The Relationship between Anemia Prevalence in Young Women and Meat Consumption in Low & Middle Income Countries

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Introduction

This PM566 final project will look at the relationship between meat consumption and anemia prevalence in young women in low and middle income countries.

Anemia is one of the most common medical conditions among menopausal women. Anemia is defined as a condition where the body lacks enough red blood cells to carry sufficient oxygen. Anemia is associated with many health risk factors and increased fatigue.

The main cause of anemia is iron deficiency. Iron is required to produce hemoglobin, a protein in red blood cells which binds to oxygen. Another secondary cause of anemia is blood loss, which occurs cyclically, usually monthly, in menopausal women; therefore, menopausal women are at an increased risk for anemia.

Iron can be consumed through diet in two forms: heme and nonheme iron. Heme iron is found only in animal products, such as red meat and poultry. Non-heme iron is plant based, and can be found in food sources such as nuts, legumes, and leafy greens. Heme iron is more readily absorbed by the body than non-heme iron; non-heme iron often requires secondary vitamins, such as vitamin C, to up-regulate proper absorption. While it is certainly possible to avoid an iron deficiency on a plant-based diet, most plant-based individuals choose to supplement their diet with iron supplements.

This project will focus solely on lower and middle income countries, as information on proper diet and supplementation is not readily available to these populations and the economic burden of anemia is greater.

Methods

Multiple data sets were used for the purpose of exploring the question posed in the introduction. The data can be organized into 3 categories: anemia data, meat consumption data, and country data.

Anemia Data

The data sets related to the prevalence of anemia in 15-49 year old women in low and middle income countries (LMIC) were exported from ghdx.healthdata.org. This data was collected by the Institute of Health Metrics and Evaluation with the funding from the Bill and Melinda Gates Foundation between January 2000 and December 2019. It was published in 2021. There were three different csv files in this set, one for mild anemia, one for moderate anemia, and one for severe anemia. The thresholds for these distinctions can be found in the paper *"Anemia prevalence in women of reproductive age in low- and middle-income countries between 2000 and 2018"*, published in **Nature Medicine** in 2021, and they vary between pregnant and non-pregnant women. The data sets detailed the prevalence of each kind of anemia every year in 82 LMICs at a 5x5km level. These csv's were downloaded from the site manually and read into data tables in the R code. From there, variable names were changed to improve ease of merging. Instead of keeping the data at the 5x5km level, the mean anemia prevalence was found by country and year. Finally, the three data tables (moderate, mild, and severe) were merged into the data table "TotalAnemia". This table included all 82 countries and the mild, moderate, and severe percentages of anemia prevalence for every year from 2000 to 2019. No values were found to be missing or unreasonable.

Meat Consumption Data

The data set related to meat food supply quantity in terms of kilograms per capita per year was exported from ourworldindata.org. This data was sourced from data published by the United Nations Food and Agricultural Organization (FAO) in 2020. The data was collected from 1961 to 2017. This csv file was also exported manually from the website and read into a data table within the R code. It contains data from 215 countries and was not found to have any missing values. The data only had 4 variables: the country name, 3 letter country code, year, and meat food

supply quantity; these variables were renamed for ease of use and to match the names of the anemia data table.

Country Data & Final Data Table

Following preliminary data cleanup and wrangling, the TotalAnemia and meatData data tables were merged together by country and year to create a new data table: TotalData. All observations from the TotalAnemia data table were kept. To add a final level of analysis, a country code data set was downloaded and read in by the R code. This csv file was found on datahub.io, and lists every country, along with its three letter country code, continent, and other identifying information; only the three letter code and continent were selected for. This country code data set was then merged with the TotalData set by code, so that every observation now included the continent as well.

Final data cleanup and wrangling was now performed. Any observations missing meat consumption values were removed. The data table was now left with data for 69 LMICs, for a total of 1258 observations. When looking at summaries and visualizations of the various variables, no data looked unreasonable. The data was now ready for further exploration via visualization, as seen in the preliminary results section.

Because both meat consumption and anemia prevalence are both normalized to population size, it is possible to compare the two variables between countries with varying population sizes or across different years while population increases or decreases.

Preliminary Results

The first step in visualizing data was viewing trends in total anemia prevalence for every country over the time period from 2000 to 2017. To do this, the prevalence of mild, moderate, and severe anemia were summed together for every year and country. This data is visualized below, separated into the various geographic regions represented for ease of viewing. A trend line was applied to each plot. This visualization was done to see if there are any trends over time of anemia prevalence.

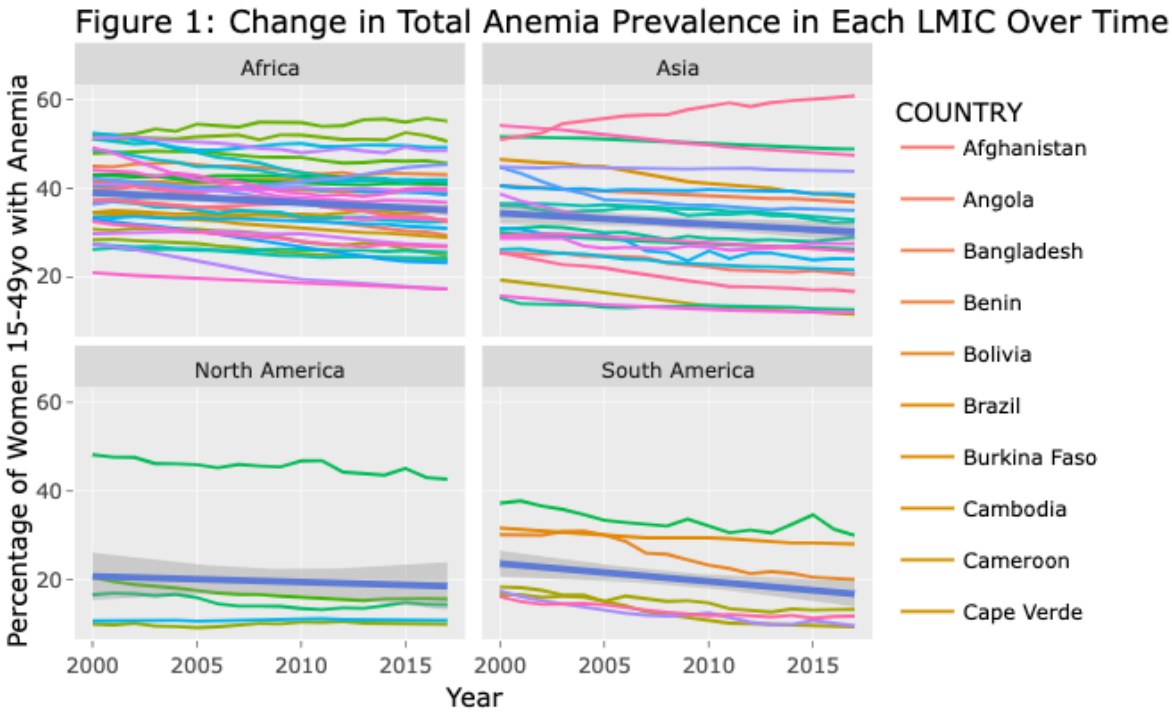


Figure 1 This figure displays the trend of anemia prevalence in young women from 2000 to 2017. For ease of viewing, there are four subplots: one for each geographic region.

Based on Figure 1, it can be seen that the total percentage of women between the ages of 15-49 with anemia ranged from 10-60%, depending on the country. Fortunately, there was an overall decrease in the prevalence of anemia in almost every LMIC, as shown by the best fit line in blue on each subplot. One clear and obvious exception to this downward trend is seen in Yemen, where the prevalence of anemia had increased by 10 percentage points over 17 years; this increase was likely due to the famine and instability present in this country. The African and Asian countries appear to have higher prevalence of anemia, while the 5 countries with the lowest prevalence of anemia are all North or South American countries.

Following this visualization, a similar visualization was created to view the trends over time of meat consumption per capita in these same countries. This visualization can be seen below in Figure 2. Similarly as in Figure 1, for ease of viewing, the plots were separated into different geographic regions and a trend line was applied within each region.

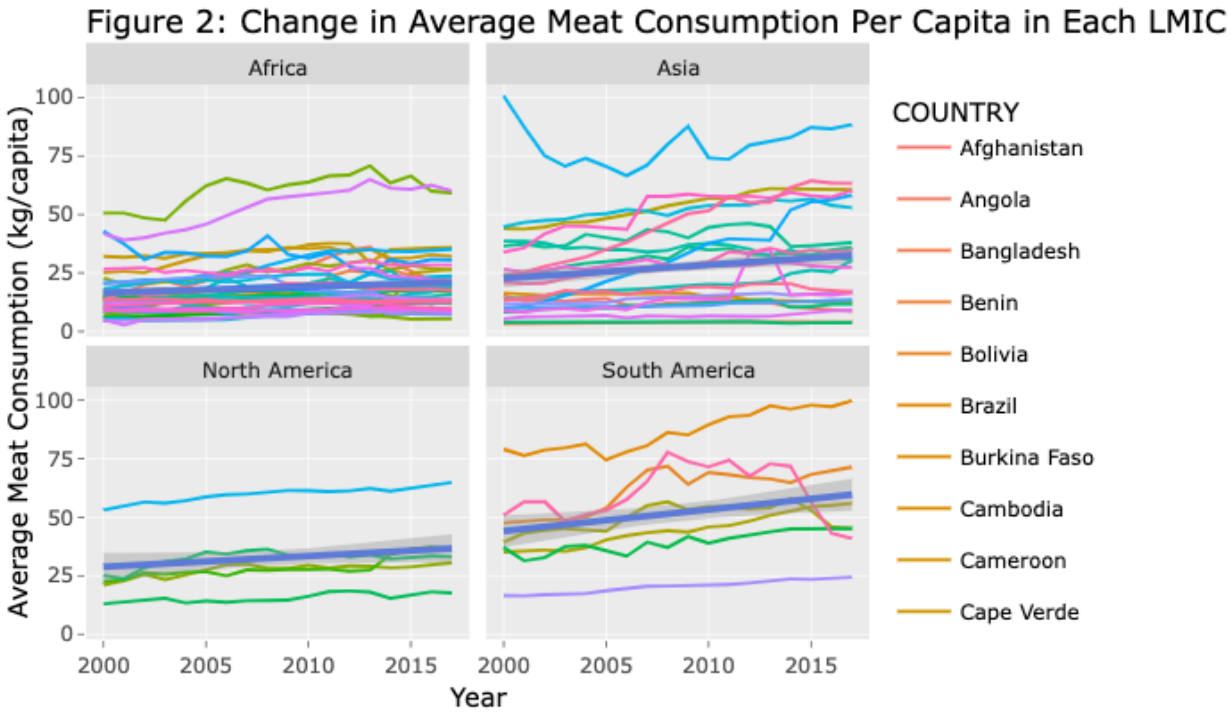


Figure 2 This figure displays the periodic trend in average meat consumption within each country between 2000 and 2017 in units of kilograms of meat food per capita.

In contrast to the trends in anemia prevalence, there was a slight increase in meat consumption in most countries. Some other trends that can be seen above include that South and North American countries have, on average, a high consumption of meat while most African countries have a lower meat consumption. The countries with the lowest meat consumption include the Asian countries of India, Sri Lanka, and Bangladesh, countries where vegetarianism is a main component of the prevalent cultures and religions.

To further investigate the differences in anemia prevalences and meat consumption per capita between different countries, a map visualization was produced, as seen in Figures 3 & 4.

Figure 3: Prevalence of Anemia in Women 15-49 in LMICs in 2017

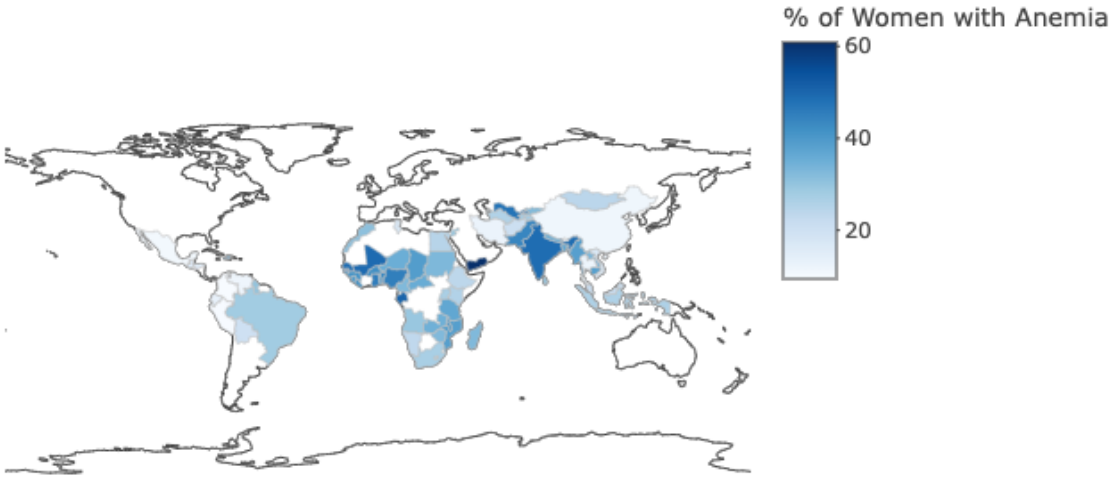
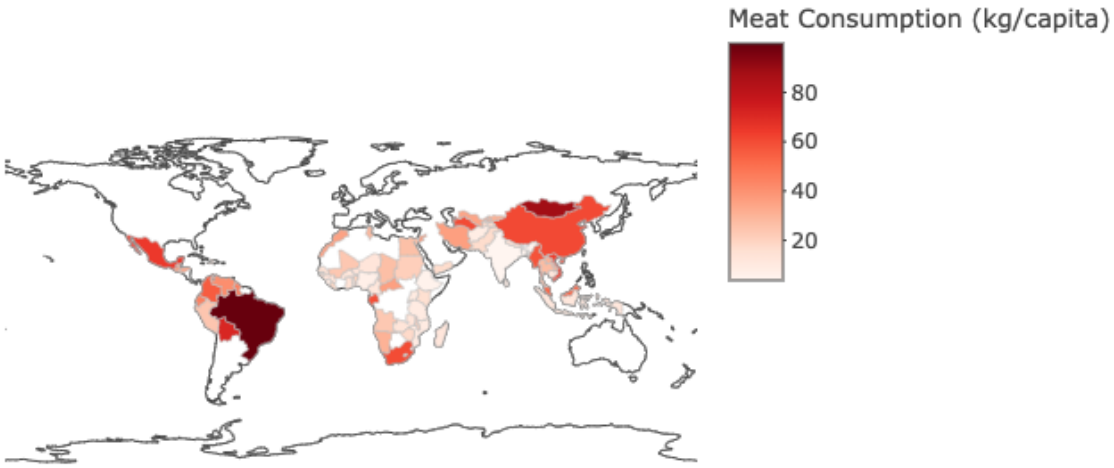


Figure 4: Meat Consumption per Capita in LMICs in 2017



Figures 3 & 4 The figures above visually display prevalence of anemia in young women and meat consumption per capita, respectively, in the Low and Middle Income Countries in 2017. Darker shades indicate higher values of anemia prevalence and meat consumption per capita respectively.

The relationship between the two variables, when comparing the two figures, appears to be inversely proportional. It is interesting to note, once again, that in many south and southeastern Asian countries, meat consumption is low due to the high prevalence of meatless diets common in the local cultures and religions.

Finally, the relationship between meat consumption and anemia prevalence was explored in a scatter plot, where anemia prevalence is on the y axis and meat consumption is on the x axis. To simplify this plot, only the average total anemia prevalence and meat consumption over the 17 year time period for each country was plotted. This could be done because almost all countries

showed relatively similar small increases or decreases within the anemia prevalence data or the meat consumption data, so the average would be a good representation of the entire time period.

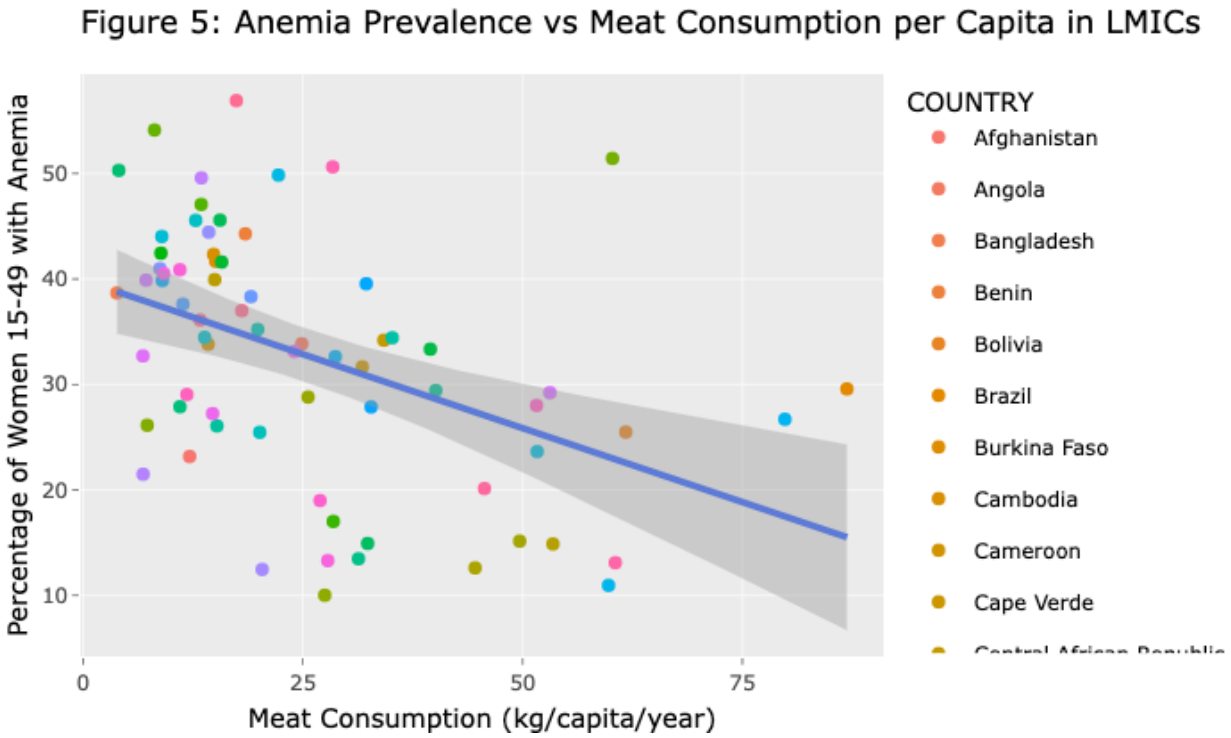


Figure 5 Figure 5 takes the average anemia prevalence and meat consumption over the time period of 2000 to 2017 to compare between the two variables. As meat consumption increases in a country, the prevalence of anemia decreases.

There is a negative linear relationship between meat consumption and anemia prevalence in LMICs, as shown by the slope of the linear best fit line. As meat consumption increases in a country, the prevalence of anemia decreases. Most African countries have low values for meat consumption per capita and high prevalence of anemia. Many South American countries have higher values for meat consumption and a lower prevalence of anemia. There are not many points which fall directly on the best fit line or in its immediate vicinity, indicating that the correlation might not be that large or that there are many outliers.

The final level of analysis included computing the correlation coefficients between the prevalence of various severities of anemia and meat consumption. These coefficients are shown in table 1 below.

Table 1: Correlation Coefficients between Prevalence of various Severities of Anemia & Meat Consumption		
Mild Anemia vs Meat Consumption	Moderate Anemia vs Meat Consumption	Severe Anemia vs Meat Consumption
-0.41	-0.43	-0.35

Table 1: The values in the above table confirm the negative relationship between meat consumption and anemia prevalence, apparent in all 3 types of anemia.

As the magnitude of these 3 coefficients fall between 0.3 and 0.5, they indicate a low to moderate correlation. As they are negative values, they indicate an inverse relationship between the variables of anemia prevalence in young women and meat consumption per capita in low and middle income countries.

Conclusion

Based on the data presented above, there is a moderate negative correlation between meat consumption and anemia prevalence. There are likely many other factors affecting the high levels of anemia found in these LMICs, some of which are also related to diet. This is only a preliminary exploration of the available data and further research could need to be done to consider the effect of other factors, such as the consumption of other minerals and vitamins or the prevalence of blood and digestive-related diseases.

To improve this exploration, more complex statistical analyses and models would have to be performed. These analyses and models would help conclude whether meat consumption is the main contributor to a decrease in anemia prevalence within women.

However, it is positive to see an overall decrease in the prevalence of anemia in almost all countries. This could be indicative of improving general female health in LMICs as well, but this, of course, would need further exploration and the use of other data sets including various indicators of female health.