LHS 610: Midterm Group Project

Does Undernourishment and Nutrition affect Covid-19 Mortality Rate?

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Background and Significance

Malnutrition includes both undernourishment and obesity and is a well-recognized cause for health issues. Among countries, is pre-existing undernourishment a risk factor for higher COVID-19 mortality? This is an important question to evaluate because it allows us to see what additional stressors for individuals with COVID-19 are at the larger country scale, and who is at more risk.

The immune system is our body's way to protect itself from foreign attacks. As such, it is an integral component to survival in the face of viral infections. "Immunological abnormalities predict outcomes, particularly the risk of infection and mortality" [1]. Nutrition holds an immunoregulatory role because we derive essential vitamins and minerals from the food we consume. In a study observing patients with kwashiorkor, while observing their antibody response to typhoid fever, researchers found the antibody affinity is decreased in patients who are malnourished[1]. There are many other factors that contribute to infection fatality such as comorbidities. In a systematic review of risk factors a study found that individuals with underlying cardiometabolic diseases such as hypertension, diabetes, coronary heart disease, etc. were at a higher risk of mortality from COVID-19[2]. Many of these afflictions affect the elderly population which often have undernutrition-associated immunodeficiency which means the nutritional insufficiencies induce decreased immune responses [3]. While the elderly lack proper nutrition, that is most commonly attributed to declines in appetite, changes in how the body processes nutrients, impairment in the ability to eat, etc. [4]. There are individuals in the young to middle age bracket that also suffer from undernourishment. In a study examining probiotics as a strategy to improve immunity, it is emphasized that "malnutrition is one of the most common causes of immunodeficiency and can lead to death" [5]. Additionally, PEM (protein-energy malnutrition) is recognized as undernourishment. This leads to the vitamin and mineral shortages explained earlier that contribute to increased susceptibility to conditions such as tuberculosis[5]. Furthermore, the consequences of undernourishment on immunity can be linked to other bodily functions such as the gut microbiota. The gut microbiome has been linked to several important responses such as regulating immune homeostasis[6]. As we can see, nutrition and the immune system are closely related through a number of factors in the body making undernourishment an important variable to consider in COVID-19 mortality.

The COVID-19 pandemic has had a drastic impact on the world health and economy. COVID-19 has had especially unfortunate consequences for those already suffering with health conditions. There is increased vulnerability among patients with chronic diseases such as Parkinson's disease (PD) [7], chronic kidney disease, coronary heart disease, transplant patients etc. exacerbating their symptoms. This susceptibility in addition to the easily spread airborne infection makes this a global health problem. Concurrently, for individuals who are otherwise "healthy" still experience the spillover effects of COVID-19 through their mental health and physical activity. With the need to curb spread there is a lack of physical activity which is an important determinant of health [8]. Finally, beyond negative patient health experiences, the COVID-19 health crisis has induced an economic crisis with necessary lockdowns, monetary policy decisions, international travel restrictions, unemployment, etc. [9].

The Datasets

In this dataset, we combined data of food, undernourished rate and global COVID-19 cases information from around the world in order to learn more about how a country's food supply correlates with the COVID fatality rate. The datasets we used are listed below.

- Dataset 1: New Food Balances Data (2018) [10]
- Dataset 2: Suite of Food Security Indicators (2018) [10]

Dataset 1 and 2 are originally obtained from the Food and Agriculture Organization of the United Nations (FAO website). The data contains food, agriculture and related information for over 245 countries. FAO's goal is to achieve food security for all populations and make sure everyone can have regular access to enough high-quality food and live healthy [10]. Those datasets were collected to shape development plans and end hunger. Thus, one of the valuable works for FAO is collecting, analyzing and interpreting food and agriculture statistics for relevant decision-making.

- COVID-19 Dataset from John Hopkins [11]

Our third dataset is obtained from Johns Hopkins University. They track how the novel coronavirus is spreading around the globe with up-to-date visuals. Their website "provides resources to help advance the understanding of the virus, inform the public, and brief policymakers in order to guide a response, improve care, and save lives. [11]".

Undernourishment is the exposure variable and COVID mortality is the outcome variable we plan to look at. Undernourishment rates are calculated by the number of cases divided by the country's population and fatality ratios are the number of deaths divided by the number of confirmed cases. The global hide inequalities within countries and the countries which face insufficient food and nutrition access may be affected more by the present COVID pandemic. We have reasons to believe that the higher undernourishment rate may indicate the higher COVID mortality rate.

The first confounder in our analysis is the energy intake (kcal) from different types of food in countries around the world (food supply). The undernourishment measures the share of population which has a caloric intake which is insufficient to meet the minimum energy requirements [13]. Thus, the average energy intake across countries should closely relate to its malnutrition situation. As we know, calories are important to protect against breakdown of muscle for energy. People need more calories than their normal diet to mount an immune response with an infection. Thus, energy intake would potentially affect the COVID worsen or recovery. Similarly, our second potential confounder --- the average protein intake (protein supply) plays an important role when it comes to malnutrition and COVID mortality. There are different types of undernourishment: protein-energy malnutrition and dietary deficiencies [14]. Because of taking unhealthy food, a person may also suffer from malnutrition. "Efforts to improve nutrition are some of the most effective forms of development aid [14]". Protein is as important as calories when protecting against muscle loss while fighting COVID-19, especially if the patients are bedridden or inactive [15]. These two variables obviously relate to undernourishment rate to some extent. Even though these two variables may not directly lead to the death of COVID patients, adequate energy and protein intake during the illness may be linked to decreased mortality.

Unstratified Analysis

We hypothesized that as the undernourishment rate increased, the greater the covid fatality rate. This positive relationship between the two variables was expected because as more individuals become more undernourished, they have lesser food supply and nutrition available to them, thereby causing them to have a weaker immune system. A weaker immune system could lessen an individual's power to fight back infections like covid-19.

We created histograms (Appendix A - Fig 2,3) to check if our variables of interest were normally distributed. Our analysis showed that both Fatality Rate and Undernourishment Rate were not normally distributed and were highly skewed to the right. Because of this we performed a Spearman's correlation test.

According to the scatterplot (Appendix A - Fig 1), there is no relationship between undernourishment rate and fatality rate. As undernourishment rate increases, the fatality rate of covid does not increase. It appears to show that undernourishment rates between 2% and 10%, have a fatality rate between 0% and 4%, however, most of the data is clustered around here.

The Spearman's correlation test (Appendix A) reveals a rho value of 0.082, showing no relationship between the two variables - undernourishment rate and fatality rate. Additionally, the p-value of 0.33 proves that this correlation is not statistically significant because it is greater than the significance level of 0.05.

Stratified Analysis (Confounder 1)

We hypothesized that as food supply increased the undernourishment and case fatality rates would both decrease. This reason for this confounder is detailed earlier in The Datasets. According to the graph (Appendix C) the food supply does not affect case fatality in the presence of undernourishment. However, we do see a relationship between undernourishment and food supply. The range of data shows that in countries with high food supply there is a lower undernourishment rate. This effect is visible in both medium and low supply as well indicating a possible strong negative correlation between the undernourishment rate and food supply. Also, the nuances between y-intercepts across food supply groups show a slight difference in case-fatality rate that indicate high supply having a lower case-fatality compared to low food supply but are not enough to show a significant relationship.

Stratified Analysis (Confounder 2)

We hypothesized that as protein supply increased, the undernourishment and case fatality rates would both decrease. The graph in Appendix B shows that the protein supply only relates with the undernourishment rate of a country. The countries with high protein supply obviously have the low undernourishment rate, but it is not the case for COVID fatality. Whereas the graph indicates the relationship between undernourishment and food supply within different levels of protein supply groups. The fitted lines have positive slope in medium and low protein supply groups, which can roughly support our assumption in unstratified analysis. For high protein supply groups, the x-axis is zoomed up and most of the points are gathered on the left side, so the fitted line might not really be significant.

Limitations

Our food supply data was filtered to the year 2017-2019, and our covid-19 data set included data from 2019 and was last updated on March 10, 2021. One limitation would be including the 2017-2018 data which might have changed our findings. Another limitation would be, the food supply dataset didn’t include any information from 2020, and this could cause a major change in our analysis since we were looking at covid-19 fatality rates.

Our datasets didn’t include associations by age-group. If the dataset included younger adults and infants, this could have skewed the analysis since covid-19 has a lesser effect on infants and younger children. These limitations could have caused information biases in our analysis.

Conclusions

Our analysis showed no relationship between undernourishment rate and fatality rate. It was expected to see a decrease in case fatality rates as food supply and protein supply increased. However, the analysis showed no relationship between food supply or protein supply with case fatality rate. But, we did see a relationship between undernourishment and food supply. Countries with higher food supply showed a lower undernourishment rate. Additionally, we noticed similar relationships between different levels of protein supply and undernourishment rate. Even though most of our analysis was inconclusive, we were able to understand the impact of food and nutrition on a person’s health. For the future, we would have to look into specific data by age group and more updated information for the year 2020-21 in order for us to analyze the relationship between the variables.

Acknowledgements

Each group member equally contributed to this group project. The analysis and write-up was divided among all the team members. We were in constant communication with each other and were always ready to help each other when needed. Here are the specific contributions by each member :

- Roma Patel: Background and Significance, Stratified analysis (Confounder 1)
- Lanxi Xu: The Datasets, Stratified analysis (Confounder 2)
- Sereen Kallerackal: Unstratified Analysis, Limitations, Conclusions, Acknowledgements

Appendix A

Fig 1: Relationship between Undernourishment Rate and Fatality Rate

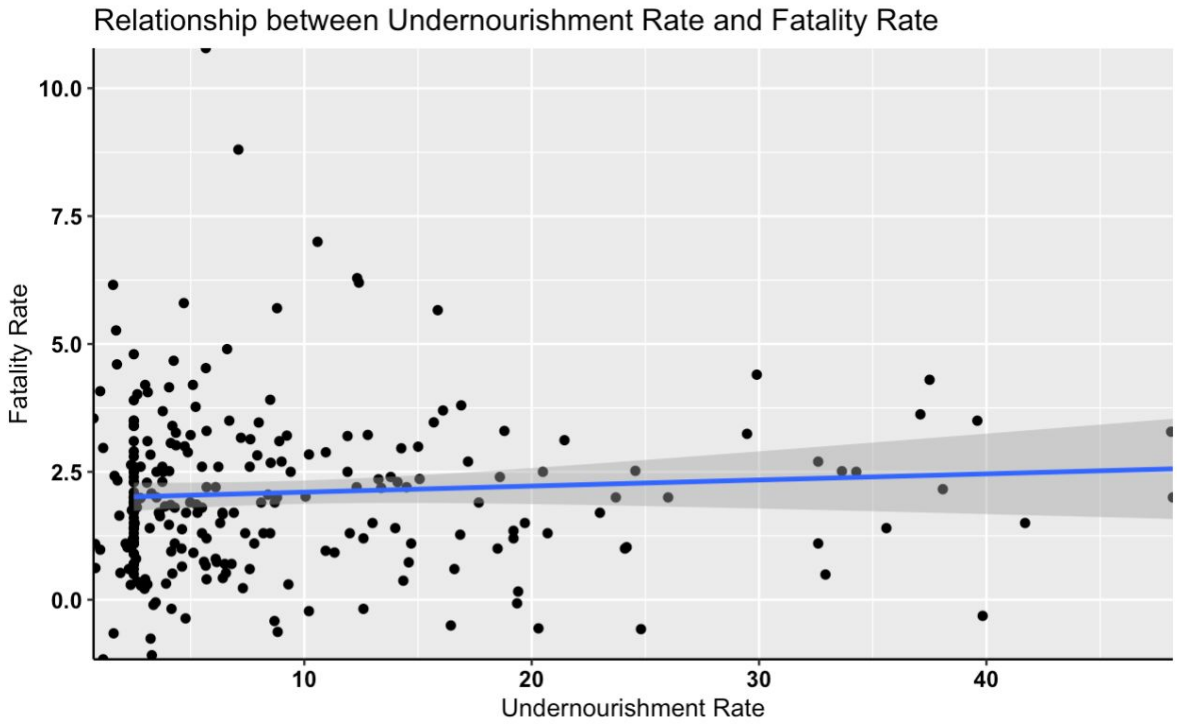


Fig 2: Distribution of Undernourishment Rate

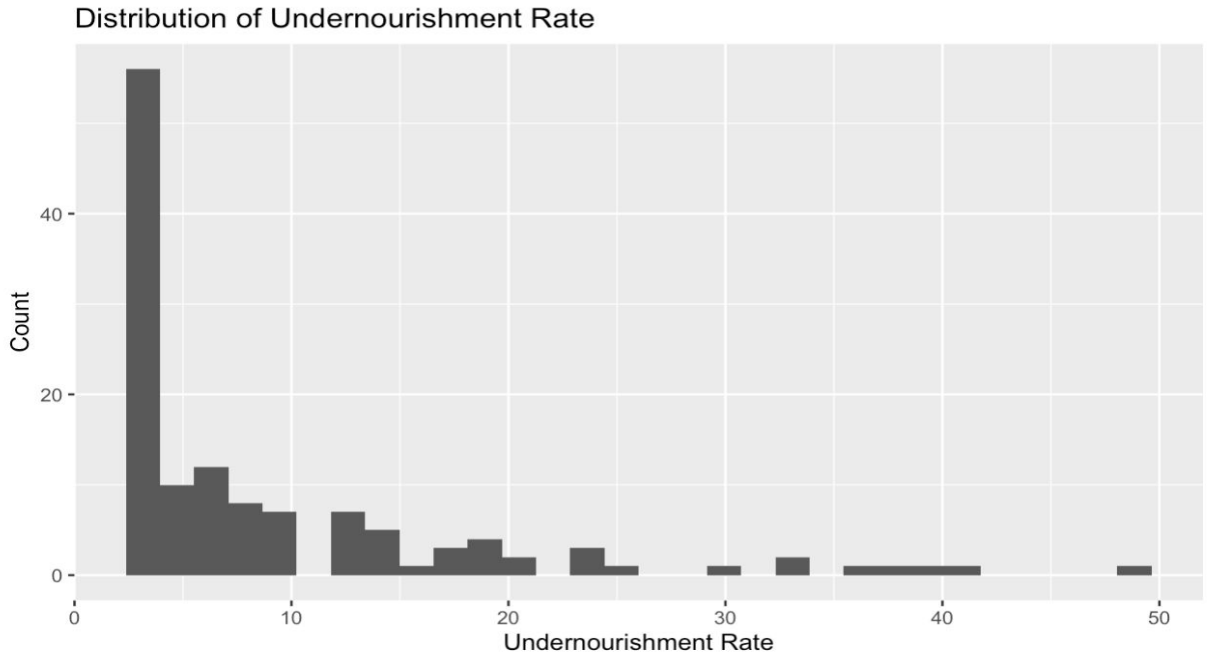
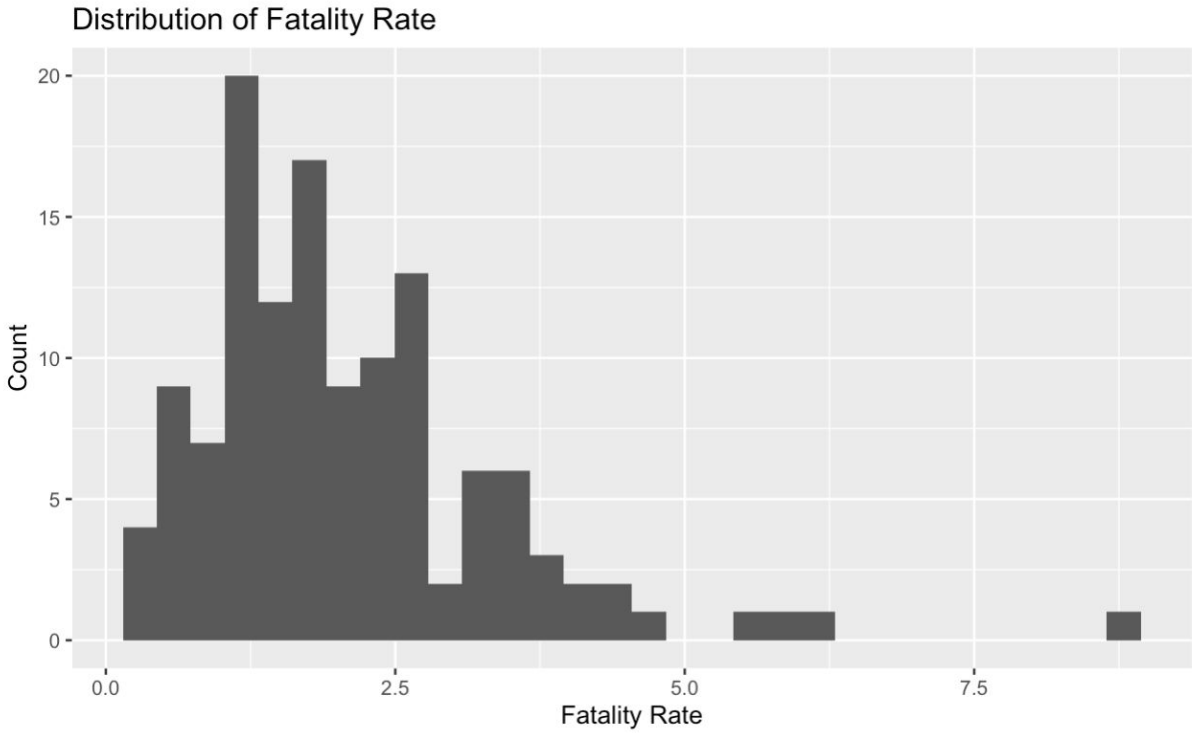
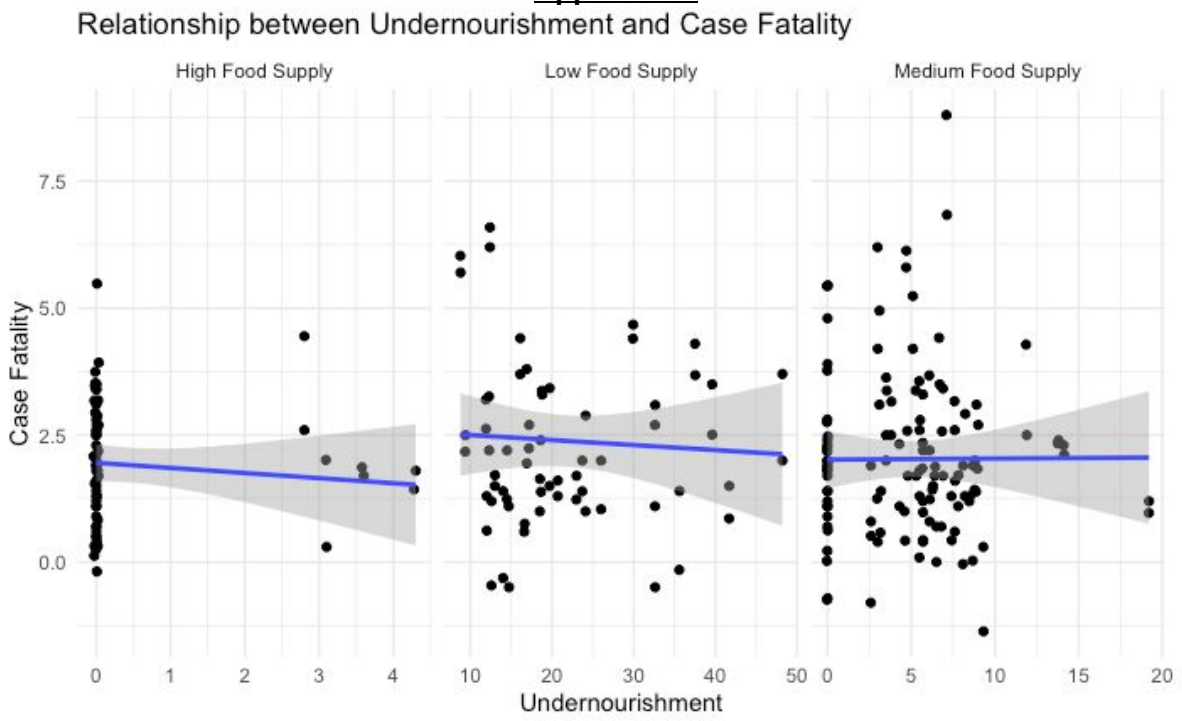


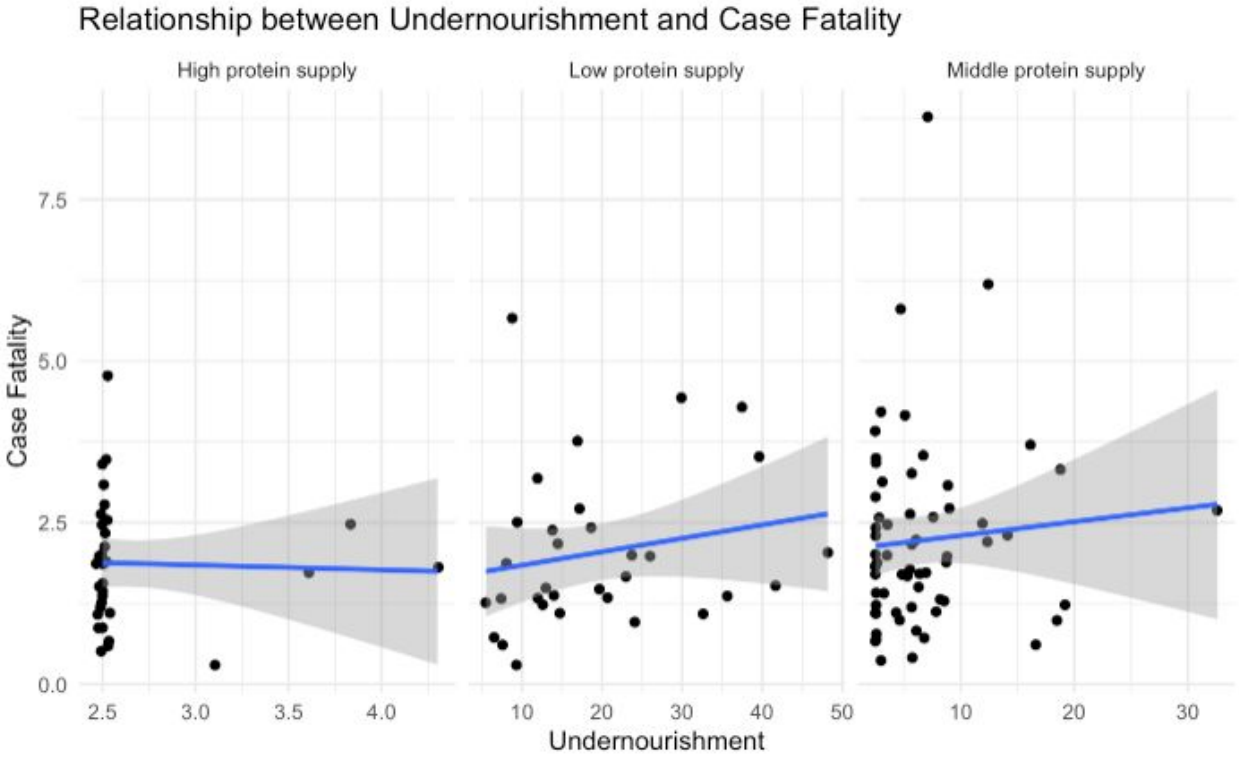
Fig 3: Distribution of Fatality Rate



Appendix B



Appendix C



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