Short Communication

# Are single entry communities and cul-de-sacs a barrier to active transport to school in 11 elementary schools in Las Vegas, NV metropolitan area?

Courtney Coughenour [a,*], Sheila Clark [a], Ashok Singh [b], Joshua Huebner [a]

[a] School of Community Health Sciences, University of Nevada, Las Vegas, 4505 S. Maryland Parkway box 3064, Las Vegas, NV 89154, United States
[b] William F. Harrah College of Hotel Administration, University of Nevada, Las Vegas, 4505 S. Maryland Parkway box 6021, Las Vegas, NV 89154, United States

## ARTICLE INFO

## ABSTRACT

Single entry communities (SECs) and cul-de-sacs minimize route choices and increase trip distance. Las Vegas' built environment facilitates the examination of these variables and active transport to school (ATS) rates. The purpose of this study was to examine the influence of SECs and cul-de-sacs on ATS rates in Las Vegas, NV elementary children. Parental-reported data was collected from 11 elementary schools on ATS rates (n = 1217). SECs and cul-de-sacs were quantified for each school zone. Logistic regression models were used to predict ATS. 23.9% of students reported ATS all of the time and 31.4% some of the time. SECs per school zone ranged from 0 to 25 (mean = 11.9). Cul-de-sacs ranged from 12 to 315 (mean = 138.3). Some ATS use was predicted by distance from school ($p \leq 0.001$;OR = 0.61), parental education (high school: $p = 0.004$;OR = 0.53, some college: $p = 0.001$;OR = 0.50, 4 year degree: $p = 0.004$;OR = 0.52) and cul-de-sacs ($p \leq 0.001$;OR = 0.99). A separate model using distance from school ($p \leq 0.001$;OR = 0.61), parental education (high school: $p = 0.002$;OR = 0.51, some college: $p \leq 0.001$;OR = 0.45, 4 year degree: $p \leq 0.001$;OR = 0.45) and SECs ($p \leq 0.001$;OR = 0.96) predicted some ATS. All ATS use was predicted by distance from school ($p \leq 0.001$;OR = 0.58), parental education (Grades 9–11: $p = 0.05$;OR = 0.61, high school: $p \leq 0.001$;OR = 0.45, some college: $p \leq 0.001$;OR = 0.41, 4 year degree: $p \leq 0.001$;OR = 0.38) and SECs ($p \leq 0.001$;OR = 0.97). A separate model using distance from school ($p \leq 0.001$;OR = 0.58), parental education (Grades 9–11: $p = 0.041$;OR = 0.59, high school: $p \leq 0.001$;OR = 0.47, some college: $p \leq 0.001$;OR = 0.44, 4 year degree: $p \leq 0.001$;OR = 0.43) and cul-de-sacs ($p \leq 0.001$;OR = 0.99) predicted all ATS. Current findings reveal that both SECs and cul-de-sacs were predictors of ATS beyond distance. Students with more SECs and cul-de-sacs in their school zone were less likely to utilize ATS.

## 1. Introduction

With a dramatic increase in childhood obesity over the past several decades, increasing physical activity rates in youth has become critical. One method to increase levels of physical activity (PA) in youth is through active transport to school (ATS). Studies show that children who use ATS accumulate significantly more physical activity and expend significantly more kilocalories than children who use passive transport (being driven in a motor vehicle) (Faulkner et al., 2009). Perceptions of physical activity, self-efficacy, social influences and parental and peer support are known to be influencing factors for childhood PA. Additionally, youth who are physically active are more likely to engage in new activities (Surgeon General, 1996) and to remain physically active into adulthood (Telama et al., 2005).

ATS rates have declined significantly over the last four decades, with 12.7% of kindergarten through 8th grade students walking or biking to school in 2009 compared to 47.7% in 1969 (McDonald et al., 2011). Efforts have been made to increase levels of physical activity through active transport in youth. Both the White House Task Force on Childhood Obesity and Healthy People 2020 initiatives recommend increasing the amount of trips made through active transport.

Research suggests that adults who live in communities with land use patterns that facilitate active transport attain more minutes of walking and physical activity per day (Rundle et al., 2016; Adams et al., 2015; Frank et al., 2006). However, research that explores the relationship between community design and active transport in youth has been limited. Understanding correlates of active transport behaviors in youth is critical to effectively increase the number of children who actively commute to school.

Trip distance has been shown to be the primary influencing factor in parental decisions regarding ATS (Nelson et al., 2008; Schlossberg et al., 2006; Timperio et al., 2006). Trip distance is reduced with greater street connectivity, or more intersections, as intersections enable the shortest

* Corresponding author.
E-mail addresses: Courtney.Coughenour@unlv.edu (C. Coughenour),
Sheila.Clark@unlv.edu (S. Clark), Ashok.Singh@unlv.edu (A. Singh),
Joshua.Huebner@unlv.edu (J. Huebner).

route to be chosen and offer a wider range of routes to choose from (see Fig. 1). Studies examining the relationship between street connectivity and ATS have shown somewhat mixed results. Braza et al. (2004) examined ATS in California elementary schools and found that the number of intersections per street mile was significantly correlated with ATS in pairwise correlations, but not in regression models. They suggest that the effect of street connectivity may be masked due to its correlation with population density and low power of the model. Schlossberg et al. (2006) examined the influence of urban design characteristics for ATS in middle school children in Oregon and found that "students whose walking areas had high intersection densities had a 10% probability of walking, compared with only 3% and 2% if they had medium or low intersection densities, respectively (Schlossberg et al., 2006)." Giles-Corti et al. (2011) reported that regularly walking to school was higher in children whose school zone had high street connectivity and low traffic volume. In an observational study, Rothman et al. (2014) found that higher intersection densities were positively correlated with walking. Though not specific to school transport, Grow et al. (2008) examined neighborhood environmental factors associated with active transport to recreational sites for adolescents. Multivariate regression models showed a positive association between parental and adolescent self-report of high street connectivity and active transport (Grow et al., 2008). Similarly, a study of youth aged 5 to 20 years in Atlanta reported that higher street connectivity was associated with more walking (Frank et al., 2007). However, Timperio et al. (2006) found that in 10 to 12 year olds street connectivity was negatively associated with ATS.

Coughenour and Bungum (2015) found that the presence of single entry communities (SECs), or single-land use housing developments that have only one entrance into and out of the development, significantly decreased street connectivity. A design feature commonly associated with SECs and single-use housing developments are cul-de-sacs. Cul-de-sacs result in a non-through street network which also increase overall trip distance (see Fig. 1). While these design features are associated with decreased street connectivity, few studies have examined the role of cul-de-sacs and single entry communities directly on ATS. The authors located two studies which assessed these features and found mixed results. A study of 9 to 10 year olds in the United Kingdom found that students with more direct routes measured by more intersections and fewer cul-de-sacs were less likely to walk to school (Panter et al., 2010). However, a study in Oregon found that fewer dead ends in the neighborhood were predictive of walking; students "with low dead-end densities had an 8% probability of walking to school, holding other factors constant, compared to 3% and 2% for those with medium and high dead-end densities, respectively" (Schlossberg et al., 2006).

Like many other metropolitan areas in sunbelt states, Las Vegas began to experience significant population growth at the peak of urban sprawl (Barrington-Leigh and Millard-Ball, 2015). As such, the dominant form of development moved from traditional neighborhoods connected through a grid-like street design, to auto-dominant suburban neighborhoods characterized by single-use developments and SECs. Because trip distance and street connectivity influence ATS (Nelson et al., 2008; Schlossberg et al., 2006; Timperio et al., 2006), and SECs and cul-de-sacs increase trip distance and minimize street connectivity, yet few studies have examined this effect on active transport, Las Vegas metropolitan area presents an opportunity to examine the influence of this urban form on youth ATS rates. The purpose of this study was to examine the influence of SECs and cul-de-sacs on parental-reported ATS rates of elementary school children in Las Vegas, NV.

## 2. Materials and methods

Surveys were collected in a large, ethnically and geographically diverse school district in the Las Vegas metropolitan area in 11 elementary schools which chose to participate in the Safe Routes to School (SRTS) program in the fall of 2013. The survey was sent home in English and Spanish with each student. If a parent or caregiver had more than one child attending the school, he or she was asked to complete it only for the child with the next birthday from the date it was received. Surveys were returned to school by the students (n = 1439).

The SRTS survey was developed by the National Center for Safe Routes to School and has been administered throughout the U.S. since 2008. As of 2013, over 525,000 surveys have been collected by the National Center (Nicholas, 2013). The survey does not collect identifying information and was designed to be completed within five to 10 min. The 50 items contained in the survey include information on child's grade level, gender, parental education, and family size, as well as the home's nearest cross streets. It also requests the distance to school in quarter- to half-mile increments and information on the usual commuting method separately for the morning (to school) and afternoon (from school) trips. This survey was assessed for reliability and validity by McDonald et al. (2011). Two week test-re-test reliability for parental report of child's usual mode of travel to and from school was reliable (98.2% agreement (kappa = 0.97) and 92.9% agreement (kappa = 0.85), respectively), and parental report of distance child lives from the school was reliable (72.3% agreement (kappa = 0.65) unweighted and 93.3% agreement (kappa = 0.77) weighted) (full results presented
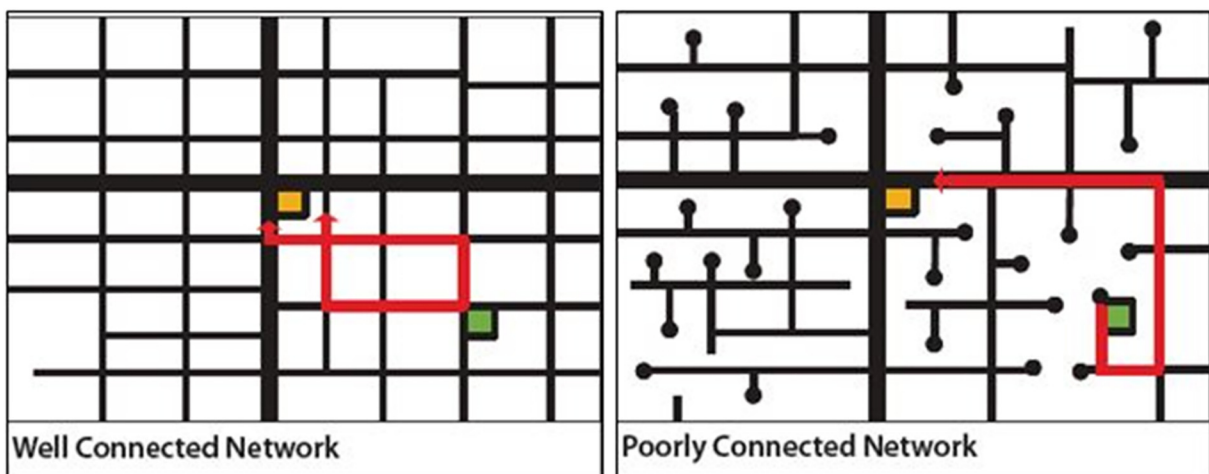


**Fig. 1.** A well connected street network with more intersections reduces trip distance and makes active travel more convenient.
Source: City of Las Vegas, 2013.

in McDonald et al., 2011). Two additional predictor variables from the SRTS survey were parental education and distance to school. Parental education choices include completion of grades 1–8, 9–11, a high school diploma or GED, some college, and a 4 year degree or greater. Distance from school options range from <0.25 miles, 0.25–0.5 miles, 0.5–1 miles, 0–2 miles, and >2 miles.

Two dichotomous variables were created to represent students who reported using ATS, i.e. walking, biking, or other (scooter, skateboard, etc.) all or some of the time. All_ATS represents students who were reported to use ATS for both morning and afternoon commutes on most days. Some_ATS represents students who were reported to use ATS for either the morning or afternoon commute, or for both, capturing a wider range of ATS users. Surveys with missing information on commuting method were excluded (n = 222), and analyses were completed for both variables on the remaining surveys (n = 1217).

To assess the school zone for SECs, ArcGIS imagery, Google maps, and Google street view was used. In order to be classified as a SEC there had to be only one entrance/exit into the development area. SECs included developments that had restricted access in the form of a guarded or remote gate as well as those that did not have a gate, but still consisted of one entrance/exit. The total number of observed SECs per school zone was recorded as a continuous variable. To assess the school zone for cul-de-sacs Google maps and Google street view were used. In order to be classified as a cul-de-sac the road had to terminate without connections to adjacent streets (through streets, even if they had large turn-around areas, were not classified as a cul-de-sac). The total number of cul-de-sacs observed per school zone was recorded as a continuous variable.

Logistic regression models for both ATS variables were developed using the statistical software environment R (R Core Team, 2015). The potential predictors in the models are: distance, number of Cul-de-sacs, number of SECs (all continuous predictors); gender (categorical with two levels: female and male), and parental education (categorical with 5 levels: grades 1–8, grades 9–11, high school diploma/GED, some college, 4 year degree).

In building the logistic regression models, we first entered all of the predictors in the model, then dropped predictors with variance inflation factor (VIF) above 5; once a model with no multicollinearity issues was found, then all insignificant predictors were dropped to obtain the final logistic regression models. The likelihood ratio test of goodness of fit was used to assess if the fitted model provided good fit; the test statistic equals the difference between the model residual deviance the deviance of the null model. The null distribution of the test statistic is chi-squared with degrees of freedom equal to the differences in degrees of freedom between the fitted and the null model. Three different pseudo-$R^2$ values were computed as measures of predictive strengths of a logistic regression model (Hu et al., 2006).

## 3. Results

There were a total of 1439 surveys returned from 11 elementary schools in Las Vegas with 1217 surveys having all questions fully and accurately completed. Table 1 shows the percentages of each mode of transport for the school commute and demographic variables for all participants.

The number of SECs per school zone ranged from 0 to 25, with a mean of 11.9 and median of 9. Cul-de-sacs ranged from 12 to 315 with a mean of 138.3 and median of 136.

### 3.1. Some ATS

In the logistic regression models for some ATS or all ATS with all of the predictors (distance from school, number of cul-de-sacs, number of SECs, and the categorical variables gender and parental education), the binary predictor gender was not significant and was dropped from the model. The logistic regression model for some ATS with predictors

**Table 1**
Student demographics and rates of transport to school in 11 elementary schools in Las Vegas, NV metropolitan area, fall 2013.

| Gender | % of sample |
|---|---|
| Male (n = 550) | 45.2 |
| Female (n = 661) | 54.3 |
| Missing (n = 6) | 0.5 |
| *Transport rates* | |
| Some active transport (n = 382) | 31.4 |
| All active transport (n = 291) | 23.9 |
| Passive transport (n = 835) | 68.6 |
| *Grade* | |
| Pre-kindergarten (n = 24) | 2.0 |
| Kindergarten (n = 139) | 11.5 |
| 1 (n = 178) | 14.6 |
| 2 (n = 226) | 18.6 |
| 3 (n = 235) | 19.3 |
| 4 (n = 208) | 17.1 |
| 5 (n = 197) | 16.2 |
| Missing (n = 10) | 0.7 |
| *Distance to school* | |
| <0.25 miles (n = 259) | 21.3 |
| 0.25–0.5 miles (n = 169) | 13.9 |
| 0.5–1 miles (n = 282) | 23.2 |
| 1–2 miles (n = 303) | 24.9 |
| >2 miles (n = 134) | 11.0 |
| Unsure (n = 70) | 5.8 |
| *Parental education* | |
| Grades 1–8 (n = 135) | 11.1 |
| Grades 9–11 (n = 112) | 9.2 |
| High school diploma or GED (n = 224) | 18.4 |
| Some college (n = 342) | 28.1 |
| 4 year degree (n = 349) | 28.7 |
| Chose not to respond (n = 55) | 4.5 |

distance from school, number of cul-de-sacs, number of SECs, and the categorical variable parental education was statistically significant ($X^2$ = 229.5, p ≤ 0.001) and had moderate pseudo-$R^2$ values of 0.15 (McFadden), 0.17 (Cox & Snell) and 0.24 (Nagelkerke). The predictors cul-de-sacs and SECs were highly collinear (r = 0.94, p ≤ 0.001) with VIF values above 7.0. We therefore decided to fit two separate logistic regression models, one with independent variables of distance from school, parental education and SECs, and another with independent variables of distance from school, parental education and cul-de-sacs.

The logistic regression model predicting some ATS with independent variables of distance from school, parental education and SECs was highly significant and had moderate pseudo-$R^2$ values. There were no collinearity issues in this model, with all VIF values <1.2. Parents who were more educated, reported a greater distance to school and whose neighborhoods had more SECs were less likely to report that their child utilized ATS some of the time.

The logistic regression model predicting some ATS with independent variables of distance from school, parental education and cul-de-sacs was also highly significant and had moderate pseudo-$R^2$ values. There were no collinearity issues in this model, with all VIF values <1.25. Similar to the model with SECs, parents who were more educated, reported a greater distance to school and whose neighborhoods had more cul-de-sacs were less likely to report that their child utilized ATS some of the time. See Table 2 for full model results.

### 3.2. All ATS

The logistic regression models for all ATS are similar: the model with predictors distance from school, parental education, cul-de-sacs and SECs was highly statistically significant ($X^2$ = 171.2, p ≤ 0.001) with pseudo-$R^2$ values of 0.13 (McFadden), 0.13 (Cox & Snell) and 0.20 (Nagelkerke). But as in the case of some ATS, suffered from multicollinearity (VIF > 7) and two separate logistic regression models

**Table 2**
Logistic regression models for some active transport to school (ATS) and all active transport to school (ATS) in 11 elementary schools in Las Vegas metropolitan area, showing odds ratio (OR), p-values, and 95% confidence intervals of predictors in the model.

|  | Model 1: some ATS | | | Model 2: all ATS | | |
|---|---|---|---|---|---|---|
|  | OR | p-Value | 95% CI | OR | p-Value | 95% CI |
| *Parental education* | | | | | | |
| Constant | 0.91 | 0.090 | 0.816–1.013 | 0.91 | 0.113 | 0.813–1.022 |
| Grades 9–11 | 0.71 | 0.180 | 0.438–1.162 | 0.59 | 0.041 | 0.359–0.978 |
| High school diploma or GED | 0.53 | 0.004 | 0.351–0.813 | 0.47 | 0.001 | 0.305–0.727 |
| Some college | 0.50 | 0.001 | 0.329–0.750 | 0.44 | ≤0.001 | 0.289–0.682 |
| 4 year degree | 0.52 | 0.004 | 0.338–0.809 | 0.43 | ≤0.001 | 0.270–0.676 |
| Distance from school | 0.61 | ≤0.001 | 0.557–0.660 | 0.58 | ≤0.001 | 0.517–0.638 |
| Number of cul-de-sacs | 0.99 | ≤0.001 | 0.994–0.997 | 0.99 | ≤0.001 | 0.996–0.999 |
| Chi-square goodness of fit test | Chi-square = 244.1, df = 6, p ≤ 0.001 Pseudo $R^2$ = 0.15 (McFadden) = 0.17 (Cox & Snell) = 0.24 (Nagelkerke) | | | Chi-square = 192.9, df = 6, p ≤ 0.001 Pseudo $R^2$ = 0.13 (McFadden) = 0.13 (Cox & Snell) = 0.20 (Nagelkerke) | | |
|  | Model 3: some ATS | | | Model 4: all ATS | | |
|  | OR | p-Value | 95% CI | OR | p-Value | 95% CI |
| *Parental education* | | | | | | |
| Constant | 0.87 | 0.012 | 0.788–0.971 | 0.89 | 0.032 | 0.792–0.990 |
| Grades 9–11 | 0.74 | 0.220 | 0.453–1.199 | 0.61 | 0.050 | 0.367–0.999 |
| High school diploma or GED | 0.51 | 0.002 | 0.335–0.775 | 0.45 | ≤0.001 | 0.294–0.700 |
| Some college | 0.45 | ≤0.001 | 0.301–0.682 | 0.41 | ≤0.001 | 0.270–0.633 |
| 4 year degree | 0.45 | ≤0.001 | 0.292–0.683 | 0.38 | ≤0.001 | 0.243–0.593 |
| Distance from school | 0.61 | ≤0.001 | 0.511–0.621 | 0.58 | ≤0.001 | 0.545–0.661 |
| Number of single entry communities | 0.96 | ≤0.001 | 0.940–0.973 | 0.97 | ≤0.001 | 0.957–0.991 |
| Chi-square goodness of fit test | Chi-square = 232.7, df = 6, p ≤ 0.001 Pseudo $R^2$ = 0.14 (McFadden) = 0.16 (Cox & Snell) = 0.23 (Nagelkerke) | | | Chi-square = 187.5, df = 6, p ≤ 0.001 Pseudo $R^2$ = 0.12 (McFadden) = 0.13 (Cox & Snell) = 0.20 (Nagelkerke) | | |

were developed, one with distance from school, parental education and SECs, and another with distance from school, parental education and cul-de-sacs as predictors.

Both of these logistic regression models for all ATS as a function of distance from school, parental education and SECs (or cul-de-sacs) turned out to be highly significant with moderate pseudo-$R^2$ values and no multicollinearity issues (all VIF values < 1.2). Parents who were more educated, reported a greater distance to school and whose neighborhoods had more SECs or more cul-de-sacs were less likely to report that their child utilized ATS all of the time. See Table 2 for full model results.

## 4. Conclusion

Although interventions to encourage ATS may have a temporary positive effect (Bungum et al., 2014), significant barriers to ATS remain. If efforts to increase ATS rates and childhood PA levels are to be effective, comprehensive understanding of the neighborhood influence on active transport behaviors is necessary. Trip distance is an important predictor of ATS, and SECs have been shown to increase trip distance and minimize route choices. This study confirms previous findings that distance to school is a predictor of ATS (Nelson et al., 2008; Schlossberg et al., 2006; Timperio et al., 2006). Current results also showed that students who had a higher number of SECs and cul-de-sacs in their school zone were less likely to utilize ATS some or all of the time. Our findings support Schlossberg et al.'s (2006) findings that fewer dead-ends were predictive of walking in middle school students in OR, but contradicts Panter et al.'s (2010) findings that 9 to 10 year olds in the U.K. with more direct routes (more intersections and fewer cul-de-sacs) were

less likely to walk to school. This contradiction may be indicative of the many cultural differences related to automobile use and active transportation between the U.K. and the U.S. For example, a 2014 travel survey revealed that 46% of 5 to 10 year olds in the U.K. walk to school (U.K. Department for Transport, 2014), compared to an estimated 21.4% in the U.S. (Yang et al., 2016).

This study found that current urban design may be creating a barrier for school aged children to utilize ATS. Current findings show that both SECs and cul-de-sacs are related to ATS beyond trip distance. The sustained demand to create private dwelling areas through cul-de-sacs, SECs, and the typically associated high privacy walls, has created new challenges for the active transportation movement. This design style increases the likelihood of reliance on motorized transportation to and from school, while simultaneously failing to take advantage of an active transport opportunity. For example, this reliance on motorized transport leads to fewer pedestrians of any age being present within the neighborhood and lower levels of social cohesion (Leyden, 2003). This may lead to higher levels of parental concern related to traffic and crime, which has been found to be a barrier to ATS (Stewart et al., 2012; Giles-Corti et al., 2011). Additionally, Schoeppe et al. (2015) reported that adults with higher perceptions of neighborhood social cohesion were more likely to permit greater distances for children's independent travel.

The demographic variable of parental education showed that higher educational status was negatively associated with ATS rates. It is well supported that lower income families are less likely to own a private vehicle, and thus, more likely to walk out of necessity rather than choice (Dargay, 2001; Dargay and Gately, 1997; McDonald, 2008; Stewart, 2011). Though we did not have the demographic variable of income to explore this relationship, income and education status are typically highly correlated (BLS, 2016). The authors can only speculate, but it may be that parents with lower educational status lacked the transportation options that more educated parents may have had.

Strengths of this study include a large sample size which enabled a robust analysis. Data was collected with the validated survey tool created by the National Center for Safe Routes to School and was distributed in English and Spanish. This study is not without limitations. ATS data was self-reported by parents rather than measured objectively. This may have resulted in a reporting bias. Distance from school was also self-reported; street level data would have provided a more accurate measure of distance from home to school. The cross sectional design does not allow us to infer causation, but supports the assertion that SECs and cul-de-sacs, at least minimally, are barriers to ATS.

Study findings highlight a need for policies supporting the development of complete streets with true connectivity to surrounding streets and adjacent communities. Policy makers, urban planners and public health professionals should create evidence-driven policies incentivizing design that promotes active living and minimizes health hindering designs.

## Conflicts of interest

None.

## Transparency document

The Transparency document associated with this article can be found, in online version.

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