Project Narrative

A preterm birth (PTB) is defined as a birth occurring before 37 completed weeks of gestation. It is a leading cause of infant mortality and morbidity. In 2013, about 36% of infant deaths in USA were due to preterm-related causes and PTB babies who survive may have development delay, breathing problems, and other health issues (CDC, 2017). PTB complications were responsible for 15% of the children who died before 5-year old in 2013 globally (Liu et al., 2015). Thus, PTB is an important health issue in USA and around the world. It is urgent to make and implement more effective health policies to reduce PTB rate, which needs a better understanding of its risk factors. Many studies have been conducted to explore the associations of PTB with risk factors, but the results are not consistent. The associations remain elusive to researchers. Most of studies applied conventional statistical methods (e.g. Ordinary Least Squares (OLS) Regression) to examine the associations of PTB with risk factors. They assume the associations do not change over space. However, the comparison of the previous results reveals that the associations actually vary geographically. Thus, the conventional methods are unable to capture the spatial variations in the associations. In recent years, a spatial statistical technique, Geographically Weighted Regression (GWR) has been applied to explore the spatial variations in associations of variables in various fields. I have also extended GWR to analyze the associations of birth outcomes with risk factors, including air pollution in Georgia (Tu et al., 2012, Tu et al., 2016, Tu and Tu, 2018). However, the previous studies including mine did not consider time dimension in the modelling of PTB, even though the associations of PTB with risk factors might vary across space and time simultaneously. More recently, GWR was advanced to Geographically and Temporally Weighted Regression (GTWR) to capture both the spatial and temporal dimensions of the associations, and has been applied to study the spatiotemporal variations in the associations of variables in various fields (Sholihin et al., 2017, Du et al., 2018, Ma et al., 2018), but GTWR has never been used to study health issues, including PTB.

A. Goals

The overall objective of this proposed project is to study the spatiotemporal variations in the associations of preterm birth with ambient air pollution, as well as socioeconomic and behavior factors in

the State of Georgia over the period of 2001-2015 by integrating Geographic Information System (GIS), conventional statistics (e.g. OLS), and spatial statistical techniques, including GWR and GTWR. The ultimate goal is to develop fresh approaches and to produce preliminary results that can be extended to study other birth outcomes and health issues so that external funds can be attracted. The study will answer the following questions: (1) What are the differences in the associations of PTB with air pollution analyzed by OLS, GWR, and GTWR? (2) How do the associations of PTB with air pollution generated by GTWR vary across space and time? (3) How are the spatiotemporal variations in the associations affected by socioeconomic and environmental characteristics of communities? The project will complement, challenge and expand the field of birth outcome study and even general environmental and health studies, because it will apply novel methods to generate new knowledge. Its novelty is embodied in the following aspects: (1) the associations of PTB with risk factors were not well understood; (2) the spatiotemporal variations in the associations have never been analyzed; (3) The major method, GTWR, has never been used in health studies. Thus, it will expand the current one-dimensional health studies that do not consider the spatial variations in the associations of health issues with risk factors, and two-dimensional health studies that only examine spatial variations in the associations, to a three-dimensional one that will explore the spatiotemporal variations.

B. Significance

This project is important to my research agenda, to the academic fields of birth outcomes and even broader health studies, to the health policy making and decision, and can also greatly benefit KSU. I have published over 35 peer-reviewed articles in the fields of environmental and health geography, five of which are about birth outcomes, including PTB and Low Birth Weight (LBW). The major method used was GWR, which significantly improved the scientific understanding of the associations of birth outcomes with risk factors and advanced the birth outcome studies from one-dimensional to two-dimensional. However, GWR can only examine the spatial variations in the associations of variables without considering the time dimension, even though the environmental and health issues generally vary over space and time simultaneously. Therefore, the approaches that involve GTWR to consider both

spatial and temporal dimensions in this project will move my research to a new level, and the approaches and preliminary results will be very attractive for external agencies to fund my future research. It will also make a significant contribution to the academic fields of birth outcome and health studies, and also health policy making and decision. The reasons are (1) the new GTWR approaches can be expanded to examine other birth outcomes and health issues, and can be followed by other environmental and health scientists; and (2) this project will generate new knowledge on the previously unknown spatiotemporal variations in the associations of PTB with risk factors, which is important and useful information for both academic research and health policy making. This project can also benefit KSU through multidisciplinary practical and academic training for students and new course development. Undergraduate students will be involved in different stages of the project. The skills and knowledge they will learn are beyond the current curriculum at KSU. The data and materials produced can be used to develop new courses (e.g. Health Geography, GIS and Public Health). KSU and the faculty can also enhance reputations in local communities by contributing to the solutions of real-world issues and in academic disciplines by developing new methods and discovering new knowledge.

C. Outcomes

The main outcomes of this project are: (1) a set of new approaches that involve GTWR and other spatial and statistical methods to study spatiotemporal variations in the associations of PTB with risk factors to be used in this and future projects; (2) a database containing birth outcomes, ambient air pollution, and socioeconomic characteristics of the communities over the period of 2001-2015 for undergraduate and faculty research; (3) a research report, a paper publication in a prestigious peer-reviewed journal, and one national conference presentation; (4) preliminary data and initial findings to support proposals for external grants; (5) an undergraduate research report from each participating student.

D. Methods

The proposed project will involve a comprehensive and thorough investigation of GIS techniques, statistical and spatial analyses to study the spatiotemporal variations in the associations of PTB with ambient air pollution, as well as socioeconomic and behavioral factors. GIS analyses will be applied to

extract ambient air quality data from USEPA national database, to derive individual birth outcome data from the state birth outcome database, to calculate socioeconomic variables, and to link individual birth outcomes variables to community-level air quality and socioeconomic variables. OLS, GWR, and GTWR will be used to analyze and compare the associations of PTB with risk factors to explore how the associations vary across space and time. I have already collected the data from various sources. The birth data that contains the birth outcomes and maternal variables has been obtained from the Georgia Department of Public Health. Ambient air pollution data will be extracted from USEPA Fused Air Quality Surfaces. Socioeconomic variables will be derived from the US Census.

The major research steps are: (1) extract birth outcomes, air pollution, socioeconomic data from various data sources (July to Aug. 2019); (2) link the individual birth outcomes and census-tract level air pollution and socioeconomic variables using ArcGIS (Sept. to Oct. 2019); (3) analyze the associations of PTB with air pollution and other variables using OLS in SPSS (Nov. to Dec. 2019); (4) analyze spatially varying associations using SpaceStat (Jan. to Feb. 2020); (5) analyze the spatiotemporal variations in the associations using ArcGIS (Mar. to Apr. 2020); (6) explore the effect of socioeconomic characteristics of communities on the spatiotemporal variations in the associations using ArcGIS and SPSS (May to Jun. 2020). The detailed schedule and plan are summarized in the timetable at the end of the proposal.

E. Qualifications

My rich research experiences and strong publication record make me highly qualified for this grant to support this project. My research interests include the integration of GIS, spatial statistics, and modeling with environmental and health studies. I have published over 35 peer-reviewed articles in prestigious journals. My publications have been citied over 1,200 times by the worldwide scholars. In recently years, I have focused my research on the studies on the spatial associations of birth outcomes with risk factors in Georgia using spatial statistics. Now it is the time to push my birth outcome research from two-dimensional that examines spatial variations in the associations to three-dimensional one that explores the spatiotemporal variations. I am confident that more high-quality papers will be published in top journals with the support of this grant and future external grants led by this grant. In addition, my extensive

knowledge and intensive skills in environmental and health geography, GIS, and spatial statistics will ensure me to complete this project successfully and on time. Furthermore, all the data and technology are ready for this project. I already have all the special software, including ArcGIS, SpaceStat, and SPSS. KSU also maintains a GIS lab accessible for the participating students.

F. Assessment

The success of this project will be assessed from four aspects. First, a comprehensive spatial database on birth outcomes, air pollution, and socioeconomic variables will be developed as a solid base for the proposed and future studies. Second, one journal paper and one conference presentation will be produced. Their quality will be judged by peer review. Third, a research report will be submitted to the college. Last, an undergraduate report will be produced by each participating student. Their proficiency in the practical application of GIS, statistics, and data analysis in the project is an indicator of the success.

G. Dissemination

The dissemination plan for this research includes the production of a paper targeting the *Environment International* and a presentation at the 2020 annual meetings of the American Association of Geographers (AAG) in April 2020. I will submit the paper in fall 2020, and it is expected to be published in spring 2021. Based on the data, methods, and findings of this project, I will write proposals to apply for external grants from various funding sources, such as National Institutes of Health (NIH), USEPA, National Science Foundation (NSF), and local and state agencies. This project is to analyze the spatiotemporal variations in the associations of PTB with air pollution. I will expand it to explore the spatiotemporal variations in the associations of other birth outcomes (e.g. LBW) and other health issues (e.g. lung cancer, Asthma) with air pollution and other risk factors in Georgia. The effects of risk factors on birth outcomes and other health issues and their changes across space and time are getting increasing attention from governments, scientists, and societies. Thus, the future direction of my research will get high interests from the potential funders. The expectation is to submit at least one proposal extending from this project for external funding by summer 2021.

Timetable

Year	Month	Activities	Duration
2019	July	Processing birth outcome data	4 weeks
	August	Processing air pollution and socioeconomic data	12 days (3 days a week)
	September to October	Connecting birth outcomes, air pollution, and socioeconomic variables	16 days (2 days a week)
	November to December	Relationship analysis of PTB and risk factors using OLS in SPSS	16 days (2 days a week)
2020	January to February	1. Spatial varying association analysis of PTB with risk factors using GWR in SpaceStat 2. Progress report submission to the College in February 3. Abstract submission for the 2020 AAG Annual Meeting	16 days (2 days a week)
	March to April	1. Analyzing the spatiotemporal variations in the associations in ArcGIS 2. Guiding students to write research reports for their Direct Applied Research courses 3. Presenting the preliminary results in the 2020 AAG Annual Meeting	16 days (2 days a week)
	May to June	1. Analysis of the effect of socioeconomic characteristics of communities on the spatiotemporal variations in the associations in SPSS 2. Interpreting results	8 weeks
	July to September	Writing the research paper	24 days (2 days a week)
	October - December	1. Complete the research paper and submit it to a Journal 2. Final report submission to the College in November	24 days (2 days a week)

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