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The relationship between municipal highway expenditures and socio-demographic status: Are safety investments equitably distributed?

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ABSTRACT

Different population groups have varying transportation needs based on their region type, socio-economic, and socio-demographic characteristics. Yet, municipal highway funding allocation methods do not typically consider these differences. Throughout the United States, municipal highway funding allocation is based upon fixed formulas that often only account for highway mileage and/or population size rather than equal benefits and funding outcomes across different population groups. This potentially creates an inequitable funding allocation process leading to safety and accessibility disparities between different population groups. This research investigates the extent to which the distribution of resources is not equal when evaluated by population group. Specifically, the relationship between municipal highway expenditures and poverty levels, population aged 65 years and older, race, and remoteness is investigated using data from the states of New York and Massachusetts. Using linear regression techniques, several models were developed that relate municipal highway expenditures with the socio-economic and socio-demographic characteristics of municipalities. The results revealed that there are clear municipal highway expenditure disparities between different population groups. Municipalities that have higher poverty levels experience a lower highway expenditure rate per local mile. Further, municipalities located in remote areas far from large metropolitan regions experience a disproportionately lower highway expenditure rate per local mile. Moreover, the results of this study indicate the need to consider how funding methods can address social differences.

1. Introduction

Local roadways are a central component of any roadway network. These roads generate access to services necessary for the livability of communities and must often serve numerous transportation modes for diverse trip purposes. Despite the diverse variety of needs of communities, the funding and resources distributed from state agencies to municipal governments for local roadway maintenance, development, and improvements in the United States are often based upon fixed formulas that do not consider population characteristics. For example, the Michigan State local roadway funding formula for municipalities is based only on the reported U.S. Census Bureau population for each municipality (60%) and their local road mileage (40%) (Hamilton, 2018). Several states have similar funding decision mechanisms. The primary New York State local roadway aid formula is based on local lane-miles within each municipality and the Georgia State local roadway aid formula is based upon the U.S. Census Bureau population and the total centerline mileage (New York State Department of Transportation, a, xxxx; Georgia Department of Transportation, 2019).

Despite the existence of consistent funding allocation mechanisms that are followed by state government agencies in the U.S., the diversity of needs within communities and of municipal government structures and efficiencies could result in inconsistent funding of different population groups throughout a region's local roadway networks. This could lead to certain population groups experiencing different levels of accessibility and roadway safety. The Tennessee Advisory Commission on Intergovernmental Relations has reported that additional measures should be considered in local road aid funding allocation to account for the wide variation in spending patterns, including types of vehicles on roads and types of roads (gravel, asphalt, concrete) (Green et al., 2005). However, these measures are often not included due to the lack of statewide data (Green et al., 2005). This can lead to unintended disparities in municipal roadway funding distributions which uniquely impact vulnerable populations.

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Research has demonstrated that individuals have different transportation needs based on their region type, socio-economic, and socio-demographic characteristics (Doescher et al., 2014; Pereira et al., 2017). While collaborative efforts of professionals are critical to achieve environmental justice goals (Fields et al., 2020), these conversations cannot exist without adequate funding mechanisms. At the state and regional government level, project scoring methods and specific grant funding mechanisms are beginning to focus on these differences of needs in their monetary distribution methods to a greater extent (i.e. Christofa et al., 2020; Federal Transit Administration, 2020). However, the current fixed-formula methods for municipal highway funding distribution are founded on the basis of equal distribution of resources (i.e. the same quantity to all groups) rather than the equitable distribution of resources (i.e. the fair distribution of resources based upon unique needs and abilities) (Theobald, 2001). Thus, the increased needs of certain population groups are not being met using the current funding allocation method. To date, literature has not investigated the potential funding disparities affecting different population groups at the municipal level. To investigate these potential disparities, this study analyzes the distribution of highway funding with socio-economic, socio-demographic, and location characteristics at the municipal level through an application of municipalities within the states of New York and Massachusetts over a four-year period. Specifically, this research investigates the relationship between municipal highway expenditures and municipal poverty levels, population aged 65 years and older, race, and remoteness from urban centers from a safety perspective. The results of this study assist in the determination of an equitable distribution of resources, revealing potential environmental justice concerns and policy implications. Specific recommendations are identified for the application regions to achieve a more equitable distribution of funds for municipally owned roads for an increased equitable safety level across all regions.

This article is organized into six sections. The following section presents a review of literature on transportation equity from a resource allocation and municipal government efficiency and funding perspective. The application regions of New York and Massachusetts in the United States are then described to provide the context of the study. The analysis methods are then presented, followed by the results of the study. The article concludes with a section that presents the research implications and recommendations as well as the limitations of this research.

2. Background

This section provides a background of current literature on transportation equity from a resource allocation and municipal road funding perspective.

2.1. Resource allocation

Research has shown that the disadvantages and benefits of transportation systems are unevenly distributed throughout different regions and population groups (Dodson et al., 2006). This is a result of equity not typically being partially or fully considered in transportation funding allocation processes. At the municipal road level, there is an increased need to account for differences in population groups.

Over 77% of roads in the U.S. are owned by local governments (Federal Highway Administration, 2018). To consider adequately road safety, or any road factor, local agencies must be considered in the process (Magnusson et al., 2020). With a wide range of municipal government types and residential characteristics, different needs by varying population groups and regions should be expected. For example, residents of small municipalities in the U.S. have been shown to walk less than those living in larger metropolitan regions (Doescher et al., 2014). These residents may make up for this walking in driving, as drivers in rural regions in the U.S. drive approximately 150% more than drivers in urban regions (Baxandall, 2013). These differences represent some of the varying transportation needs at the municipal level. Differences in transportation needs can exist for members of certain socio-demographic and/or socio-economic population groups. Previous literature has shown that accessibility levels are lower for older aged individuals or those born in an ethnic minority or economically disadvantaged family (Alsnih and Hensher, 2003; Pereira et al., 2017). Injustice in transportation services of disadvantaged groups can lead to their social exclusion (Pereira et al., 2017). Research has suggested accessibility should be the primary focus of transport researchers and policy-makers when addressing questions and decisions aimed to combat transport disadvantage and social exclusion (Pereira et al., 2017). The level of accessibility within a region depends upon the transportation funding that is available. However, relevant research on local roadway funding equity remains limited in literature.

Unequal allocation of resources is not uncommon in transportation. For example, cycling infrastructure was found to be unequally distributed in Bogota,´ Colombia by city planners (Torres-Barragan et al., 2020). Boyles (2015) describes how resource allocation is often subject to budget constraints that aim to minimize the total cost or prioritize projects with high benefit/cost ratios (Boyles, 2015). One common benefit/cost ratio funding allocation method focuses on increasing road safety. For this reason, several methods have been developed to identify high crash locations, often referred to as "hotspots" (e.g. Schultz et al., 2015; Lee and Khattak, 2019). Funding allocation based on safety-related issues has proven to effectively improve highway safety in those areas and prevent future crashes; however, crashes also occur in areas with low traffic volumes, where a large density of crashes has a very low chance of occurring. Rather, in these often more rural areas, crashes are less concentrated and more likely to be scattered throughout a roadway network. These regions are also more likely to experience higher fatal crash rates (National Center for Statistics and Analysis, 2019). While the funding "hotspots" may maximize the cost/benefit in terms of safety, benefited areas will also always be concentrated in urban areas as even a small roadway improvement is multiplied by the volume of road users in the funding allocation formulas that are used. Boyles (2015) notes this funding decision mechanism alone is not feasible, as concentrating funds in urban areas is not responsible or fair (Boyles, 2015). In short, this process can lead to inequitable maintenance and transportation infrastructure funding allocation decisions.

To overcome this issue and account for equity within the funding process, some regions have developed scoring methods for project funding decisions that include equity, noise, accessibility, safety, air quality, and physical activity considerations of a project along with other economic features (Christofa et al., 2020). However, these project scoring methods are not yet widely used, and none of them consider all of these factors (Christofa et al., 2020). Further, these developed scoring methods are framed on a project-basis, not from a systematic funding perspective. In urban areas, metropolitan planning organizations (MPOs) are required to consider equity implications of their transportation plans and processes and ensure that underserved communities receive a fair distribution of benefits from a regional system (Williams et al., 2019). A study of equity considerations within project prioritization across Florida MPOs found that they are making major strides towards incorporating equity in their processes (Williams et al., 2019). However, even in these processes, widespread equity performance measures and targets for project prioritization are lacking for MPOs and regional planning organizations (RPOs) across the United States (Karner, 2016; Williams et al., 2019). What's more, many municipalities do not fall within MPO boundaries. In New York, approximately 60% of towns are not within MPO regions and therefore, do not directly benefit from MPO funding. Thus, equitable distribution of municipal funding remains an important concern worthy of studying and improving. Yet, municipal roadway funding distribution is still primarily based on fixed formulas developed at the state level. Equity, to date, has not been considered in these formulas. Grants have also been developed to increase transportation equity in certain regions (i.e. Federal Transit Administration, 2020; Moving California, 2020). However, these grants are only available to those who have the means to apply for these grants, such as the staff to prepare such grant applications. Grants also offer a less stable funding source than a systematic, fixed funding source. These grants, when received, also have the ability to potentially distort the current investment planning, decision-making, and evaluation processes of equity considerations that existed prior to receiving these grants. This could be exacerbated further if the grant funding is only allowed to be used for specific equity purposes that may not equally benefit all granted municipalities. For example, assume that municipal highway funding was planned to be allocated to build sidewalks in an underserved neighborhood. Later, an equity-centered grant was received that provided funds to improve bicycle facilities for the same underserved neighborhood. Since the municipality now might have felt that their communities were provided with an improvement, they may not plan to continue with their plan to provide sidewalks for the neighborhood. Further, safety specifically is not the primary consideration in these types of funding, or sometimes not considered at all. In a systematic review of transportation equity literature, Guo et al. (2020) found that researchers have not adequately assessed safety impacts from an equity perspective.

The fixed formulas that control the distribution of roadway funding from state governments to municipal governments allocate an equal distribution of resources often based solely upon population size and/or local roadway mileage. This equal distribution would be equitable if the populations receiving these funds had equal abilities and equal needs (Theobald, 2001). However, this is not the case, as the infrastructural, socio-economic, and socio-demographic differences between population groups and regions lead to varying transportation needs (Pereira et al., 2017). Thus, this current funding method is inequitable and likely disproportionally affects disadvantaged population groups. Without an equitable municipal highway funding method, accessibility and road safety cannot be equally considered across different population groups.

2.2. Municipal highway funding and expenditures

Municipal transportation funding can be gathered through a number of capacities, including through individually applied-for grants, emergency aid, and generated revenue from a tax base, among other avenues, at the local, regional, state, and federal levels. Overwhelmingly, the highest revenue generator for local highway funds in the U.S. comes from state general funds (Ohlms, 2014; Federal Highway Administration, xxxx). Property taxes are the second highest source of revenue (Ohlms, 2014). Generating revenue may be more difficult for some municipalities with certain characteristics. Previous literature suggests rural municipalities may not have the ability to use their resources efficiently and/or may have fewer resources to begin with due to their inability to generate their own revenue from municipal service fees and/or taxes (MacManus and Pammer, 1990; Brown, 1980). This lack of revenue generation in rural areas likely stems from their lack of services that could generate funding through user fees in these regions and/or lower per-capita income levels (MacManus and Pammer, 1990). Further, rural governments have smaller tax bases; as a result, highway costs are higher per capita for rural residents (Long, 1987). Overall, rural areas are negatively associated with revenue-generating capabilities. Still, the full impact of socio-demographic and socio-economic characteristics on municipal highway funding decisions are limited in the literature.

3. Application areas

This research used town data from New York State and the Commonwealth of Massachusetts in the U.S. to apply this study. For consistency, cities and villages were not included. Given the differences in funding and government structures between New York and Massachusetts, the two areas were studied separately. The choice of two states that differ in their types of funding and government structures allowed for a more general method to be developed that can be representative. In addition, focusing on two specific application regions allowed for a more complex study with specific data measures that would not otherwise be available, a common motivation for application-based studies (Feagin and Orum, 1991).

Both New York and Massachusetts are diverse, with large rural areas and substantial urban areas existing within each state. These states also experience similar seasons and weather patterns, making road maintenance requirements similar in nature. Thus, through these similarities, while acknowledging the structure differences between each state, comparisons within the results of this study can be made. Furthermore, it is noted that while the primary local highway state aid funding source is described for each state in the following sections, multiple funding sources, such as MPOs, may provide additional funding for a given region. These additional funding sources are accounted for in this study within the municipal highway funding expenditures.

3.1. New York

The municipal structure of a region controls many aspects of how projects are completed and services are provided. In New York, local regions are broken into villages, towns, cities, and counties (Division of Local Government Services, 2018). Public roadway miles under the jurisdiction of counties and local governments are inventoried through the Local Highway Inventory (LHI) by the NYSDOT Highway Data Services Bureau annually (NYSDOT Highway Data Services Bureau, 2018). This inventory provides the local lane-mileage needed to fulfill the funding distribution formulas of the Consolidated Local Street and Highway Improvement Program (CHIPS) for the State, the major funding source for local highway programs.

Individual allocations of funding to municipalities under CHIPS are calculated annually primarily based on LHI mileage at the municipal level and motor vehicle registrations at the county level (New York State Department of Transportation, a, xxxx). More specifically, under Section 10-c of the State Highway Law, all roadways not under the maintenance and/or operational jurisdiction of the state receive funding based on a specific allocation system. First, 41.40% of CHIPS funding is appropriated to New York City and to all counties outside of New York City. Second, the balance of funding available (58.60%) is appropriated to various jurisdiction systems based on the estimated relative vehicle miles traveled, with cities receiving 42.7% (or 25.02% of the total), counties receiving 18.5% (10.84% of total), villages receiving 10.7% (6.27% of total), and towns receiving 28.1% (16.47% of total). Finally, within each jurisdictional system, the distribution of funding allocated to each municipality is based on the ratio of lane miles under their maintenance jurisdiction to the total number of lane miles under operational jurisdictional (New York State Department of Transportation, a, xxxx).

3.2. Massachusetts

The municipal government structure in Massachusetts differs from that in New York as villages do not exist in the former. Three-hundred fifty-one municipalities (towns and cities) own approximately 30,000 centerline miles of pavement throughout Massachusetts (Leavenworth, 2016). These roadways are tracked in the MassDOT Road Inventory File (Massachusetts Department of Transportation, 2017).

Municipalities in Massachusetts are allocated base highway funds from the state called "Chapter 90 funds" (Leavenworth, 2016). These funds are allocated based on a composite of three factors: 58.33% centerline road miles, 20.83% population, and 20.83% employment (Massachusetts Department of Transportation, 2017; Leavenworth, 2016). Unlike New York, funds are not distributed prior to spending; rather, Chapter 90 funds are distributed through reimbursements on a project-by-project basis. These roadway projects are 100% reimbursable through the program, meaning that municipalities are not required to contribute to them. Still, this reimbursement cannot exceed the annual budgeted funding allocation amount.

4. Methods

In this research, municipality location, as well as socio-economic and socio-demographic characteristics of municipalities were studied alongside highway funding expenditures to investigate potential disparities between different population groups. The measures used within this study were decided based on information that was available for the application regions and do not constitute an exhaustive list. To avoid multicollinearity between variables as much as possible, only specific socio-demographic and socio-economic variables were selected. These variables were based upon previous research findings related to funding and inequities (Pereira et al., 2017; Alsnih and Hensher, 2003; MacManus and Pammer, 1990; Brown, 1980). Specifically, variables of remoteness, population size, poverty, age, and race were included as the measures for analysis. Prior to analysis, data was gathered and processed. The variable representing remoteness from an urban region was estimated using geographic information system (GIS) methods. The planned model development consisted of various combinations of the independent variables to investigate different relationships with municipal highway expenditure rates. The following section describes these processes in further detail.

4.1. Data

Town data from New York and Massachusetts were gathered for the 2015–2018 period. The scope of this research was only within the context of towns for the two application regions. Villages and cities were not included due to the different funding structures that exist for villages and cities compared to towns in the application regions. Thus, to maintain consistency in both the needs of certain regions and their funding structures that have been set by the state, this research only included town data. Town data was chosen over village or city data as towns are mid-sized compared to the two other options and included the highest count of data. Overall, towns offered the greatest diversity of characteristics given the large sample size.

Many data sets were required to complete for this research from a variety of sources. The following sections describe how these data were gathered and/or calculated. The final data used in the analysis is shown in Tables 1 and 2. It is noted that the Town of Gosnold, Massachusetts, which has a population of approximately 75 residents and only 2 local centerline miles, had $0 in highway expenditures for only the year of 2015 (MassGIS, 2020; Massachusetts Department of Revenue Division of Local Services, xxxx; Massachusetts Department of Transportation, 2017). No other towns in Massachusetts or New York had $0 in recorded highway expenditures for any year that was included in this study.

4.1.1. Demographic and population data

Demographic and population information for both New York and Massachusetts towns was gathered from the United States Census Bureau. The American Community Survey was used to gather annual city and town population estimation totals for the 2015 to 2018 period for both New York and Massachusetts (Population Division of the U.S. Census Bureau, 2018). Socioeconomic data were also gathered from the Census Bureau using a Census Data API Key and the R package "tidycensus" (Walker, 2020). Population estimates of people in poverty, people whose race is white alone, and people who are 65 years and older were gathered. Poverty is measured by the U.S. Census Bureau using a set of money income thresholds that vary by family size and composition (U.S. Census Bureau, 2019). Since the required data specificity were on a subcounty scale and included non-urbanized areas, these socio-economic and socio-demographic data were not available for every individual study year. Rather, they were available as an estimated value from 2014 through 2018 through the American Community Survey. As a result, the values for these data were kept constant for each individual year in the data organizing process. Given the significant volume of towns in each study area (932 in New York and 312 in Massachusetts) and explanatory, not predictive, focus of this research, this was determined to not be a significant limitation of this research. The socio-economic and socio-demographic data variables were processed as percentages of the town population for analysis.

4.1.2. Highway expenditure data

Town highway expenditures for both New York and Massachusetts were gathered for this research. Town highway expenditure data for New York were obtained from the Office of the New York State Comptroller for each town for the years 2015 through 2018 (Office of the New York State Comptroller, xxxx). Highway expenditures in New York are defined as "expenditures for administration, construction, repairs and maintenance of highways and walkways" (Division of Local Government and School Accountability, 2016). These include expenditures related to engineering, permanent improvements, machinery, and sidewalks. Massachusetts town highway expenditures were obtained from the Massachusetts Department of Revenue Division of Local Services Municipal Databank/Local Aid Section (Massachusetts Department of Revenue Division of Local Services, xxxx). Highway, street lighting, and snow and ice removal expenditures, related salaries and wages, construction, and capital outlays were combined to form the annual highway expenditures for a given town.

4.1.3. Local mileage data

Local roadway mileage within each town was gathered. In New York, this data was obtained from the 2017 Highway Data Services

Table 1
Summary Statistics of New York Town Data.

Variable	Mean	Standard Dev.	Min	Max
Annual Highway Expenditures	$1,232,639	$3,192,302	$22,551	$63,133,168
Local Lane Miles per Town	124.7	187.2	6.4	3,499.1
Annual Highway Expenditures per Local Lane Mile	$8,712	$6,105	$1,062	$90,676
Population	9,672	37,566	34	768,103
Miles to Population 50,000 +	33.4	27.7	0	146.8
Population in Poverty	11.0%	5.3%	0%	37.1%
Population White Alone	93.8%	6.8%	48.9%	100%
Population 65 and Over	18.7%	4.8%	2.0%	44.4%

Table 2
Summary Statistics of Massachusetts Town Data

Variable	Mean	Standard Dev.	Min	Max
Annual Highway Expenditures	$1,542,422	$1,286,352	$0	$7,267,605
Local Lane Miles per Town	69.9	36.6	2.0	228.2
Annual Highway Expenditures per Local Centerline Mile	$21,538	$13,042	$0	$96,437
Population	10,853	10,158	75	60,803
Miles to Population of 50,000 +	16.4	11.9	0.0	50.4
Population in Poverty	5.9%	3.2%	0%	20.9%
Population White Alone	92.0%	6.5%	65.4%	100%
Population 65 and Over	19.1%	6.1%	7.8%	44.9%

Repository (New York State Department of Transportation, b, xxxx). As the highway funding decision mechanisms at the state level in New York are primarily based upon local lane mileage data, not centerline mileage data, the former was gathered for this research (New York State Department of Transportation, a, xxxx). Local road mileage data for Massachusetts towns was obtained from the 2016 Massachusetts Road Inventory Year End Report (Massachusetts Department of Transportation, 2017). Unlike New York, town centerline miles are most often used for allocating State Aid to communities rather than lane miles. Thus, town centerline mileage data was recorded and gathered instead of lane mileage data in Massachusetts (Massachusetts Department of Transportation, 2017). According to the Office of Transportation Planning (Massachusetts Department of Transportation, 2017), "centerline miles" refer to the "linear length of a road segment." For divided highways, "only the length of one side of the roadway is counted." "Lane miles" are defined differently, as they refer to the "linear length of lanes of a road segment." In this case, "the number of lanes on both sides of the roadway are counted in the mileage calculation.".

4.1.4. Distance from urbanized region data

The distance from each town center to the closest urbanized region within the same state was calculated using ArcMap version 10.7.1. GIS municipal boundary and 2010 U.S. Census population data was gathered for New York and Massachusetts from the New York State GIS Program Office and MassGIS, respectively (New York State GIS Program Office, 2020; MassGIS, 2020). ArcMap was used to calculate the planar, or straight-line, distance from the center of each town to the closest city/town with a population of 50,000 or more residents according to the 2010 U.S. Census. This specific population was chosen as the U.S. Census defines urbanized regions as those that have a population of 50,000 or more residents (Ratcliffe et al., 2016). It is noted that planar distance measurements do not account for geographic and infrastructure barriers, which on the contrary is captured by measures such as travel time or road miles; however, this approximation of distance was determined adequate for this study given the strong correlation between planar distance and travel time on roads (Phibbs and Luft, 1995). This distance data was collected to include in the study as the distance from urbanized areas represents the remoteness of a town. This allows for an investigation of the relationship between highway expenditures and remoteness. The use of this distance variable, alongside population size, is necessary to include as municipalities of the same size will experience differences in their lived experiences depending on their distance to an urban region. Residents living in a municipality that resides closer to an urban region will have different living experiences and transportation needs than residents living in a municipality in a very remote region, even if the municipality has the same population size (McKnight et al., 2019).

4.2. Model development

The development of multiple regression models were considered for this research. Separate models were developed for both New York data and Massachusetts data due to their different funding structures for roadways, including different local highway program funding algorithms. New York local highway expenditures were normalized by the number of local lane miles while Massachusetts expenditures were normalized by the number of local centerline miles as these different figures are used in their independent state highway funding algorithms. Additionally, current funding decisions are completed at the state level for municipalities; thus, having one model per state allows the results to be compared more directly to their funding allocation algorithms. Socio-economic and socio-demographic variables tend to be highly correlated, depending on the specific variables and regions/ individuals studied. Multicollinearity in regression can lead to highly skewed or misleading results. Thus, regression analysis methods that can account for highly correlated variables were first considered, including profile regression and ridge regression (Liverani et al., 2016). However, these methods were found to be unnecessary after Variance inflation factor (VIF) tests using ordinary least squares (OLS) regression methods were completed. More specifically, all variable combinations were tested through several OLS regression models using R version 3.5.3. Using the "car" package (Fox and Weisberg, 2019), the VIF values were calculated, revealing that all VIF values from all possible model combinations were below 2.5, with the majority of VIF values below 2. VIF values provide a direct indication of the effects of multicollinearity on the variance of the *i*th regression coefficient (O'Brien, 2007). In other words, these values reveal how much the variance of a variable has been inflated by a lack of independence. Given the relatively large sample sizes in this study and low reported standard errors, the data was determined to not be highly correlated (O'Brien, 2007). Thus, OLS regression models were determined to be most appropriate for this study.

The goal of this study was to investigate and test causal hypotheses related to highway funding and socio-economic and socio-demographic factors of municipalities. This type of analysis is considered an explanatory analysis, as statistical methods are used to test hypotheses related to theoretical constructs (Shmueli, 2010). The explanatory power of a model in this case is often reported as adjusted R-squared values and statistical significance, or p-values. There are multiple approaches that can be used to investigate exploratory relationships. These include methods of splitting by population group and transforming data, as used by Chen et al. (2017) or performing Chi-square and Kruskal–Wallis tests to determine correlation, as done by Ragaini et al. (2020). A simple linear regression and multivariate regression approach was identified and chosen to be applied to this study. This method allowed us to specifically investigate each primary independent variable through simple linear regression and multivariate linear regression to uncover the individual correlation strength of each variable through the resulting adjusted R squared value, identifying which variables are more influential than others and avoid high variance. Using simple linear regression to investigate exploratory relationships is common in transportation engineering literature (e.g. Iyer and Jain, 2020; Jun, 2012; Yared et al., 2020). Further, these modeling methods are commonly used in the social science domain, allowing for this research to have broad applicability and familiarity with non-engineering scholars (e.g. Beroho et al., 2020; Abraham et al., 2020; O'Brien et al., 2018).

5. Results

After the OLS regression modeling was concluded, several relationships were identified. Tables 3 and 4 report the models and model results of the selected variables on town highway expenditures per local lane (for New York) or centerline mile (for Massachusetts). Models 1 through 4 include a single explanatory variable in the model. Model 5 includes all of these variables and Model 6 adds the population size as an additional independent variable.

6. Discussion

As demonstrated in Tables 3 and 4, the percent of the population in poverty variable was found to be significant in Model 1 for both states. This demonstrates that an increase in the population portion living in poverty within a municipality is correlated with a decrease in highway expenditures per local mile. Yet, poverty level is no longer significant after accounting for other variables in Models 5 and 6 in Massachusetts, while it remains significant for New York. This may be due to the Massachusetts highway funding allocation method considering the employment rate within their formula. Still, this significance in New York demonstrates a need to investigate the funding revenues of municipalities with high poverty rates compared to those with low poverty rates, such as the potentially differing tax rates and service fees of these communities. Further, this disparity may be connected to the history of federal housing, tax, and transportation policies that have traditionally reinforced racial and low-income residential segregation (Oliver and Shapiro, 2001). This finding also aligns with previous research stating that those born into an economically disadvantaged family have reduced accessibility levels (Pereira et al., 2017; Deka and Lubin, 2012). Municipalities with a lower expenditure rate per local mile may also have lower accessibility, simply due to the fact that they have fewer resources. The investments made with the resources these municipalities do have may also favor the modes of transportation used by wealthier population groups, such as highways, rather than pedestrian or bicycle facility improvements. Even in a single city, infrastructure has been shown to be significantly worse in poor areas compared to wealthy areas, as demonstrated in a study by Torres-Barragan et al. (2020) where conditions for cyclists were shown to worse in areas of poverty than in wealthier areas in Bogotá, Colombia. While beyond the scope of this research, studies investigating where funding is spent by municipal highway departments should be considered in future research.

The percent of white alone population variable was significant in Model 2 for both states. In both cases, an increase in the white alone population is correlated with a decrease in municipal highway expenditures per local mile. This variable maintained significance in Models 5 and 6. Thus, the racial disparity of highway expenditures cannot be confirmed through this study. Further, given the known racial injustices within the transportation system (Pereira et al., 2017), this study does not provide clarity to arrive at a conclusion as to whether or not the current expenditure rate per local mile is equitable between white and non-white population groups. Future analysis within communities must first be conducted to determine if all transportation needs within a community are met.

The percent of population aged 65 years and older variable was significant in Model 3 for New York, but not for Massachusetts. In New York, the results demonstrate that for an increase in the population percentage aged 65 years and older, there was a decrease in highway expenditures per local mile. Again, this may be due to employment as a formula consideration in Massachusetts municipal funding allocation methods. After accounting for the other variables through the more comprehensive models, the correlation changed. In Models 5 and 6 for both states, the results demonstrated that for an increase in the percentage of older population, there was an increase in highway expenditures per local mile. Given the increased needs and vulnerability of those in older population groups (Pereira et al., 2017), this result does not immediately demonstrate a need for change. Nonetheless, an investigation of the transportation funding needs and costs for older populations would be beneficial to reveal if accessibility and road safety needs are being met.

The distance to the nearest urban municipality of 50,000 residents or more variable was significant in Model 4 for both states. The results demonstrate that for an increase in distance from a highly urban municipality, there is a decrease in highway expenditures per local mile. This correlation holds true for Models 5 and 6 as well for both states. This result aligns with previous research demonstrating the limited resources rural regions have for highway expenditures (MacManus and Pammer, 1990; Brown, 1980). Further, the results of Model 6 demonstrate that remoteness leads to a lower highway expenditure rate, while a larger population leads to an increase in the expenditure rate. Thus, smaller populations that also tend to be more remotely located are more likely to experience the lowest expenditure rate. Based on the evidence from previous research, this result confirms what would have been expected. Further, this lower expenditure rate in rural regions is of increased concern, as rural regions experience a higher fatal crash rate and are less likely to register as safety hotspots, where addition funding is commonly targeted (National Center for Statistics and Analysis, 2019).

Table 3
OLS Regression Models Predicting Town Highway Expenditures (Million USD) per Local Lane Mile in New York

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Percent of Population in Poverty	−.0316*** (.0019)	–	–	–	−.0155*** (.0018)	−.0153*** (.0018)
Percent of White Alone Population	–	−.0353*** (.0014)	–	–	−.0325*** (.0014)	−.0300*** (.0015)
Percent of Population 65 years and older	–	–	−.0079*** (.0021)	–	.0066*** (.0019)	.0063*** (.0063)
Distance to Town/City 50,000+ (miles)	–	–	–	−.0064*** (.0003)	−.0047*** (.0003)	.0045*** (.0003)
Population	–	–	–	–	–	.0128*** (.0026)
Constant	.0122*** (.0002)	.0418*** (.0013)	.0102*** (.0004)	.0108*** (.0002)	.0412*** (.0012)	.0387*** (.0013)
Adjusted R-squared	.07	.16	.00	.08	.24	.24
N = 3,571						*p⩽.05, **p⩽.01, ***p⩽.001

Table 4
OOLS Regression Models Predicting Town Highway Expenditures (Million USD) per Local Centerline Mile in Massachusetts

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Percent of Population in Poverty	−.0513*** (.0119)	–	–	–	−.0113 (.0118)	−.0166 (.0058)
Percent of White Alone Population	–	−.0760*** (.0054)	–	–	−.0680*** (.0055)	−.0544*** (.0060)
Percent of Population 65 years and older	–	–	−.0079 (.00623)	–	.0523*** (.0065)	.0502*** (.0064)
Distance to Town/City 50,000+ (miles)	–	–	–	−.0369*** (.0030)	−.0389*** (.0037)	−.0286*** (.0041)
Population	–	–	–	–	–	.2309*** (.0442)
Constant	.0246*** (.0008)	−.0914*** (.0050)	.0230*** (.0012)	.0276*** (.0006)	.0811*** (.0050)	.0652*** (.0058)
Adjusted R-squared	.02	.14	.00	.11	.24	.25
N = 1,172						*p⩽.05, **p⩽.01, ***p⩽.001

7. Conclusions

Previous research has demonstrated that transportation equity disparities exist between different population groups. The objective of this study was to investigate the relationship between socio-economic, socio-demographic, and location characteristics of municipalities with their highway expenditures rate per local mile with a safety focus. OLS regression models were developed that included independent variables representing these characteristics using data from the states of New York and Massachusetts. The methods of this research are easily scalable given the availability of data used to any U.S. state. State population data and location data is widely available throughout the U.S. Local mileage data and municipal highway expenditure data can likely be obtained from any state agency, given the requirement to often report these measures to federal agencies. The results of this study reveal that there exist highway expenditure disparities between different population groups. The limitations as well as the research implications and recommendations for policymakers and practitioners are included in the following sections.

7.1. Limitations

The primary limitation of this study is the application of these methods to only two U.S. states and it's focus on safety and accessibility. Several equity considerations/factors (i.e. air quality, noise, walkability, etc.) were not considered this research. This study also did not include international data. Further, only specific socio-economic and socio-demographic variables were selected for this study to narrow the scope. This study only included the overall municipal highway expenditure rate and did not consider local tax rates or land use factors, nor did this study did not investigate the explicit reasons for the revealed disparities. This study did not directly investigate the impact of declining versus growing regions, both economically and by population, which should be considered in future research. This study is also limited by the investigation of expenditures only at the municipal level and did not include federal or state capital investments or other types of funding that were not captured by the expenditure values. Municipalities were chosen at the level of analysis due to data limitations and current funding allocation mechanisms; however, municipalities can often be comprised of very heterogeneous populations with widely varying socio-economic status and socio-demographic characteristics. Thus, future research should consider smaller blockgroups and regions of towns to capture differences across these populations. Finally, this study did not consider how local highway funding was used and how each investment was allocated. This is important to consider when assessing the equity of investments. Overall, future studies should consider these limitations that were beyond this current scope to further the state-of-literature in this area of research. Additionally, next steps of this research should consider alternative methods that would consider different perspectives and reveal new aspects to these relationships, such as splitting and transforming population group methods used by Chen et al. (2017).

7.2. Research implications and recommendations

Despite the study limitations, this research found that there are clear municipal highway expenditure rate differences between varying population groups. These results indicate the need to consider social differences in systematic funding methods for equitable accessibility and road safety, as is done in some current project scoring methods in the U.S. (Christofa et al., 2020). The research implications and recommendations from this study include:

- Municipalities with high poverty levels spend less on their transportation per local mile than municipalities with lower poverty levels. To improve transportation equity, state governments and other funding agencies should consider methods to support different revenue streams that could assist these low-income municipalities. This could be in the form of adding a variable demonstrating poverty to a funding formula or through the creation of accessible transportation grants specifically built for regions in poverty, such as the Helping Obtain Prosperity for Everyone (HOPE) program by the Federal Transit Administration (Federal Transit Administration, 2020). This application-based program provides funding to local, state, and transit agencies to support projects that address transit challenges faced by areas of poverty.
- Racial disparities of municipal highway expenditures could not be concluded from this study. However, based upon the current state of literature, there is a need to conduct additional research on racial disparities from a highway funding perspective, including the municipal mobility and infrastructure needs of different population groups based on race. Further, despite the collinearity issues, transportation studies have shown that Black, Indigenous, and People of Color (BIPOC) have higher levels of poverty compared to white persons (e.g. (Deka and Lubin, 2012; Klein et al., 2018)).
- Municipalities with larger older populations have a higher expenditure rate. While this result does not immediately demonstrate a need for funding changes, an investigation of the transportation funding needs and costs to accommodate older populations' travel needs would be beneficial. This may reveal if accessibility needs are being met at the current funding level for this population group, which is necessary to evaluate given their increased vulnerability as a population. Further, despite these findings, there are other local investments that support the accessibility issues that this population group faces, including distance to health care service loca-

tions, paratransit availability, and walk-ability of their community. These other funding sources should be considered by agencies when evaluating the needs of their older population and ageing population to allow their residents to safely and equitably age in place.
- Increased remoteness and decreased population size lead to a lower municipal highway expenditure rate. This disparity is in addition to the higher fatal crash rates experienced by rural driving populations (National Center for Statistics and Analysis, 2019). Further, a lack of non-automotive transportation options in rural regions makes this type of investment even more critical to maintain safe and accessible options for these populations. To combat this inequality, state agencies and other funding agencies should investigate methods to increase financial support for small, remote municipalities. This could be in the form of adding a variable demonstrating remoteness to a funding formula or the creation of grants based on remoteness and population size.

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CRediT authorship contribution statement

Alyssa Ryan: Conceptualization, Methodology, Formal analysis, Resources, Data curation, Investigation, Writing - original draft, Writing - review & editing, Visualization, Funding acquisition. **Eleni Christofa:** Conceptualization, Resources, Writing - review & editing. **Camille Barchers:** Conceptualization, Resources, Writing - review & editing. **Michael Knodler:** Conceptualization, Writing - review & editing, Funding acquisition, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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