Title

Maternal Mortality Rates and their Correlation to Food Deserts

Authors

Bao, Adelaide
Schmulbach, Arianna
Zhou, Elizabeth
et al.

Publication Date

2021-04-01

Maternal Mortality Rates and their Correlation to Food Deserts

Adelaide Bao, Arianna Schmulbach, Elizabeth Zhou, Gurashish Khangura, Lula Desta

Public Health and Health Sciences Undergraduate Laboratory @ Berkeley

Undergraduate Student Mentor: Riya Shrestha

University of California, Berkeley

Abstract

Maternal mortality is defined as the number of deaths related to complications during or after childbirth. Food deserts are defined as regions that have limited access to affordable and healthy food options. This study utilized R to analyze data from the United States Department of Agriculture Economic Research Service's Food Access Research Atlas and maternal mortality rates from the UCSF paper "Maternal Morbidity and Outcomes Including Mortality, California 2001-2006." to search for an association between the two variables. The research atlas maps areas in Northern California with low access to grocery stores, as well as provides information on food access throughout the United States using census tracts. The independent variable in this study is food access and the dependent variable is maternal mortality. After analyzing the data collected using R, correlation graphs were created and intercepts and R values were identified. This information was used to further understand the relationship between food access and maternal mortality. For this study, we focused our scope on the Bay Area counties of Alameda, Contra Costa, Marin, San Francisco, Santa Clara, Solano, and Sonoma, which are located in Northern California.

Key Words: Maternal and Child Health, food deserts, Northern California, maternal mortality

Introduction

The purpose of this study is to investigate any existing correlation between proximity to healthy food options in Northern California counties—specifically Alameda, Contra Costa, Marin, San Francisco, Santa Clara, Solano, and Sonoma—and maternal health outcomes. This paper was developed alongside a cultural shift in public health research in which researchers have begun to investigate potential causes of maternal health disparities beyond existing mother-blame narratives. Studies that compare major obstetrical complications across the United States have shown disproportionate cesarean delivery at a rate five times higher in hospitals with lower performance, the question where else existing institutional barriers impact poor health outcomes arose (Glance et al., 2014). Our team specifically examines how residence in a food desert impacts maternal mortality rates.

It has been long recognized that nutrition intake impacts the health and wellbeing of all patients, but the degree to which the geographic distribution of healthy and unhealthy food stores impacts patient health outcomes remains a point of research. Some studies suggest that low access to fresh and healthy food can increase diet-related death, although most studies acknowledge income as a confounding variable (Main Street Birmingham, 2010). Income and food access are intrinsically linked: suburban and high-income neighborhoods have access to quality fresh produce retailers whereas urban and low-income neighborhoods have reduced access to fresh produce. When such healthy food options are available, the prices are higher and the quality is lower (Main Street Birmingham, 2010). It is crucial to investigate whether these physical barriers to healthy food options impact patient health outcomes while healthcare and public policy grow beyond the cultural competency model and establish a structural competency model. While cultural competency models viewed individual level interventions as adequate solutions, the structural competency model views eliminating structural barriers as the appropriate solution. We examine whether food deserts are one such barrier that must be alleviated to improve maternal health outcomes.

The counties of focus in this paper are Alameda, Contra Costa, Marin, San Francisco, Santa Clara, Solano, and Sonoma of Northern California, also referred to colloquially as the Bay Area. In examining this area, our team assumes that these closely related counties maintain a level of cultural homogeneity around maternal health, but this may not be the case. However, by limiting our investigative scope to the Bay Area, we can assume the sample has more homogeneity compared to a much broader investigation at the national level.

We hypothesize that in the Bay Area, higher rates of maternal mortality will be correlated to a high percentage of food deserts within the county. Using statistical analysis, we attempt to distinguish between the effects of income disparity and the effects of low access to healthy food. However, our team acknowledges the presence of other confounding variables, such as racial discrimination, diabetes, education level, and social environment. Our specific research method focuses on using secondary data that allows us to collect data from a broad timescale and retrieve vital information from across seven counties within the Bay Area. Using R to analyze this data, we are able to assess any existing correlation between maternal mortality in a given county and the prevalence of food deserts in that county. Throughout this study, we reference data from the USDA Food Access Research Atlas which maps out food deserts across the United States alongside a display of poverty rates and median income. For our maternal mortality data, we reference UCSF's "Maternal Morbidity and Outcomes Including Mortality, California 2001-2006" report (Remy, Oliva & Clay, 2008).

Methods

For our own data, we utilized the Food Access Research Atlas provided on the United States Department of Agriculture Economic Research Service's website (Economic Research Service). This database provides food access data via the implementation of a census tract within the entire United States. We downloaded the "Archived Food Desert Locator Data File" from the website. This data set provides several useful findings, including the total population of each tract and the percentage of low income individuals living in food deserts. Using R, we filtered this data for counties within California and subsequently filtered for counties within the Bay Area. This approach allowed us to determine the total population in the Bay Area with low food access to a supermarket or large grocery store, as well as the percentage of people within the region experiencing such food insecurity.

In the Food Access Research Atlas, three main indicators are available to measure food access for individuals and neighbourhoods: namely, accessibility to healthy food sources, individual-level resources, and neighborhood-level resources. A tract is said to have low accessibility if at least 33 percent of the tract's population or a minimum of 500 people in the tract are far from a large grocery store or supermarket. In the Food Access Research Atlas, there are several minimum distance bounds from supermarkets to living spaces that can characterize accessibility. The definition chosen was that anything more than 1 mile from a supermarket or large grocery store in urban areas, and more than 10 miles from a supermarket or large grocery store in rural areas, would be considered low access. Apart from standardizing the data, these bounds made the data more manageable to analyze within our given time constraint. A census tract is considered rural if the centroid of that tract is located in an area with a population of less than 2,500; all other tracts are considered urban tracts. Methods used to assess distance to the nearest supermarket are the same for each of these bounds: a county is split up by a 1⁄2-km square grid. Next, the distance to the nearest supermarket is measured for each grid cell by calculating the distance between the geographic center of the 1⁄2-km square grid that contains estimates of the population and the center of the grid with the nearest supermarket. Once the distance from a supermarket is calculated for each square in the grid, the estimated number of people for which the nearest supermarket is over 1 mile away in urban areas or over 10 miles away in rural areas is summed and the tract is determined to be low-access if its population exceeds the metrics stated above. For many instances to be considered a food desert, a tract must also be a low-income census tract. Previously, data from the 2000 Decennial Census were used to estimate low-income census tracts.

We also took data from the UCSF paper "Maternal Morbidity and Outcomes Including Mortality, California 2001-2006." Specifically we utilized Table 11, which shows the estimated number of deaths of ever-pregnant hospitalized women and pregnancy-associated deaths per 10,000 deaths of women between the years 2001 and 2006. This table included women from ages 10 to 60 and divided the data by Bay Area county. The study used the Poisson distribution to determine significance between the data due to the small numerator. The incorporation of this data allowed us to compare it to our Food Access Data Set.

We utilized R to create four correlation graphs. The first graph compared maternal mortality and food deserts for every pregnant woman with residence in the county. The second compared maternal mortality and food deserts for pregnancy associated death with residence in the county. The third graph compared maternal mortality and food deserts with low income for ever-pregnant women with residence in the county. Lastly, the fourth graph compared maternal mortality and food deserts with low income for pregnancy-associated death with residence in the county. From there, we calculated the line of best fit and r squared for each graph to determine correlation.

Results

Ever-pregnant deaths are defined as deaths of women who were pregnant at their time of death (Remy et. al, 2008). Pregnancy-associated deaths are defined as the deaths of women while pregnant or within 1 year of termination of pregnancy, irrespective of cause (Remy et. al, 2008). This paper compiles data for two independent variables: the percentage of people with low food access in a county and the percentage of people with low food access or low income. Their respective effects on two dependent variables — death rates of ever-pregnant women, and pregnancy-related death rates — are examined through correlation graphs.

Low Food Access and Ever-Pregnant Deaths

The y-intercept (18.6) of **Figure 1-1** represents the predicted number of deaths of ever-pregnant women per 10,000 if there was 0% of people in the county with low food access. The slope of **Figure 1-1** (-0.950) indicates that a one unit increase in the percent of low access in a county is associated with a decrease in the death rate by 0.950. The R-squared value shown in **Figure 1-2** (0.157) represents the fraction of the variation in the values of the death rate that is explained by the line of best fit. This means that R is -0.396, which is the correlation coefficient or the strength of linear association between x and y. This moderately negative correlation indicates that the number of deaths of ever-pregnant women generally decreases as their access to food decreases.

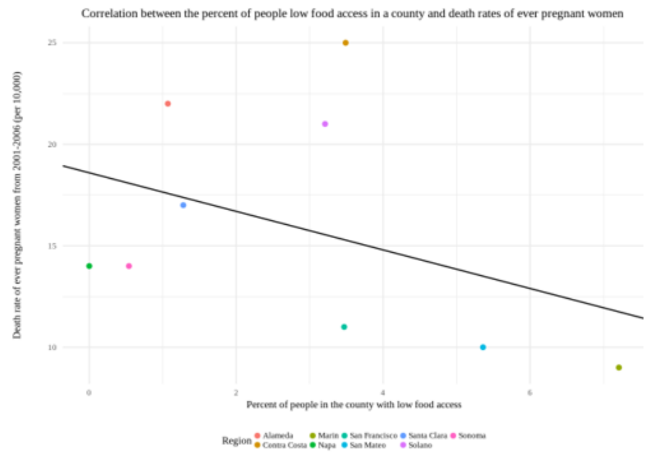

Figure 1-1: Correlation graph between low food access and deaths of ever-pregnant women

Calculate line of best fit

```
mat_EP_lm <- lm(EP_Residence ~ percent_lowa, mat_mort)
library(broom)
tidy(mat_EP_lm)
```

```
## # A tibble: 2 x 5
##   term         estimate std.error statistic  p.value
##   <chr>           <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)    18.6       3.02       6.16 0.000464
## 2 percent_lowa   -0.950     0.833     -1.14 0.292
```

Calculate r squared

```
library(broom)
glance(mat_EP_lm)
```

```
## # A tibble: 1 x 12
##   r.squared adj.r.squared sigma statistic p.value    df logLik   AIC   BIC
##       <dbl>         <dbl> <dbl>     <dbl>   <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1     0.157        0.0363  5.61      1.30   0.292     1  -27.2  60.3  60.9
## # … with 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>
```

Figure 1-2: Exact values of the y-intercept (18.6), slope (-0.950), and R-squared value (0.157) of Figure 1-1.

Low Food Access and Pregnancy-Associated Deaths

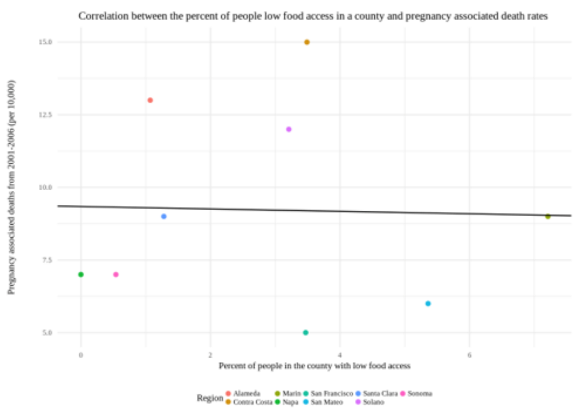

Figure 2-1: Correlation graph between low food access and pregnancy-associated death rates.

```
mat_PA_lm <- lm(PA_Residence ~ percent_lowa, mat_mort)
library(broom)
tidy(mat_PA_lm)
```

```
## # A tibble: 2 x 5
##   term         estimate std.error statistic p.value
##   <chr>           <dbl>     <dbl>     <dbl>   <dbl>
## 1 (Intercept)    9.34       1.97     4.75   0.00209
## 2 percent_lowa  -0.0416     0.543   -0.0766 0.941
```

Calculate r squared

```
library(broom)
glance(mat_PA_lm)
```

```
## # A tibble: 1 x 12
##   r.squared adj.r.squared sigma statistic p.value    df logLik   AIC   BIC
##       <dbl>         <dbl> <dbl>     <dbl>   <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1  0.000838        -0.142  3.65   0.00587   0.941     1  -23.3  52.6  53.2
## # … with 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>
```

Figure 2-2: Exact values of the y-intercept (9.34), slope (-0.0416), and R-squared value (0.000838) of Figure 2-1.

The y-intercept (9.34) of **Figure 2-1** represents the predicted number of pregnancy-associated deaths per 10,000 if there was 0% of people in the county with low food access. The slope of **Figure 2-1** (-0.0416) indicates that a one unit increase in the percent of low access in a county is associated with a decrease in the pregnancy-associated death rate by 0.0416. The R-squared value shown in **Figure 2-2** (0.000838) represents the fraction of the variation in the values of the death rate that is explained by the line of best fit. This means that R is -0.0289 which is the correlation coefficient or the strength of linear association between x and y. Since the correlation coefficient is so small, there is essentially no relationship between low food access and pregnancy-associated deaths.

Low Income/Food Access and Ever-Pregnant Deaths

The y-intercept (16.4) of **Figure 3-1** represents the predicted number of deaths of ever-pregnant women per 10,000 if there was 0% of people in the county with low food access or low income. The slope of **Figure 3-1** (-1.44) indicates that a one unit increase in the percent of low access in a county is associated with a decrease in the death rate by 1.44. The R-squared value shown in **Figure 3-2** (0.00449) represents the fraction of the variation in the values of the death rate that is explained by the line of best fit. This means that R is -0.07 which is the correlation coefficient or the strength of linear association between x and y. This could be interpreted as a weakly negative correlation, but given that many of the individual data points are far from the best fit line, it is likely that there is no correlation between low income/food access and the number of deaths of ever-pregnant women.

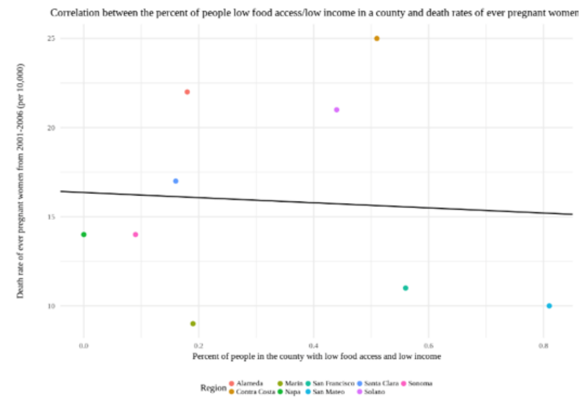

Figure 3-1: Correlation graph between low food access/low income and death rates of ever-pregnant women.

Calculate line of best fit

```
EP_lowi_lm <- lm(EP_Residence ~ percent_lowi, mat_mort)
library(broom)
tidy(EP_lowi_lm)
```

```
## # A tibble: 2 x 5
##   term         estimate std.error statistic p.value
##   <chr>           <dbl>     <dbl>     <dbl>   <dbl>
## 1 (Intercept)     16.4       3.34     4.90  0.00175
## 2 percent_lowi    -1.44      8.10    -0.178 0.864
```

Calculate r squared

```
library(broom)
glance(EP_lowi_lm)
```

```
## # A tibble: 1 x 12
##   r.squared adj.r.squared sigma statistic p.value    df logLik   AIC   BIC
##       <dbl>         <dbl> <dbl>     <dbl>   <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1   0.00449        -0.138  6.09    0.0315   0.864     1  -27.9  61.8  62.4
## # … with 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>
```

Figure 3-2: Exact values of the y-intercept (16.4), slope (-1.44), and R-squared value (0.00449) of Figure 3-1.

Low Income/Food Access and Pregnancy-Associated Deaths

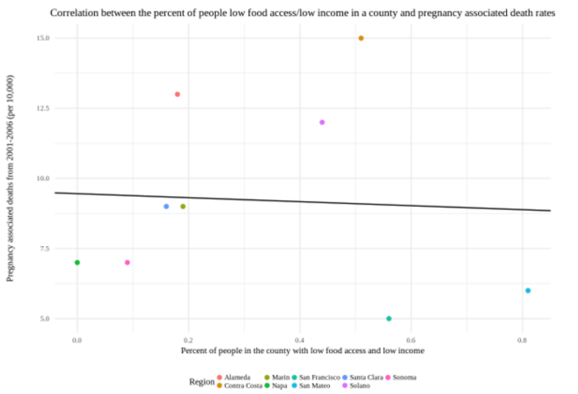

Figure 4-1: Correlation graph between Low Income/Low Food Access and Pregnancy-Associated Deaths

Calculate line of best fit

```
PA_lowi_lm <- lm(PA_Residence ~ percent_lowi, mat_mort)
library(broom)
tidy(PA_lowi_lm)
```

```
## # A tibble: 2 x 5
##   term         estimate std.error statistic p.value
##   <chr>           <dbl>     <dbl>     <dbl>   <dbl>
## 1 (Intercept)     9.46       2.00     4.73  0.00213
## 2 percent_lowi   -0.714      4.86    -0.147 0.887
```

Calculate r squared

```
library(broom)
glance(PA_lowi_lm)
```

```
## # A tibble: 1 x 12
##   r.squared adj.r.squared sigma statistic p.value    df logLik   AIC   BIC
##       <dbl>         <dbl> <dbl>     <dbl>   <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1   0.00308        -0.139  3.65    0.0216   0.887     1  -23.3  52.6  53.2
## # … with 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>
```

Figure 4-2: Exact values of the y-intercept (9.46), slope (-0.714), and R-squared value (0.00308) of Figure 4-1.

The y-intercept (9.46) of **Figure 4-1** represents the predicted number of pregnancy-associated deaths per 10,000 if there was 0% of people in the county with low food access or low income. The slope of **Figure 4-1** (-0.714) indicates that a one unit increase in the percent of low access in a county is associated with a decrease in the pregnancy-associated death rate by 0.714. The R-squared value shown in **Figure 4-2** (0.00308) represents the fraction of the variation in the values of the death rate that is explained by the line of best fit. This means that R is -0.0289 which is the correlation coefficient or the strength of linear association between x and y. Since the correlation coefficient is so small, there is essentially no relationship between low income/food access and pregnancy-associated deaths.

Discussion

The purpose of this study was to identify the relationship between maternal mortality and access to food within counties in the Bay Area. Through our primary research method, we were able to pull relevant data from previous studies revolving around maternal mortality rates within counties in the Bay Area and use government sites to gather data on the prevalence of food deserts in certain counties. Through our findings, we were able to conclude that there were no significant ties between high mortality rates in connection to a high percentage of food deserts within counties in the Bay Area. On all four of our graphs, we noticed that they all showed a negative relationship between low food/income accessibility and maternal mortality, which we found to be extremely surprising. The graph with the most prominent negative correlation was “Correlation between the percent of people with low food access in a county and death rates of ever-pregnant women”, furthermore disproving our hypothesis (Figure 1-1).

Our research was limited by our primary research method. We were limited to secondary data, meaning we were reliant on data that was already collected. Due to the limitations of the data, detailed data such as being able to see the racial demographics and age range of mothers were not available. This lack of access to such information could have impacted our results. Although our findings found no correlations between high maternal mortality rates in connection to a high percentage of food deserts, we recognize the role confounding variables. We believe variables such as family planning and being able to access a healthcare facility in a timely manner to have possibly played a significant role in the lack of correlation between food access and maternal mortality rates within counties in the Bay Area. With the rise of family planning, mothers are now having children at a later age in hopes of increasing their chances of having a healthier pregnancy and baby. According to CDC, "the average age of first-time mothers increased by 1.4 years from 2000 to 2014, with most of the increase occurring from 2009 to 2014" (Mathews, 5). The negative correlation between lack of food access and maternal mortality could be attributed to the rise in family planning, as more individuals are choosing not to have children until they are financially capable of being able to provide for their families. Another big confounding variable is that we are accounting for the entire county's maternal mortality rates, we cannot specify how many maternal mortalities came from women living in a food desert vs not. This means that we are accounting for communities with access to fresh food as well as those in higher income brackets in all the county counts, which could cause a skew in the data. Overall, further research is needed in regards to the confounding variables that we believe have contributed to the negative correlation between food access and maternal mortality in Bay Area counties.

Conclusion

Through our study, no significant positive correlation was found between maternal morbidity and food deserts in the Northern California counties of Alameda, Contra Costa, Marin, San Francisco, Santa Clara, Solano, and Sonoma. As mentioned previously, some limits to this study included the use of secondary data and confounding variables such as maternal age and method of data collection. It would be interesting in the future to see further studies done with more thorough data collection of individual maternal mortality outcomes of women within food deserts versus outside rather than accounting for county wide data.

References

1. Cohen, J., Daw, N., Engelhardt, B. et al. (2017). Computational approaches to fMRI analysis.
2. Economic Research Service (ERS), U.S. Department of Agriculture (USDA). Food Access Research Atlas, https://www.ers.usda.gov/data-products/food-access-research-atlas/
3. Main Street Birmingham. (2010, August). *Examining the Impacts of Food Deserts and Food Imbalance on Public Health in Birmingham, Alabama*. Mari Gallagher Research & Consulting Group. https://www.marigallagher.com/.
4. Glance, L. G., C, S., LM, W., A, E., CJ, B., DA, A., … Makary, M. A. (2014, August). Rates Of Major Obstetrical Complications Vary Almost Fivefold Among US Hospitals: Health Affairs Journal. Health Affairs. https://www.healthaffairs.org/doi/full/10.1377/hlthaff.2013.1359.
5. Mathews, M.S., Hamilton, Ph.D., T. J., Brady E. "Mean Age of Mothers Is on the Rise: United States, 2000–2014." *NCHS Data Brief*, 2016, pp. 1–8. *CDC*, www.cdc.gov/nchs/data/databriefs/db232.pdf.
6. Remy, L., Oliva, G., & Clay, T. (2008). Maternal morbidity and outcomes including mortality, California 2001–2006. Family health outcomes project. San Francisco: University of California.