the life expectancy difference is significant, it is not true to directly jump to a conclusion it is for every case for men and women living in<sup>[12]</sup>. Life expectancy measures are given for people who live similar livelihoods and end up dead at the end through a process rather than measuring for the richest women/men compared to the poorest women/men<sup>[12]</sup>. One can also infer the knowledge of whether someone is smoking or they are in older ages of their life from their children count. Furthermore, one can also infer the fact that if someone is obese, which means higher BMI, they might be quit smoking recently, or vice versa is true for the lower BMI measures. Since smoking prevalence is higher by five times in adult males, we can also indicate that sex(gender) can also be inferred from the smoking factor of the person<sup>[13]</sup>. Furthermore, in the end, *figure 1* then gives us the end-scientific model in such a way that we can find the total and direct effects of the region and gender by the abovementioned information and more.

Bayesian analysis of the data for the total and direct effects of region and sex will be conducted with the regular PyMC3 Markov Chain Monte Carlo algorithm that is used by the sampler. Furthermore, there will also be basic statistical analysis to see whether these values are correlated and give measures corresponding to the results. The PyMC3 package of Python gives us four chains of MCMC samples for our desired statistical model. The model will be created by taking the *figure 1* directed acyclic graph as the

reference to build the model for direct and total effects of the desired features. For the prior statistical analysis, it is seen that before actually working on the dataset now, some correlations between various features should be stratified to find the direct effect of the gender and region. Also, find the correlation between male-female differences and smoking, smoking, and BMI. It is also noted that children can also be one of the factors to be taken into account in the correlation of BMI for gender regardless of male or female for the beginning; the correlation limit in this experiment will be determined by the famous economic principle called Pareto Principle which indicates that eighty-percent of the cases will be driven by twenty-percent of the indicators, so if the correlation is below twenty-percent correlation will be neglected and reported in the analysis. Later on, samples that are created by the MCMC sampling algorithm will be analyzed with diagnostic tools to measure if the sample is reliable. These measures are measures such as R-hat, trace-plots, and a number of effective samples, and various other tests will be used, such as WAIC and PSIS. In the end, we compare our four models to see which one gives better results for inferential analysis and prediction on a different basis.

In the model, the Bayesian multiple linear regression method and hierarchical analysis method will be used. The hierarchical method can be used to analyze the different regions in the system for model creation. For more intricate systems for some steps other than multiple linear regression, splines can be used after the behavior of the data in regular statistical analyses is determined. If the charge is assumed that behave logarithmically, exponentially, or in a polynomial shape, etc., a different system rather than linear regression without separating data into different sections would be more desirable. This behavior will be reported in the study if any such behavior exists in the analyses in the pre-process.

If the behavior is linear for the features for the charge, then the multiple linear regression method is to be followed. Else non-linear approaches such as splines are to be followed.

The charge predictions for gender and regions are to be visualized with summary statistics, and the highest density interval for 91 percent interval is given. 91 is picked because it is below 10 percent from tails with a slight difference. For the last step, it is to be concluded with the difference between males and females also with the regional differences to be simulated, and the differentiation statistics as the main result to be reported after specific interventions to make the gender and region independent from each other charge independently from the rest.

# Review

In the literature, it is seen that age and gender play a significant role in the determination of the prices of health insurance<sup>[4]</sup>. Still, many contrary regulations started to be integrated into the governmental systems against the latter, gender, playing a role in the health insurance prices and premiums. A private institution with the closing gap in premiums between the government-issued health insurance and the gender gap is now over in the EU faces a drastic decline in people who buy and continue private insurance coverages. Also, with the increasing costs, many exits the entire healthcare insurance system<sup>[14][15]</sup>.

This price gap mentioned in the system is according to one of the insurance companies run in India named, Gender Rating, and still in use in India<sup>[15]</sup>. Turkey also still has this gender gap, but women after a certain age have the risk of breast cancer and other reproductive system problems<sup>[1]</sup>. By Merzel<sup>[16]</sup>, it is also discussed that in low-income zones such as Central Harlem, NYC, people with low-income most of the time cannot afford private coverage, but females have the opportunity to have it covered when they are in the workforce, with that being said, females do not get affected by low-income or socioeconomic factors. On the other hand, male counterparts are heavily influenced by fewer available opportunities even in the workforce due to companies not offering them insurance making them less covered within the year 2000<sup>[16]</sup>. Literature states that certain states in the United States of America and after Obamacare now have better coverage for people from different socioeconomic backgrounds<sup>[5]</sup>. It is stated in the 2008 Los Angeles Times article that being female increases the insurance price rates drastically<sup>[17]</sup>. It is still for every one in ten women affects women between 19 to 64 age, which consists of nearly 98 million people in the United States<sup>[18]</sup>. In Taiwan, elderly or mid-aged women have different cancer insurance policies with lower claim rates for dread diseases which shows that the system is biased towards gender/age<sup>[19]</sup>. In the IFFCO-TOKIO factors article, it is stated that ten factors affect the health insurance premiums in most insurance policies. These are the recent day's age, medical history, occupation, policy duration, BMI, smoking, and location; as stated in Orlu, prices are determined by gender. Still, the premiums are not as given in the IFFCO-TOKIO article<sup>[1][20]</sup>. Lastly, Huang and Salm mentioned that the ban on gender-based pricing increased the number of people who buy health insurance, even though the new prices are slightly lower, but not drastically<sup>[21]</sup>.

Another important factor to add that is not discussed in the priorly in the review is the region effect that is causing the current price disparity between whom can access how affordable health insurance and how much coverage from the premiums they can get at the end result in the United States<sup>[2]</sup>. According to Wengle<sup>[7]</sup>, in the US, living in urban areas or in rural areas highly differentiates the prices and the premiums that people can have access to in the healthcare industry for insurance. For the lower competition environments, insurance companies tend to use their monopolistic power to increase the cost<sup>[7]</sup>. Hence the price is higher for the areas which have fewer health insurance companies<sup>[7]</sup>. The Affordable Care Act, or in abbreviation ACA, was initiated in the first quarter of 2010 by Barack Obama to eliminate unequal access to healthcare, eliminate the gender, smoking, and various other factors that are used in the pricing of healthcare insurance<sup>[6]</sup>. However, region was not put in the ACA, which led companies to use the region as one of their main factors in determining new prices in different regions<sup>[2]</sup>.

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