Mapping the Effects of Pollution on Diabetes in Durham, NC

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Hypothesis

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Abstract

Background

Though the impact of environmental pollution on chronic disease remains largely unknown, previous case control studies have begun to examine the adverse effects of particulate matter ($PM_{2.5}$) on prevalence of type 2 diabetes. Based on multivariate regression models in these studies, a 1% increase in diabetes prevalence is seen with a 10 μg/m^3 increase in $PM_{2.5}$ exposure due to impairment of vascular reactivity.

Presentation of the hypothesis

This study proposes the use of Geographic Information Systems (GIS) to illustrate the correlation of diabetes to the anthropogenic footprint to target healthcare delivery and policy for diabetes-related health mitigation. GIS is used to overlay variables of diabetes prevalence, social determinates of health, and particulate matter concentration as layers on a map allowing targeted prevention programming.

Testing of the hypothesis

Though $PM_{2.5}$ can be harmful in many contexts, for adults with diabetes, it becomes adverse as it enters the bloodstream, placing the body under oxidative stress. The window of opportunity for testing the hypothesis is large in that ambient air pollution and patients with diabetes are abundant. Using a longitudinal, matched, family cohort design, we are able to assess the long and short-term exposure of $PM_{2.5}$ to better understand the nature and timing of the onset of disease.

Implications of the hypothesis

The hypothesis has the potential to identify high risk patients and could provide the basis for future work to assess risk at the neighborhood level. Based on risk acceptance and aversion, targeted policy interventions within states, counties, and neighborhoods may advance the state of the science for improving health and reducing health risk at a population level.

Introduction

Epidemiological Studies

Though many studies have examined the relationship between pollutants such as ozone and effects on respiratory health such as asthma, few have begun to study relationships of environmental pollutants to chronic conditions such as diabetes[1]. There is a growing body of literature that suggests links between particulate matter ($PM_{2.5}$) and the prevalence of type 2 diabetes[1,2]. The primary hypothesis is that $PM_{2.5}$ induces oxidative stress and inflammation, which leads to anabolic insulin resistance.[1,2,3] Many studies claim that primary sources of $PM_{2.5}$ and other related pollutants like NO_2 are at highest concentrations

near heavily trafficked areas.[3] Long-term exposure of pollutants may cause far more stress in localized areas of tissues and vital organs, resulting in cumulative effects on the body over time.[3,4]

Diabetes

Diabetes and related cardiovascular and metabolic comorbidities are remarkably common for many residents of Durham County, North Carolina. According to the CDC, 12.9% of the adult population and in certain neighborhoods upwards of 23.4% of inhabitants are burdened with diabetes.[5,6] Although diabetes significantly increases chances of developing comorbid conditions and dramatically lowers quality of life, it is also closely associated with non-health related, social determinates of health, including poverty and low socio-economic positions reflected by an individuals' build environment.[7,8] Examples include pollution-dense locations for housing and poor access to sidewalks, transportation, safe water and clean food sources.[8]

The CDC lists five broad categories of factors that influence health: genetics, behavior, environmental and physical influences, medical care, and social factors (CDC).[6] Here, social conditions can be thought of as the conditions or context in which people are born, live, learn, worship, and age. In the hypothesized study social determinates affecting health include level of income, education, and race.

Environmental Health

Atmospheric pollution is a symptom of an industrialized and urban world and plays a central role in a warming climate,[9] advanced ecological collapse,[10] resource inequality,[11] and population health.[9,11] Though many studies have examined the correlations between pollutants such as ozone and respiratory health, few have begun to study relationships to chronic conditions such as diabetes. There is a growing body of literature that suggest links between particulate matter ($PM_{2.5}$) and the prevalence of type 2 diabetes.[1–3] The primary hypothesis is that $PM_{2.5}$ induced oxidative stress and inflammation which leads to insulin resistance.[3,4] Many studies claim that primary sources of $PM_{2.5}$ and other related pollutants like NO_2 are at highest concentrations near heavily trafficked areas.[1,4] Less commonly studied however are the effects of the environment, natural and build, on these same health outcomes.[7] Therefore, we seek to understand the relationship of atmospheric pollutants with diabetes.

The field of environmental justice considers the compounding repercussions of poverty, race, and inequality on peoples lived experience.[12] For this reason, it is difficult to conduct studies that deduce conclusive relationships between the health and environmental variables because the prevalence of confounding factors must be adequately accounted for. That being said, a study of this nature has the potential to illuminate environmental inequalities and discrimination from a geographic, and quantitative lens.

Presentation Of The Hypothesis

Geographic Information Systems (GIS) provides a multidisciplinary approach to understanding health disparities at the state, county, and neighborhood levels. Applying a geospatial methodology allows us to identify communities at high risk: weather that be environmental, health related, or both. Further we can understand accessibility within a community, re-market those assets, or introduce policy to make amenities available for those without. Most importantly, GIS allows us to target risk.

Though our preliminary analysis compiles and utilizes only the publicly available data, primarily from the Durham Community Compass and Environmental Protection Agency (EPA) datasets, we propose testing a more comprehensive method for parsing community characteristics and understanding what constitutes effective resource allocation for patients with diabetes.

Proposal

Based on a preliminary analysis and literature review, the potential for identifying strong correlations between diabetes and $PM_{2.5}$ is high. This study proposes a robust methodology for affirming this relationship, and for identifying opportunities for future intervention strategies through the use of Geographic Information Systems (GIS) to visually and quantifiably analyze data and environmental relationships with prevalence of diabetes.

The proposed methodology begins by combining three key data sources: healthcare data, survey-based demographic data, and $PM_{2.5}$ concentrations at several locations within Durham County. In combination, these sources help characterize the current state of health within the county. Accessing or collecting the $PM_{2.5}$ concentrations will require funding, time, and support of local organizations, and is perhaps the most challenging. By utilizing GIS specific tools such as “hot spot maps”, or the “nearest neighbor analyst” we propose to visually understand areas of greatest need.

Limitations of the Hypothesis

The results from a methodology of this nature have the potential to be deceiving, if taken alone. Therefore, a regression analysis to adjust for the confounding nature of the social determinates of health would be needed to limit bias and determine the validity of statistical inferences. Likewise, ongoing funding is needed to assure access to electronic geocoded data, survey informatics, and the continued and accurate measurements of $PM_{2.5}$. To address this limitation, the support of local organizations will be needed, including the Duke Center for Prevention, to study the toxicology and physiological processes related to chemical pollutants in the body; the Nicholas School of the Environment, to provide materials and monitoring time; and the North Carolina EPA and National Institute of Health (NIH) to assess and analyze relationships between health and pollution. Lastly, the hypothesis is limited by the timeliness, currency and availability of the proposed data sources. Adjustments for this limitation would take into account actuarial omissions and reporting delays.

Testing The Hypothesis

An academic health system in the southeast has an automated geocoding infrastructure to standardize and scale the previously tedious process of associating health conditions with patients addresses. Linking patient addresses to their health conditions provides a more detailed picture of social, economic, and political determinates of health that patients experience. Furthermore, a matched, family cohort study would provide us with data to assess the long and short-term environmental exposures. Data sources that link patient addresses to medical records is a critical component of the analysis. Survey based data is important to consider because it explains the variables that may influence health of patients. More specifically, there are many covariates of health and the environment that need to be accounted for when building statistical models to measure the direct relationships between pollution and diabetes.

Enabling the geocoded data to be combined with public health, census tract data, and information about the built/natural environment allows investigators to paint a full picture of the multifactorial components and additive nature of the influence of social and environmental drivers on disease burden and disease outcomes.

Environmental Analysis

Environmental analysis can be conducted by the use of air quality monitors such as the PCE-RCM 05 which are used to measure localized concentrations of particulate matter, as well as temperature and humidity. A number of these monitors would need to be placed throughout Durham County in both populated and rural regions to assess the impact of traffic and industry. Averaged daily concentrations of $PM_{2.5}$ would be sufficient, but monitoring would need to take place over the course of several weeks.

Implications Of The Hypothesis

Implications spanning the intersection of healthcare, health policy, and environmental science emerge. First, identifying neighborhoods and communities at high risk for developing diabetes due to environmental pollution may allow further development of targeted interventions to mitigate illness. Second, aligning health polices, and environmental science initiatives has multiple benefits including lessening the anthropogenic footprint, improving the accessibility of outdoor spaces and promoting a community profile of healthy living. A spatial analysis of this nature only begins to illuminate possibility as a useful tool in the medical and public health world.

Declarations

Ethics for approval and consent to participate

This study relies on data from the Duke Medicine Electronic Medical records. Participants gave approval for this data to be shared for research purposes.

Consent for publication

Not applicable

Availability for data and materials

The datasets generated and/or analyzed during the current study are not publicly available to protect patient's medical information but are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

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Author's contributions

Ms. Zwecker cleaned and analyzed the study data and was chiefly responsible for developing, researching, writing, and editing the manuscript. Dr. Granger contributed to the conception and design of the study and interpretation of the data. She also participated in revising and critical review of the content of the manuscript.

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