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Project Title
Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density

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Research Need
Existing research demonstrates that at-risk populations—groups with demographic, economic, social, or physical characteristics who are disproportionately vulnerable to adverse health outcomes—are more likely to be exposed to heavy traffic and air pollution [1-10]. This disparity is a problem because numerous adverse health outcomes—including lung cancer, premature mortality, cardiovascular disease, respiratory disease and asthma, poor birth outcomes, and injury—are associated with living close to high-traffic roads and being exposed to high traffic density [11-17].

However, to fully understand how exposure affects at-risk populations, we need to consider two inter-related issues. First, estimates of traffic exposure depend on the spatial scale of investigation. Disparities in traffic exposure identified in studies at the national level are often heterogeneous at a regional scale. For example, Rowangould (2013) found that low-income and minority households are, on average, more likely to live near high volume roadways; yet, there are counties "where no disparities are present, or where disparities work in the opposite direction" [18]. Therefore, to learn what mechanisms underlie disparities in traffic exposure, we must investigate this question at the regional level.

The second issue is that the distribution of traffic density across a region is a function of transportation and land use policies and plans. "Smart growth" strategies, such as urban infill and open space protection, may increase population densities in areas with highest traffic density. However, these strategies may actually decrease disparities in exposure to traffic density if new residents in high-traffic areas are from higher income groups. Thus, older patterns in health disparities may no longer be true today. Integrating public health concerns into transportation and land use planning requires additional knowledge about the effects of such policies.

Research Question

Our research addresses these two issues and asks whether infill development in the Denver metropolitan region has resulted in changes in the exposure of at-risk populations to high traffic density. We will also examine whether regional conservation efforts and other smart growth efforts have played a role in these changes.

To answer this question, we use time series data representing travel and population over 1997-2010—a period of "smart growth" in the region. [19] The study uses exposure to traffic density as the primary metric to represent public health risk because it is widely used in epidemiologic studies as an indicator of exposure to air pollution and because it is related to various adverse health outcomes. In addition, transportation planning literature has linked traffic density to poor residential livability in neighborhoods, including barriers to transit access and physical activity. [20-22]

Significance of the Research

We know that the interaction of transportation and land use systems concentrates high traffic density in specific neighborhoods, with resulting transportation and public health consequences. But what we do not yet know, and need to better understand, is how smart growth policies affect the distribution hazardous and protective environments in regions. Moreover, it is important to understand how transportation and land use planning and policy making can be used to *reduce* health disparities. To advance research in this area, we must develop multilevel and longitudinal models that represent changes in both the built environment and in population health and exposure [23].

The Denver metropolitan region is an important case for such an analysis because it has experienced significant population growth and infill development over the past two decades, much of which has been centered near regional public transport investments. As a result, the Denver's Regional Council of Governments (DRCOG) and non-profit organizations such as Mile High Connects and the Piton Foundation are monitoring the equity outcomes of these regional dynamics [24].

In addition to their relevance for local policy and planning, lessons from the Denver metropolitan region have implications for other regions seeking to manage the equity, environmental, and economic outcomes of growth. In particular, this case offers lessons relevant to other growing cities and micropolitan regions emerging across the West. Thus, findings from this regional analysis can be interpreted and applied in a variety of other contexts.

The transportation profession increasingly recognizes the linkages between transportation and public health. In January 2015, the Transportation Research Board approved a new Task Force with the goal of increasing the use of public health research in corridor design, operations, and management strategies [25]. The authors of this proposal have been involved in proposing and developing this Task Force and anticipate that it will be a forum for sharing the findings of this study. In addition, the new Task Force builds on current efforts by the U.S. Department of Transportation to develop a Health and Transportation Corridor Planning Framework, which is a step-by-step tool for integrating information about public health into corridor planning being piloted by five communities [26]. Our proposed research responds directly to these efforts because corridor planning is a smart growth strategy that we can address through this research project.

Research Objectives

Although "smart growth" regions may have lower air pollution emissions overall, increasing population densities imply higher exposure to localized concentrations of air pollution [27-29]. The gaps in our knowledge are how transportation and land use policies "pattern" this exposure and whether functional elements of transportation and land use systems, such as infill areas and arterial corridors, contribute to higher exposure among at-risk populations.

To answer these questions, the research is organized to accomplish three primary objectives:

1. Explore and test the following hypotheses about *who* in the Denver region is exposed to the highest traffic density, *where* these exposures are highest, and *whether smart growth strategies in the region explain* patterns in disparities or equality.

   Descriptive hypotheses:
   - H_o: At-risk populations (poverty versus non-poverty, Hispanic versus non-Hispanic, children and older adults versus adults, African-American versus white, deprived not deprived) have the highest exposure to traffic density in the city/county of Denver and throughout the region in 1997 and 2010.

   - H_o: At-risk populations' share of exposure to traffic density in infill areas decreases between 1997 and 2010, and it stays the same in non-infill areas between 1997 and 2010.

   Explanatory hypotheses to test with statistical modeling:
   - H_o: The change in share of at-risk populations' exposure to traffic density between 1997 and 2010 at the regional level, and for the city/county of Denver, is due to smart growth policies, including infill development and conservation actions (i.e. it is not due only to overall increases in traffic density in the region).

2. Identify the critical land use and transportation policies that contribute to the patterns of exposure observed in the study.

3. Propose future integrated land use / transportation policies to promote equity in dense (urban) and low-density (ex-urban/regional) geographies.

Research Methods and Analytical Approach

For the first phase of the research, we will use a traffic density model in GIS, demographic census block and block-group level data, and economic indicators to quantify populations' exposure to traffic density at both 400m (~1/4 mile) and 800m (~1/2 mile) scales. The dimensions of the grid cells are theoretically linked to exposure to negative externalities of traffic such as air pollution and noise (400m and 800m), though planning, health, and environmental literatures generally fail to agree on a single threshold for "high" traffic density [1,7,19, 30]. Each variable will be computed for both 400m and 800m grids.

Traffic density is a constructed variable based on vehicle miles traveled (VMT) estimated from DRCOG's travel models. The DRCOG travel models were developed using a combination of traffic counts across the region as well as the Front Range Travel Survey, which is a 12,000-

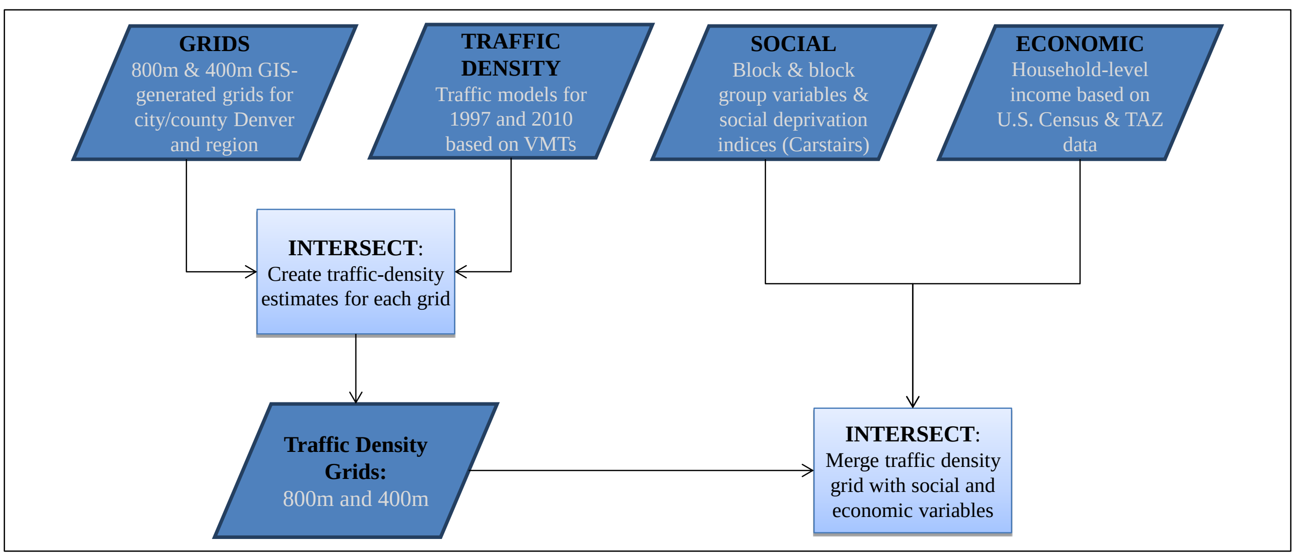
household travel diary survey conducted in 1997 and 2008.   Every major and minor roadway, including freeways and arterials, includes a continuous daily VMT estimate. We will compute the linear meter of each roadway within grid cells and the proportion of daily VMT attributable to each roadway segment. Traffic density will then be calculated as the sum of traffic over all roadways within each cell.

Social and economic indicators will be constructed based on U.S. Census decennial and American Community Survey block and block group level data. Variables will include, but are not limited to, age, gender, race/ethnicity, poverty, unemployment and income. Socio-economic indicators for each grid cell will be calculated based on the percentage of block group that lay within a grid and applying the percentage as a weight to each socio-economic indicator. Each indicator will then be a composite sum of all the weighted block groups within a grid cell (see Figure). The use of grid cells will help account for the possibility of changes to block group boundaries over time. We will also use the socio-economic variables to create the Carstairs Index and Townsend Index, both indices of social deprivation to measure at-risk populations [31-32].

During this first phase of the project, we will also collect historical information about "smart growth" policies and actions in the region and code this information into a land use dataset that identifies areas of change during our study period.

The second phase of the project will develop a statistical model to investigate the effects of infill development patterns (and other smart growth patterns identified through our policy review) on longitudinal changes with at-risk populations exposure (the dependent variable).

Figure. Spatial Framework for Traffic Density Model



We will develop a statistical model appropriate for the time-series exposure dataset constructed in the first part of the project. Our research question requires the model to capture changes in exposure due to infill processes in specific neighborhoods, above and beyond the overall growth in traffic in the region. Thus, the modeling will draw on techniques of hierarchical linear modeling to estimate the effects of neighborhood-scale changes on neighborhood exposure, and a second level to explain the contribution of overall regional changes to neighborhood-level exposure.

Expected Outcomes

Based on literature, previous reports, and preliminary analysis of 2010 data, we expect to find that the city and county of Denver (the region's core with significant infill development) does not exhibit the expected disparities in exposure to traffic density among at-risk populations in 2010. However, we do expect to see evidence of these disparities in the region's core in 1997, suggesting that infill development during the study period in Denver has resulted in lower disparities. In addition, we expect to find that disparities in traffic exposure do exist at the regional level both in 1997 and in 2010.

If these findings were confirmed, this would be important because they would provide evidence that smart growth strategies reduce health disparities at a local level, but not necessarily by improving the health outcomes of vulnerable populations. They would also highlight the need to consider the distributional effects of smart growth policies in the larger regional context if disparities simply shift to areas with lower population density. Such findings would be consistent with other research about the suburbanization of poverty and would highlight the need for smart growth policies to address more diverse populations.

Deliverables from this research will include:

1. A methodological framework and documentation for analyzing changes in exposure to traffic in a dynamic region.
2. A policy-relevant report of our findings for policy- and practice-oriented audiences, as well as peer-reviewed publications of our findings for audiences wishing to replicate the study.
3. Presentations of this work at the Transportation Research Board Annual Meeting for national dissemination, as well as a local research briefing through the University of Colorado Denver Center for Sustainable Urbanism.
4. A plan for future research, including scaling the project to include other regions in the Mountain West.

Project Phasing

Planning phase, spring 2015: Collect and prepare secondary data. Conduct a thorough literature review to identify potential variables of interest, and refine our hypotheses.

Phase 1, summer 2015: Develop traffic density model. Conduct descriptive analyses. Review and code historic planning and policy documents to establish a "smart growth" layer for GIS model. Submit article to TRB by August 1, 2015 deadline.

Phase 2, summer/fall 2015: Develop statistical model to test whether smart growth policies in Denver and the Denver region contribute to disparities in at-risk populations' exposure to traffic density, or whether these policies reduce health disparities.

Phase 3, fall 2015/winter 2016: Present preliminary findings at the TRB annual meeting and at a research briefing seminar at the University of Colorado Center for Sustainable Urbanism.

Phase 4, spring/summer 2016: Finalize documentation and publications. Prepare final report for the Mountain Plains Consortium.

Relevance to Strategic Goals

The work primarily falls under the heading of livable communities, but it also highly relates to both economic competitiveness and environmental sustainability. This research will provide a practical framework for evaluating the effects of integrated transportation and land use planning to help us understand how to better integrate sustainability goals into transportation system design.

Educational Benefits

This study will be the basis for Kara Silbernagel's thesis in Public Administration and Urban Planning. Ms. Silbernagel has conducted preliminary analyses with the data and contributed to this proposal.

In addition, this study will be integrated into Dr. McAndrews's "Transportation and Land Use" graduate course and "Planning Healthy Communities" graduate course. For these courses, we will develop a case study that highlights the multi-disciplinary interactions among transportation, land use planning, and public health. This case study can be shared on the website of the College of Architecture and Planning and published on the TRB Health and Transportation Subcommittee website.

Work Plan

The proposed scope of work is scheduled for a one-year timeframe, beginning with notice to proceed from the Mountain Plains Consortium. Major project steps include the following:

Task	Timeline
Initiate secondary data collection efforts	Ongoing, start in month 1
Literature review	Months 1-2
Build GIS database	Months 1-2
Project objective 1: Traffic density model and policy research	Months 2-3
Submit paper to TRB based on objective 1	Month 4
Project objective 2: Develop statistical model	Months 4-8
Project objective 3: Present preliminary findings, integrate feedback into final deliverables	Months 8-10
Project objective 4: Finalize publications and submit	Months 10 – 12

Project Cost

Total Project Costs: $120,000.00
MPC Funds Requested: $60,000.00
Matching Funds: $60,000.00

Source of Matching Funds: University of Colorado Denver

TRB Keywords

Smart growth; arterial roads; corridor planning; traffic density; public health; health disparities

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