2020

# The Relationship between Upstream Variables and Diabetes in Ohio

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**Abstract**

Chronic illness is a significant contributor to disease burden in the US. Among these chronic conditions, diabetes is one of the most prevalent. Knowing the relationships between various factors and the prevalence of diabetes would be beneficial to creating targeted approaches to address this major public health problem. Therefore, the objective of this project was to elucidate the relationship between social determinants of health (unemployment, food environment index, and access to exercise opportunities) and access to care variables (ratio of population to primary care physicians and percent uninsured) with prevalence of diabetes by county in Ohio. This was done through Spearman correlation statistical analysis of data collected from the CDC County Health Rankings and Roadmaps Database. Results showed a weak negative correlation between diabetes prevalence and access to exercise, and a weak positive correlation between diabetes prevalence and percentage uninsured and PCP (primary care provider) ratio. Diabetes prevalence showed no correlation to food environment index. Results showed a moderate positive correlation between unemployment rates and diabetes prevalence. Additionally, a linear regression was performed to determine how well the selected social determinant of health and access to care variables accounted for the observed variance in diabetes between counties. The stepwise regression showed that the model was significant with percent unemployment having the greatest contribution to the observed variance in diabetes prevalence. Access to exercise opportunities was also found to have a significant contribution to the best model.
Key Words: Diabetes, Access to Care, Social Determinants of Health

**Introduction/Literature Review**

Chronic illness has become a significant part of the healthcare burden in the United States. In 2015, approximately 9.4% of the US population, or approximately 1 in 10 individuals, had diagnosed diabetes [1]. In 2012, diabetes was the 7th leading cause of death in the United States and accounted for $245 million in direct and indirect healthcare spending[1].

Conventional wisdom dictates that the overall effects of diabetes on the population are moderated by access to care[2] and social determinants of health[3,4]. In 2015 in Ohio, significant disparities in diabetes prevalence were found, showing the highest prevalence in older adults, blacks, those living in rural areas, and those with low income and education[5]. Despite the observed correlations between the social determinants of health and diabetes prevalence, most Type 2 Diabetes prevention programs in current use focus on diabetes-specific medical[6,7] education and nutrition-focused[8,9] lifestyle education.

Given the fluctuation of these variables within a small distance, analysis of county-based datasets within a given state may allow for a more accurate analysis of variance and correlation. Furthermore, no known studies have clarified the relation of insurance, an access to care variable, to diabetes prevalence. Knowing what variables have the greatest correlation with prevalence of diabetes would allow future public health interventions to focus on factors with the highest correlation to disease burden (defined as prevalence of diabetes). This knowledge will also allow for the creation of novel targeted upstream approaches to decreasing the health burden of diabetes.

**Hypothesis/Specific Aims/Research Questions**

1. How do social determinants of health relate to diabetes prevalence?
    a. Does diabetes prevalence correlate with access to exercise opportunities by county in Ohio?
    b. Does diabetes prevalence correlate with food environment index by county in Ohio?
    c. Does diabetes prevalence correlate with % of individuals who are unemployed by county in Ohio?
2. How do access to care variables relate to diabetes prevalence?

   a. Does diabetes prevalence correlate with ratio of population to primary care physicians (PCP ratio) by county in Ohio?
   b. Does diabetes prevalence correlate with % of individuals under 65 who are uninsured by county in Ohio?
3. How well do the above-mentioned access to care variables (PCP ratio, percent uninsured) and social determinant variables (access to exercise opportunity, food environment index, percent unemployment) account for variance in diabetes prevalence by county in Ohio?

## Methods

### *Context/Protocol*

All data was obtained from CDC Wonder's public use databases and was analyzed in compliance with the standards outlined in the Public Health Service Act (42 U.S.C. 242m(d))[10]. Specifically, data was pulled from the CDC's 2017 County Health Rankings database. Rankings of diabetes prevalence, access to exercise opportunities, food environment index, unemployment, insurance rates, unemployment rates, and access to primary care physicians where obtained by county. Data collection was limited to the state of Ohio.

### *Data Collection*

Data on food environment index was aggregated from the USDA Food Environment Atlas (2015) and Map the Meal Gap (2015). The Food Environment index scores counties on proximity to healthy foods and income/food insecurity, weighting each variable equally. Both variables were scored from a range of 0 (worst) to 10 (best). Proximity to healthy food was based on the percentage of the population that had a "family income of less than or equal to 200% of the federal poverty threshold," and living within 10 miles of a grocery store in rural areas and within 1 mile in nonrural areas. Food insecurity is based on a two-stage fixed effects model which estimates the "percentage of the population that did not have access to a reliable source of food during the past year." The model was created using information from the Community Population Survey, Bureau of Labor Statistics, and American Community Survey. Data on access to exercise was aggregated from the Business Analyst, Delorme map data, ESRI and US Census Tigerline Files (2010, 2016). Access to Exercise Opportunities was defined as the percentage of the population who resided within a census block that was within half a mile of a park, or resided within an urban census block within one mile of a recreational facility or

resided within a rural census block that was within three miles of a recreational facility. This measure is limited by the inability to account for all possible exercise opportunities within the community and additional factors that affect the accessibility of the park or recreational facility. Data on unemployment was obtained from the Bureau of Labor Statistics (2016). Unemployment was defined as the "percentage of the county's civilian labor force, age 16 and older, that is unemployed but seeking work." Unemployment was estimated using modeled data from the Current Population Survey, Current Employment Statistics and the Unemployment Insurance system.

Data on insurance was obtained from Small Area Health Insurance Estimates (2015). Uninsured is defined as the "percentage of the population under age 65 without health insurance coverage." Uninsured measures were created using statistical modeling by The Small Area Health Insurance Estimates. Data on access to primary care physicians was obtained from the Area Health Resource File/American Medical Association (2015). Access to primary care physicians was calculated as a "ratio of the number of individuals served by one physician in a county, if the population was equally distributed across physicians." Both D.O.s and M.D.s were defined as primary care physicians.

Data on diabetes prevalence was obtained from the CDC Diabetes interactive atlas (2014), which used CDC's Behavioral Risk Factor Surveillance System (BRFSS) data to provide county-level estimates. Diabetes prevalence is defined as the "percentage of adults aged 20 and above with diagnosed diabetes in a given county."

### *Data Analysis*

Given the nonparametric nature of the independent variables (percent uninsured, PCP ratio, percent unemployed, access to exercise opportunity and food environment index), two-tailed Spearman's Correlational tests were performed comparing each of the independent variables with the prevalence of diabetes. The correlation was considered statistically significant if two-tailed significance was $<.05$. Spearman's rho $\geq .3$ was defined as a weak correlation and rho ($\rho$) $\geq .5$ was defined as a moderate correlation. Additionally, a linear regression was performed to analyze what proportion of the observed variance in diabetes between Ohio counties could be accounted for by the independent variables.

**Results**

Initial analysis of the distribution of independent variable datapoints showed non-parametric distributions (Table 1). Because of this distribution pattern, a Spearman's bivariate correlational analysis was performed (Table 2).

**Table 1**: Variance within Independent Variables

| *Social Determinants of Health* | **Mean** | **SD** | **N** |
|---|---|---|---|
| Access to Exercise Opportunities | 68.4 | 19.2 | 88 |
| Food Environment Index | 7.7 | .7 | 88 |
| Percent Unemployment | 5.3 | 1.2 | 88 |
| *Access to Care Variables* | | | |
| Primary Care Physician-Population Ratio | 104.1 | 58.9 | 87 |
| Percent Uninsured | 6.9 | 1.7 | 88 |

Abbreviation: SD = Standard Deviation, N = number of data points in analyzed sample

**Table 2**: Spearman's Bivariate Correlations with Diabetes Prevalence by Ohio County

| *Social Determinants of Health* | ρ | **Significance (2-tailed)** | **N** |
|---|---|---|---|
| Access to Exercise Opportunities | -.34 | .001 | 88 |
| Food Environment Index | -.28 | .007 | 88 |
| Percent Unemployment | .51 | .001 | 88 |
| *Access to Care Variables* | ρ | **Significance (2-tailed)** | **N** |
| Primary Care Physician-Population Ratio | .40 | .001 | 87 |
| Percent Uninsured | .40 | .001 | 88 |

Results showed that there was a weak negative correlation between diabetes prevalence and access to exercise opportunities ($\rho = -.34$, $p = .001$) and food environment index ($\rho = -.28$, $p = .007$). As access to exercise and food environment quality decreased, diabetes prevalence increased (Figs 1, 2).

**Figure 1:** Correlation of Food Environment Index with Diabetes Prevalence

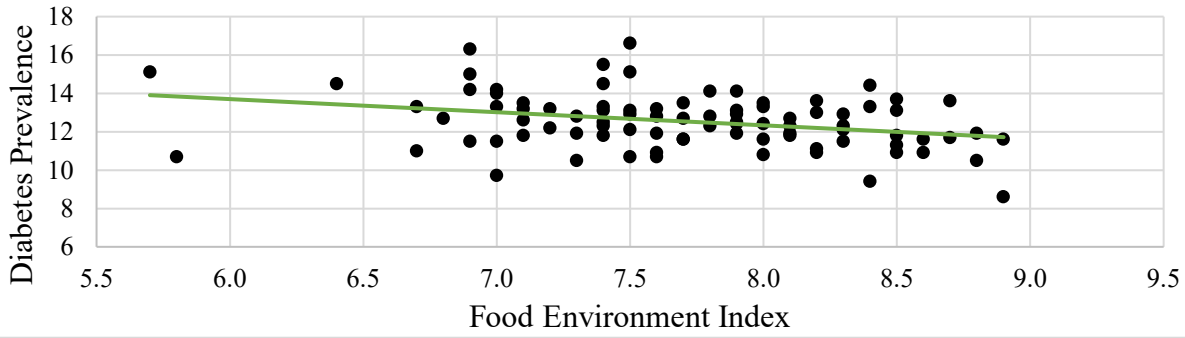
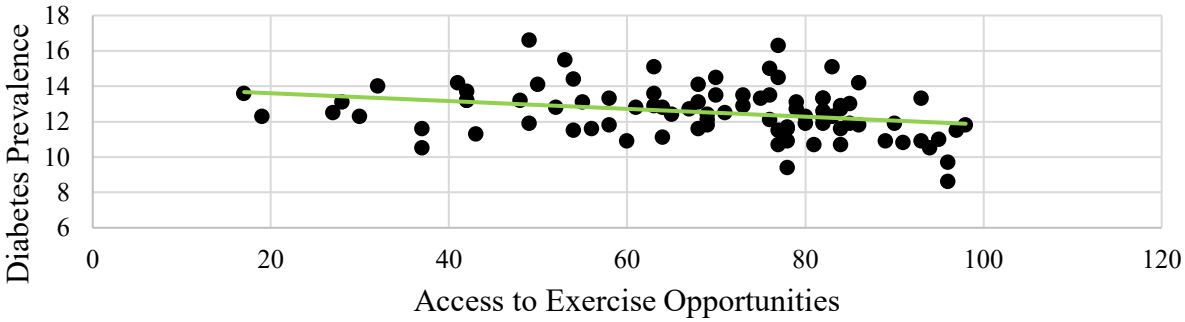
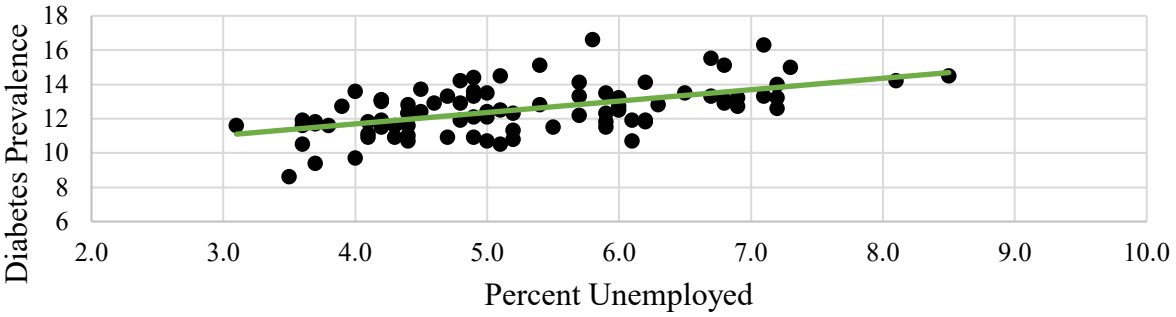



**Figure 2:** Correlation of Food Environment Index with Diabetes Prevalence




Analysis revealed a weak positive correlation between diabetes prevalence and percent uninsured ($\rho = .40$, $p = .001$) and primary care physician to population ratio ($\rho = .40$, $p = .001$). Additionally, a moderate positive correlation was found between diabetes prevalence and percent unemployed ($\rho = .51$, $p = .001$). The relationship between diabetes prevalence and percent uninsured is depicted in Figure 3 as a typical example of the positive correlational relationships observed.

**Figure 3:** Correlation of Percent Unemployed with Diabetes Prevalence



A linear regression was used to determine how the independent variables (percent unemployed, access to exercise, food environment index, PCP ratio, and percent uninsured) accounted for the variance seen in diabetes prevalence. A step wise linear regression of the independent variables indicated the best fitting model was significant ($F_{2,84} = 44.83$, $p < .001$), accounting for 34.2% of the variance in diabetes prevalence between Ohio counties. Percent unemployment had the greatest contribution to the model ($B = .633$, $t = 5.71$, $p < .001$) with access to exercise opportunities ($B = -.017$, $t = -2.50$, $p = .014$) also significantly contributing. Food environment index, percent uninsured and PCP ratio did not significantly add to the model.

**Discussion**

Both social determinants of health (access to exercise opportunities, food environment index, and unemployment) and access to care variables (PCP-population ratios and percentage with health insurance) are correlated with the prevalence of diabetes by county in Ohio (Table 2, Figure 1). The incidence of Type 2 Diabetes is intricately linked to a population's access to quality nutrition, exercise opportunities, and life stressors. A 2014 study found that diets "rich in wholegrains, fruits, vegetables, legumes and nuts; moderate in alcohol consumption; and lower in refined grains, red or processed meats, and sugar-sweetened beverages" reduce the risk of developing diabetes[11]. Furthermore, exercise has been shown to be an effective method of prevention and management for Type 2 Diabetes[12]. Unfortunately, access to nutritious foods and exercise opportunities are stratified by socioeconomic status, with those in lower socioeconomic categories having less access[13,14]. This suggests a potential mechanism for the finding that unemployment rates were associated with the greatest proportion of variance in diabetes prevalence. Therefore, unemployment may be a marker for diabetes risk and provides a possible population for targeted diabetes interventions. This theory is supported by previous research that showed a relationship between unemployment and declines in physical health, including the development of new-onset diabetes[15,16]

Furthermore, in 2007, a systematic review found that diabetes cost an estimated $174 billion in indirect and direct healthcare costs in the US[17]. While some studies found lifestyle intervention programs to be cost-saving in diabetes prevention[18,19], others reported more ambiguous results[15]. Perhaps, targeting such lifestyle interventions to at risk populations, such as those with a high percentage of unemployment, would improve the relative cost-benefit profile

of the treatment model. Given that there is currently no clear-cut solution as to the most cost-effective method of diabetes management and treatment, future studies could look at whether strategies aimed at reducing unemployment were able to offset this societal cost without a significant increase in expenditures.

This study was limited by a small sample size (n = 88) and potential lack of generalizability due to limiting data analysis to only one state. Future studies could expand the number of data points and states included in the sample set analyzed. Additionally, the current study was limited by the use of aggregate data sets based on county-wide averages. In the future, analysis of smaller geographic areas or individual-level data points could provide a better representation of correlations between socioeconomic and access to care variables due to the potential for large socioeconomic disparities within a given county.

Future studies could focus on whether the correlations of social determinants of health and access to care variables with diabetes prevalence found between Ohio counties are generalizable to the rest of the US as well as other countries. Additionally, looking at whether counties with significant changes in unemployment rate were correlated with proportional changes in diabetes prevalence would provide stronger support to the theory that the correlation seen in this study is indicative of a causative relationship.

**Conclusion**

These results provide greater support to the conclusion that diabetes is intricately related to social, economic and health factors. Lower socioeconomic status, perhaps caused by unemployment, is associated with decreased access to exercise opportunity and nutritious foods. Lack of access to these essential components of a healthy lifestyle may cause a greater incidence of diabetes in these populations. This theory was supported by the finding that diabetes prevalence by county in Ohio had a significant weak correlation with access to exercise opportunities, food environment index, primary care physician to population ratio and percent uninsured. A linear regression showed that percent unemployment was associated with the greatest proportion of variance in diabetes prevalence by county. Access to exercise also had a significant contribution to the best model. These results suggest that diabetes prevention strategies which consider the correlation between unemployment and diabetes prevalence in their

approach, either through an upstream approach or through selection of a targeted population for inclusion, may be more effective in reduction of disease burden and overall societal costs.

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