2017

STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Final Report

Evaluating the Relationship Between School Site Selection, Residential Developments & School Transportation in North Carolina

(Project # 2016-016)

Authors: Noreen McDonald, Ph.D., University of North Carolina at Chapel Hill; and W. Mathew Palmer, MURP, University of North Carolina at Chapel Hill

April 2017

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Acknowledgment of Sponsorship: This work was sponsored by a grant from the Southeastern Transportation, Research, Innovation, Development and Education (STRIDE) Center. The authors are grateful for the comments received from three anonymous reviewers.

AUTHORS

Noreen McDonald, Ph.D., University of North Carolina at Chapel Hill

W. Mathew Palmer, MURP, University of North Carolina at Chapel Hill

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ABSTRACT

The purpose of this research is to understand whether – and to what extent – the built environment around a school influences the public and private costs of transporting students to that school and to measure those relationships over time. Assessing these relationships will allow school districts and communities to understand the impacts on school transportation operations and costs of decisions about neighborhood design and school location.

This research expands on prior STRIDE-funded research that explored the relationship between community design factors such as residential development density, street network connectivity and school transportation operations and costs. This project collects secondary data available in North Carolina to develop a unique dataset showing the relationship between land use, via the distances between residential homes and schools, and school transportation costs using a sample of 50 North Carolina elementary schools. This approach advances the research agenda by 1) evaluating the land use distribution distances for four urban public schools systems; 2) exploring the relationship between local built environment conditions and school travel rates; and 3) accounting for social, economic and demographic factors in school travel mode choice. This larger sample size also increases the generalizability of the research to a range of built environment and community types. Further, the collection of this data has resulted in the largest paired school land use and transportation dataset in the United States; a de-identified version of the data will be made available to other researchers in the Southeast region.

The results support national and regional policy efforts that articulate the economic benefits of constructing schools in more residentially dense areas for elected and professional school and community decision makers.

EXECUTIVE SUMMARY

According to the US Department of Education, Americans spend $20 billion annually to bus 25 million elementary and secondary children to school. Not only is this annual educational expenditure sizable, trends indicate that the cost of busing children to school are increasing. Between 1995 and 2007, constant-dollar school busing costs increased 51%; yet, student enrollments only rose by 11% over the same period (U.S. Department of Education, National Center for Education Statistics 2009; National Center for Education Statistics 2009).

Declining state and local revenues make it imperative for school districts to efficiently manage transport costs in order to preserve funding for classroom activities without sacrificing students' ability to get to school. Based on preliminary STRIDE funded research, coordination of land use decisions via school site selection in relation to residential developments may be one approach to ensuring efficient use of transportation funds.

The impact of school site selection decisions on overall school transportation costs is still a nacent research area; school districts and municipalities regularly make educational facility and land use decisions without fully understanding school travel implications of this relationship. For example, school district facility decisions on whether to build, renovate, or close a district's schools directly influence the locational distribution of schools within the district; the geography of schools, in turn, impacts the district's school transportation network.

Education-related land use and transportation issues are particularly relevant for the southeastern United States, where, during the 2000s, the regional cost outlays averaged $9.4 billion per year for school construction and $3.1 billion per year for school transportation. These costs represent between 3.5 and 4.8 % of all education expenditures for each state in the southeastern region.

This project builds on the previously funded STRIDE project, *Quantifying the Cost of School Transportation,* in which we selected 20 recently-built schools in North Carolina (11 schools in urban, suburban and rural contexts) and Florida (9 schools in urban and rural contexts) and collected data on the multimodal costs of school transportation. These schools were selected to document the variation in school costs by location type (urban, suburban, and rural) and nearby built environment characteristics.

This updated study uses a sample of 50 elementary schools located in one of four major North Carolina urban public school systems – Charlotte-Mecklenburg County Schools; Guilford Public Schools; Durham Public Schools and Cumberland Public Schools. The total population of elementary schools in these four urban public schools districts is 244 elementary schools. School-level home to school distance distributions were calculated for each school in the population. The sample frame was constructed using the percentage of enrolled student population residing within 1.5 miles of a school site; quintiles were constructed using this percent enrolled school-level measure. This distance (1.5 miles) was chosen as it reflects the minimum reimburseable distance for State of North Carolina funded school bus travel.

There are several important findings from this study that support coordinated planning as it relates to residential developments, school site selection and derivative school transportation operations and costs. First, a district-level distributional analysis reveals important differences in home-to-school distance distributions between school districts. This suggests that there may be additional omitted variables (e.g. institutional variation; municipal and/or county policies) in relation to school site selection and residential development. Second, variation in home-to-school distance distributions at the school-level also suggest that there are key contextual factors at play even within a school district. These include density, age of school and street network design.

I. INTRODUCTION

This project entails research that addresses the STRIDE themes of livability and safety. Schools are a critical part of public infrastructure contributing to economic and community development, and social integration (Vincent 2006). Getting children to school safely and at reasonable cost to the public sector are crucial elements of a livable community. Despite the importance of schools in our communities, educational facility planning remains disconnected from transportation and local land use planning (McDonald 2010; Steiner et al. 2011).

The most commonly cited factor in a family's school travel decision making is the distance from home to school (National Center for Safe Routes to School, 2014). A fundamental transportation and land use concept, school planning and transportation research has thus far not evaluated how distances from home to school vary between and within school districts. This research project evaluates home to school distributions between and within four major public school districts at the elementary school level; in doing so it sheds new light on critical factors in school transportation systems and the role of land use planning.

II. BACKGROUND

Americans spent $21.8 billion to bus students to school and invested $50 billion in school construction in 2010 (Filardo et al. 2010; U.S. Department of Education, National Center for Education Statistics 2012). These investments in public infrastructure and services are massive and on-going. Despite the size of these investments, little attention has been paid to school transportation and planning outside of experts in educational facilities and pupil transportation.

Yet, research indicates that decisions about where to locate schools and how to provide transportation have important impacts on the larger transport system and community development and deserve wider attention from planners and engineers (Vincent 2006; McKoy, Vincent, and Makarewicz 2008; Vovsha and Petersen 2005). At the same time, municipal governments, state transportation departments, and school districts are entering an era of reduced fiscal capacity where they are required to provide better results with less funding. Given these responsibility, planners and engineers from local government agencies and school districts must understand the short- and long-term cost considerations of student transportation and the connections with school location decisions.

STRIDE-funded research suggests that the density of residential developments within a one-half mile radius of newly constructed schools influence school transportation system design, mode splits and costs among public and private actors (STRIDE, 2015). This research, conducted by STRIDE-partners at UNC Chapel Hill, North Carolina State University and the University of Florida, evaluated school transportation costs for 20 schools in the Southeastern United States – 11 in North Carolina and 9 in Florida. The findings from this research suggest that the policy interest in the economic benefits of Smart Growth policies, such as siting schools near residential developments, is warranted. Unfortunately, the limitations presented by the small sample size

limit the generalizability of the work outside the study context. In addition, the existing research focuses on one point in time and thereby fails to understand how land development changes after a school is built and the resulting impacts of those changes.

III. RESEARCH APPROACH

Emerging from the larger research objective and background regarding the intersection of school siting and transportation, the goal of STRIDE project number (2016-016) was to evaluate the relationship between community design factors and school transportation operation and cost outcomes for public institutions. This project builds on the previously funded STRIDE project, *Quantifying the Cost of School Transportation*, in which we selected 20 recently-built schools in North Carolina (11 schools in urban, suburban and rural contexts) and Florida (9 schools in urban and rural contexts) and collected data on the multimodal costs of school transportation. These schools were selected to document the variation in school costs by location type (urban, suburban, and rural) and nearby built environment characteristics.

Upon a thorough review of existing data available for analysis in respect to the research objectives, it became evident that a baseline evaluation of home to school distances comparing four urban public school districts in North Carolina was a necessary first step. Further, analysis comparing home to school distances within school districts – school to school comparisons – sheds additional light on the role of residential land use in respect to enrolled students distances.

Population

In respect to study population, we evaluate the enrollment distance profiles for 244 public elementary schools located in the Piedmont region of North Carolina. Specifically, these schools are located in one of four major public urban school districts – Charlotte-Mecklenburg, Cumberland, Durham, and Guilford County Schools. Through focusing on elementary schools located in the same bio- and economic region, we assume that school assignment and siting factors are comparable. Further, the Piedmont is a relatively consistent geographic and topographic terrain unlikely to have significant physical challenges for transportation system

optimization; this can be an issue for regions with mountainous and/or coastal terrain. We define the Piedmont geographically as any school in a Local Education Agency (LEA) location within or between the Iredell-Statesville LEA to the west and the Wayne County LEA to the east. Schools considered for the study are public, geographically assigned elementary schools that are not serviced via express bus routing. We have selected this study area in order to ensure comparable time and regional socio-political considerations, such as state policies and economic trends.

Data Collection

Data on home to school distances for each of the 244 schools were derived from the North Carolina Department of Public Instruction's TIMS database (Transportation Information Management System). The TIMS database is a collection of school bus operational data for schools and LEAs across the state.

Future research with this dataset will evaluate the influence of residential land use and community design factors on the number of school buses that service a school, as well as the number of bus riders. The sample frame will be constructed using the percentage of enrolled student population residing within 1.5 miles of a school site; quintiles were constructed using this percent enrolled school-level measure. This distance (1.5 miles) was chosen as it reflects the minimum reimburseable distance for State of North Carolina funded school bus travel.

IV. FINDINGS AND APPPLICATON

This project collected and analyzed enrolled elementary student distribution data from four urban public schools districts in North Carolina – Durham Public Schools, Cumberland County Schools, Guilford County Schools and Charlotte-Mecklenburg Schools. Below, we compare school size and enrollment distribution statistics across the four districts. We then review the geographic distributions for each of the four schools districts via school district profiles.

Figure 1. Overview of Public School District Elementary School Enrollment

	Elementary Schools	Average Enrollment	Std Error
Durham	30	529	30.8
Cumberland	52	468	31.3
Guilford	67	466	17.1
Charlotte-Mecklenburg	93	673	20.1
Study Totals	242		

Discussion: Average School Size by School District

The number of students enrolled within elementary schools in each of the four urban school districts is intimately related to both the number of schools within the district and the geographic distribution of students attending school. Figure 1 suggests that Charlotte-Mecklenburg Schools (CMS) are significantly larger on average (672.7 students) than those in Durham (528.7 students), Cumberland (467.7 students) and Guilford (466.0 students). This statistic relates most directly to the distributions that follow in *Figure 2*, which highlights the absolute and relative student enrollment statistics given several geographic measures.

Based on previous STRIDE-funded research, it is likely that with larger enrolled populations at school sites, Charlotte-Mecklenburg Schools would also have larger physical school campus footprints. Thus, it is likely that CMS elementary schools have lower enrolled

students within one-half mile of the school site. Further, it will be important to note in *Figure 2* how the distribution of enrolled students for Charlotte-Mecklenburg Schools changes as the geographic scope changes relative to the other urban school districts; relatedly, while Durham has the second largest elementary schools on average, how do their enrolled distance statistics relate to those of both CMS at the upper-end and Guilford and Cumberland County Schools, which have smaller average school sizes?

Figure 2. Overview of Public School District Enrolled Student Distribution Data

	Avg No. Students		Percent Students	
Enrolled Students: Within 0.5 Mile	**Value**	**Std Error**	**Value**	**Std Error**
Durham	41.2	8.3	10.0%	2.2%
Cumberland	31.3	3.7	7.6%	1.0%
Guilford	33.8	4.8	8.2%	1.3%
Charlotte-Mecklenburg	35.2	4.3	5.4%	0.7%
Enrolled Students: Within 1.0 Mile	**Value**	**Std Error**	**Value**	**Std Error**
Durham	108.1	18.3	23.9%	4.3%
Cumberland	122.2	12.6	26.7%	2.6%
Guilford	98.1	10.1	22.9%	2.4%
Charlotte-Mecklenburg	147.7	13.0	22.2%	2.0%
Enrolled Students: Within 1.5 Mile	**Value**	**Std Error**	**Value**	**Std Error**
Durham	172.4	23.5	36.1%	5.1%
Cumberland	200.6	19.0	43.2%	3.4%
Guilford	160.7	13.2	36.4%	3.0%
Charlotte-Mecklenburg	270.6	19.0	39.8%	2.6%

Discussion: Average School Size by School District

Analysis of enrolled student distributions around school sites reveals several important trends. In particular, this analysis evaluates how enrollment statistics for each district change looking across distances of one-half mile radius around a school site, one mile around a school site, and one and one-half mile around a school site.

Findings: 0.5 Mile from the School Site

Within one-half mile of a school site, Durham Public Schools have both the highest average number of students (41.2 students) and the highest relative percentage of enrolled students (10%). However, it is important to note the standard errors for these statistics are also substantially higher than those in other districts (8.3 students and 2.2%, respectively). This suggests that DPS has considerable variability from school to school regarding enrolled population distances; some schools appear to be quite dense, while other are considerably less dense within one-half mile. Comparatively, Charlotte-Mecklenburg has the second highest number of students living within one-half mile (35.2 students) and the lowest percent enrolled living within one-half mile (5.4%). The standard errors are smaller for CMS, which makes sense given its population size (N=93).

These findings regarding enrolled student distance distributions support the concept that Charlotte-Mecklenburg's larger school sizes, which on average are 150 students more than Durham and over 200 students more than Guilford and Cumberland, would have lower enrolled student numbers within the immediately surrounding area (one-half mile) of a school site – on average there are six less students living within one-half mile of a Charlotte elementary school than a Durham elementary school. Similarly, in respect to relative percent enrolled within one-half mile, Durham has 10% of its enrolled students within one-half mile, while Charlotte only has about 5% living within one-half mile. Future research will look at how these differences in immediate surrounding student residential geographies influence school travel modes and costs, accounting for built environment characteristics.

Findings: 1.0 Mile from the School Site

Moving the geographic lens of analysis from one-half mile around a school to one mile around a school, Cumberland and Charlotte demonstrate substantial increases in the absolute and relative amount of students living within one mile of a school. Cumberland's enrolled population grew from 31.3 students to 122.2 students, a 91 student increase, and from 7.6% enrolled living within a half-mile to 26.7% enrolled living within one mile, an absolute-percent increase of 19.1%. Comparatively, Charlotte's enrolled population grew from 35.2 students living within one-half mile to 147.7 students living within one mile, a 112.5 student increase, and from 5.4% of the enrolled population living within one-half mile to 22.2% living within one mile, an increase of 16.8%). Thus, by shifting the focus from one-half mile to one mile, Charlotte-Mecklenburg Schools exhibited the largest increase in absolute number of students enrolled, whereas Cumberland County Schools gained the most students relative to the overall enrolled population.

The geographic focal shift to one mile radius around a school demonstrates a separation of the school district densities; whereas the one-half mile radius exhibited tight clustering of average number of students between 31 and 41 within a half mile, within one mile of a Charlotte Mecklenburg elementary school there are 25 more students than Cumberland County, 40 more students than Durham County, and 50 more students than Guilford County. These findings suggest that Charlotte-Mecklenburg Schools are operating in an environment that is likely to be both more dense in respect to school-age populations and that the overall built environment that supports greater densities within a one-mile distance. The findings also suggest that Durham in particular may have a dense clustering of students within one-half mile of a school – but as the

distance of evaluation is increased there is a decrease in Durham's student enrollment density.

Findings: 1.5 Miles from the School Site

Using a geographic radius within one and one-half mile around a school, we observe a further separation in the absolute and relative amount of students enrolled within a school between each of the four urban public school districts. At this level of geographic analysis, we see that Charlotte-Mecklenburg has the highest average number of students living within 1.5 miles of a school site at 270.6 students. This student demographic statistic is 70 students greater than the next closest school district, Cumberland (200.6 students), and about 100 students greater than both Durham and Guilford County Schools (172.4 and 160.7 students, respectively).

These numbers suggest that the effects of both school-aged demographics and the built environment around a school site can have a significant impact on the location of students in relation to their school – within one and one-half miles, Charlotte has, on average, at least 70 more students than any of the other three urban public school districts. Moreover, these findings would suggest that while other urban populations may cluster around a school site within one-half mile or one mile, Charlotte's density is considerably more uniform; the increasing distances of demographic evaluation from one-half, to one mile, to one and one-half mile continue to increase Charlotte's absolute number of students in relation to the other urban districts.

Cumberland County Schools maintain the highest percentage of enrolled students (on average) within one and one-half miles of the school site. This finding is of interest along several lines of thought. While Cumberland County does not have the uniform density or absolute numbers of students within a given distance as Charlotte-Mecklenburg, its schools are 205 students smaller on average than Charlotte-Mecklenburg Schools. Thus, Cumberland has a higher percentage of its students that live within one and one-half mile at 43.2% than Charlotte

(39.8%), Durham (36.1%) or Guilford (36.4%). From a transportation and land use planning perspective, the high relative enrollment percentages within 1.5 miles of a school for Cumberland County (43.2%) may have significant implications for the school transportation and operations of the district's schools. Nearly half of all Cumberland students live within the non-reimburseable 1.5 mile distance for state-level funding of school buses. In future analysis, we will evaluate whether the school transportation network that supports Cumberland schools and students reflects these spatial and demographic statistics.

Findings: Standard Errors

Somewhat unexpectedly, Durham Public Schools exhibited much greater variability in the home-to-school distances than the other three urban public school districts. Moving from one-half mile, to one mile, to one and one-half miles, Durham's standard errors increased from 8.3 students, to 18.3 students, to 23.5 students. Comparatively, Guilford County Schools exhibited to most stability in respect to standard errors, increasing from 4.8 students, to 10.1 students, to 13.2 students across the three geographic ranges for evaluation.

In part, these differences can be explained by population size; Guilford County Schools has 67 elementaries and Durham Public Schools has 30 elementaries. However, this variability also suggests that there may be locational differences in demographics and the built environment that are greater in Durham County than in Guilford County. Interestingly, both are consolidated school districts that merged previously separate urban and county school districts. The findings also suggest the need for additional research into factors that contribute to such variability in future research.

Durham Public Schools | Population 30 Elementary Schools

With 30 public elementary schools in its school district, Durham Public Schools (DPS) was the smallest of the four urban school districts in this study. Figures 3 and 4 reflect the enrollment and student distribution profile for DPS.

Figure 3. Durham Public Schools Average School Size

Durham Public Schools: Enrolled Student Distribution Profile		
Number of Elementary Schools	30	
Avg School Size	**Value**	**Std Error**
	528.7	30.8

Figure 4. Durham Public Schools Enrolled Student Distribution

	Avg No. Students		**Percent Students**	
	Value	**Std Error**	**Value**	**Std Error**
Demographics: 0.5 Mile	41.2	8.3	10.0%	2.2%
Demographics: 1.0 Mile	108.1	18.3	23.9%	4.3%
Demographics: 1.5 Mile	172.4	23.5	36.1%	5.1%

Cumberland Public Schools | Population 52 Elementary Schools

With 52 public elementary schools in its school district, Cumberland County Public Schools (CCS) was the second smallest of the four urban school districts in this study. Figures 5 and 6 reflect the enrollment and student distribution profile for CCS.

Figure 5. Cumberland County Public Schools Average School Size

Cumberland Public Schools: Enrolled Student Distribution Profile		
Number of Schools	52	
Avg School Size	**Value**	**Std Error**
	467.7	31.3

Figure 6. Cumberland County Public Schools Enrolled Student Distribution

	Avg No. Students		Percent Students	
	Value	**Std Error**	**Value**	**Std Error**
Demographics: 0.5 Mile	31.3	3.7	7.6%	1.0%
Demographics: 1.0 Mile	122.2	12.6	26.7%	2.6%
Demographics: 1.5 Mile	200.6	19.0	43.2%	3.4%

Guilford Public Schools | Population 67 Elementary Schools

With 67 public elementary schools in its school district, Guilford County Public Schools (GCS) was the second largest of the four urban school districts in this study. Figures 7 and 8 reflect the enrollment and student distribution profile for GCS.

Figure 7. Guilford County Public Schools Average School Size

Guilford County Public Schools: Enrolled Student Distribution Profile		
Number of Elementary Schools	67	
Avg School Size	**Value**	**Std Error**
	466.0	17.1

Figure 8. Guilford County Public Schools Enrolled Student Distribution

	Avg No. Students		Percent Students	
	Value	**Std Error**	**Value**	**Std Error**
Demographics: 0.5 Mile	33.8	4.8	8.2%	1.3%
Demographics: 1.0 Mile	98.1	10.1	22.9%	2.4%
Demographics: 1.5 Mile	160.7	13.2	36.4%	3.0%

Charlotte-Mecklenburg County Public Schools | Population 93 Elementary Schools

With 93 public elementary schools in its school district, Charlotte-Mecklenburg County Public Schools (CMS) was the largest of the four urban school districts in this study. Figures 9 and 10 reflect the enrollment and student distribution profile for CMS.

Figure 9. Charlotte-Mecklenburg County Public Schools Average School Size

Charlotte-Mecklenburg Public Schools: Enrolled Student Distribution Profile		
Number of Elementary Schools	93	
Avg School Size	Value	Std Error
	672.7	20.1

Figure 10. Charlotte-Mecklenburg County Public Schools Enrolled Student Distribution

	Avg No. Students		Percent Students	
	Value	Std Error	Value	Std Error
Demographics: 0.5 Mile	35.2	4.3	5.4%	0.7%
Demographics: 1.0 Mile	147.7	13.0	22.2%	2.0%
Demographics: 1.5 Mile	270.6	19.0	39.8%	2.6%

V. Conclusions, Recommendations and Suggested Research

This research sheds light on several important findings that support coordinated planning as it relates to residential developments, school site selection and derivative school transportation operations and costs.

First, district-level distributional analysis reveals important differences in home-to-school distance distributions between urban public school districts. This suggests that there may be additional omitted variables to this study (e.g. institutional planning and construction; municipal and/or county land use and development policies; the surrounding built environment; nearby residential demographics) in relation to school site selection and residential development. District-by-district comparisons across these four urban public school systems also sheds light on the importance of evaluating enrollment statistics across geographic ranges – in this study we looked at 0.5 miles, 1.0 mile, and 1.5 miles. Looking at enrollment statistics across these distances reveals information about the need for comprehensive spatial and demographic understanding.

Second, variation within a school district, here observed through the standard error, reveals substantial differences that may be at play within a school district, such as the aging out of subdivisions by generational cohorts, the age of a school in relation to other schools in the district, and surrounding built environment factors – such as building heighth and street network design. Collectively, these contextual factors require further evaluation in order to understand how urban public school districts may adequately plan for school facility and transportation support of a community.

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