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Transit use for single-parent households: Evidence from Maryland

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ABSTRACT

Single parents face unique transportation barriers in their lives. Although helping single parents obtain private vehicles (e.g., car donation programs) would be a potential solution, we cannot ignore the high expense of maintaining and operating a vehicle, which may impose a heavy financial burden on single-parent families and constrain their ability to access opportunities and services. In contrast, public transit could be a more accessible and affordable transportation mode that benefits single-parent families. This study examined the association between public transit use and single parents using 2017 National Household Travel Survey and American Community Survey data for Maryland, United States. Using zero-inflated negative binomial (ZINB) regression, we found that single parents used transit more than the average resident, and census block groups with more single-parent families had more transit commuters, holding other demographic and socioeconomic variables constant. This association was more significant in large metropolitan and urban areas than the state average. The findings highlight the vital role of public transit in single parents' daily travel. We discussed policy implications related to helping single parents access opportunities and services.

1. Introduction

In 2016, one third of households with children younger than 18 were headed by single parents in the United States (U.S. Census Bureau, 2017a). The increasing number of single parents has caused concerns about the welfare and equity of this vulnerable group (Kilkey, 2018). Research shows that single parents are twice as likely to experience financial hardship than couple parents (Brown and Moran, 1997). In addition, single parents have more difficulty accessing reliable childcare services, which affects their employment decisions (Burstein and Layze, 2007). The impacts of economic hardship, childrearing, and conflicts in their work–life schedule are significantly associated with increased parenting stress among single parents (Berryhill and Durtschi, 2017). Single parents' dual roles as the financial provider and primary nurturer also increase the constraints on their time and energy (Berryhill and Durtschi, 2017). Evidence indicates that single parents, as the only child caregiver, usually spend more time and energy on childrearing responsibilities than couple parents, regardless of whether they are active in the labor market (Hallberg and Klevmarken, 2003).

Time constraints, combined with economic hardships, cause challenges for single parents and significantly limit their mobility and accessibility (Morency et al., 2011). These limitations further influence single parents' decision-making regarding housing and transportation. To improve the well-being of single parents and their children, it is important to ensure access to reliable and affordable transportation. However, little is known about the patterns of transportation mode choice among single parents. Traditionally, there are two paths to improve the mobility and accessibility of single parents: improving transit and providing cars. Transit advocates, on one hand, emphasize the quality of transit facilities, which has been used as a critical index to rank the best and worst cities for single parents (Comen and Frohlich, 2016). The Pittsburgh Foundation (2019) recommended offering bus tickets to low-income single-parent families that live central cities and subsidizing alternative transit solutions (e.g., ride-sharing) in suburban and rural areas. On the other hand, some charitable organizations appealed for “car donations for single moms” to improve their mobility and accessibility (Alexa, 2014). The federal and state governments also encourage people to donate their cars to low-income single mothers by offering tax deductions as an incentive (Hall, 2018). For example, the Transportation Assistance Program in Maryland provides “reliable used vehicles” to low-income families, which include single-parent families (Maryland Department of Human Services, n.d.). In addition to vehicle donation programs, loan and lease-to-own programs are available to help single parents overcome travel barriers.

An underlying question to this debate is what transportation modes match single parents' needs. In particular, it is unclear whether and to what extent the provision of public transit is important for single parents' travel. A growing body of research suggests that many single parents live in high-density urban areas and economically and physically disadvantaged

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neighborhoods, and they may disproportionally rely on public transit due to their low income and low car ownership (Blumenberg and Waller, 2003; Chlond and Ottmann, 2007; McLanahan and Garfinkel, 1989; Murakami and Jennifer, 1997; Renwick and Bergmann, 1993). Nevertheless, we question whether single parents' reliance on public transit is also related to their family structure, regardless of socioeconomic status and car ownership.

In this study, we explored the relationship between single parents and the use of public transit at both the individual and neighborhood levels for the state of Maryland in the United States. We chose Maryland as the study area because it has a well-developed public transit system and one of the largest U.S. metropolitan areas (i.e., Baltimore–Washington, DC). Intermodal transit services are provided in not only high-density and high-poverty urban centers (e.g., downtown Baltimore) but also sprawling and wealthy suburbs (e.g., peripheral areas of Baltimore and Washington, DC), making this region well suited to answer our questions. The study aimed to provide implications for inclusive transportation planning and policies tailored to the needs of single-parent households and improve their well-being.

2. Literature review

Previous research indicates that single-parent families have a unique residential pattern and transportation characteristics related to their housing locations (Blumenberg and Waller, 2003; Chlond and Ottmann, 2007; McLanahan and Garfinkel, 1989; Murakami and Jennifer, 1997; Renwick and Bergmann, 1993). Compared to couple parents, single parents usually have more daily trips, spend more time on transportation, and spend more time outside their home per day on average (Chlond and Ottmann, 2007). In addition, single parents may have complex trip chains and long trip times (Pritchard et al., 2014). Yet they usually travel shorter distances per trip and per day than married parents (Chlond and Ottmann, 2007). Single parents also tended to have shorter nonwork travel and activity times than one-worker, two-adult families (Srinivasan and Ferreira, 2002). Furthermore, the proportion of work-related trips among single parents is much lower than that of average working-age adults (Blumenberg, 2016). Regarding driving behaviors, single parents are usually characterized as having limited access to private vehicles (Alexa, 2014). Although most working single parents still rely on cars to commute, the rate of using a car to commute is much lower for single parents in central cities (Pawasarat and Stetzer, 1998). Furthermore, transit use among working single parents is negatively correlated with car ownership (Pawasarat and Stetzer, 1998). Thus, single parents may spend much more money on transportation than others, especially in areas poorly served by public transit (Edin and Lein, 1997).

The characteristics of single parents' travel patterns are related to their socioeconomic status and financial situation. Compared to two-parent households, single-parent households have a higher risk of financial instability, job displacement, conflicting work–life schedules, and stressful parenting (Berryhill and Durtschi, 2017; Brand and Thomas, 2014; Elliott et al., 2015; Meier et al., 2016; Quinn and Allen, 1989). Blumenberg (2016) argued that financial hardship limits single mothers' access to private automobiles and other transportation modes. Wang and Chen (2015) found that locations with a high proportion of single-parent families have less job accessibility. Lucas (2004) and Rosenbloom (1987) further discussed how the transportation poverty of single-parent families increased their job isolation, long-term unemployment, social segregation, and adverse effects on their health.

The gender disparity may also affect single parents' travel patterns, because more than 80% of single-parent families are led by single mothers (U.S. Census Bureau, 2017a). Rosenbloom (1987) and Taylor et al. (2015) explored gender differences in household-serving travel, such as child-serving and grocery trips. Mothers were more involved in child- and household-serving trips regardless of their income, labor force participation, age, and educational attainment (Rosenbloom, 1987; Taylor et al., 2015). That may be one reason why single parents try to reduce their commute time (Chlond and Ottmann, 2007). Rosenbloom (1998) observed that women had a substantially higher percentage of transit trips and drove fewer miles than men on average. More importantly, unlike the travel pattern for men, women's use of transit increased as their income increased (Rosenbloom, 1998). At the highest level of annual income measured ($70,000 and more), women made 66% more trips than men (Rosenbloom, 1987). This indicates that women might be more likely to use public transportation regardless of their socioeconomic status.

A few studies provide more insights into the importance of public transportation for single parents. Based on microdata for the New York region, Maciejewska et al. (2019) found that single mothers of color greatly relied on public transit after controlling residential location, transit access, income, and other sociodemographic characteristics. By exploring data in Detroit, Lee et al. (2018) found that low-income single mothers, who were disproportionally concentrated in urban Detroit, were much less likely to have private cars and tended to walk and use public transit more often (Lee et al., 2018). Drawing from qualitative research, Ojambo (2015) and the Pittsburgh Foundation (2019) highlighted the severe issue of inadequate public transportation services for single mothers, which impeded them from accessing daycare, grocery stores, and workplaces. Some single mothers reported that they relied on buses even though they could get a car because they did not drive or faced obstacles to getting a driver's license (Pittsburgh Foundation, 2019). Battiste (2014) further pointed out that high gas prices curtailed the affordability of private automobiles for single parents. Other studies found that low-income working single parents often take the bus for childcare trips in the morning (Barnes, 2008; Battiste, 2014; Harburger and White, 2004). Although previous studies have implied the importance of transit for single parents, more analyses are needed to provide more robust and representative evidence. This study aimed to fit this research gap.

3. Method

3.1. Data

3.1.1. Individual-level data: National Household Travel Survey

We obtained individual-level travel data from the 2017 National Household Travel Survey (NHTS) (Federal Highway Administration, 2017). Then, we extracted a sample of 2608 subjects in Maryland. NHTS collects daily travel data for a large, nationally representative sample in the United States and its major census divisions and add-on areas (McGuckin and Fucci, 2018). The objective of the survey is to provide “high-quality information to serve government agencies, industry, and the public in a manner that promotes understanding” (McGuckin and Fucci, 2018). The NHTS data include information on travel behavior in the 30 days before the survey date, along with demographic and socioeconomic variables for each person and household. The data allowed us to estimate the association between the frequency of public transit use and single-parent status, while controlling other individual and household covariates. The limitation of the NHST data, however, is the lack of detailed geographical information regarding the survey respondents. To mitigate this, we analyzed the association at the neighborhood level using American Community Survey (ACS) data.

3.1.2. Neighborhood-level data: American Community Survey

Neighborhood-level data were obtained from the 2017 ACS 5-year estimates dataset through American FactFinder (https://factfinder.census.gov). ACS is an ongoing nationwide survey that collects information on various topics about U.S. residents every year (U.S. Census Bureau, 2017b). It provides high-quality data at different geographic levels, given its large sample size (more than 3.5 million) and geographic coverage, but it lacks individual-level information. ACS data contain various household characteristics related to demography, employment, income, and transportation

for each census block group (CBG).[1] We used these neighborhood-level data to examine the association between the number of transit commuters and the number of single-parent families in a CBG, holding other variables constant. Maryland featured 3926 CBGs.

3.2. Samples

To control for the effects of the spatially varying built environment and validate the results, we estimated individual-level and neighborhood-level models with different samples.

3.2.1. Samples for the individual-level model

We selected three samples for the individual-level model. The first was the full sample, i.e., all individuals in Maryland. The second sample included individuals who lived in large metropolitan statistical areas (MSAs)[2] in Maryland (e.g., the Baltimore–Columbia–Towson MSA and part of the Washington, DC–Arlington–Alexandria MSA). The third sample included individuals who lived in urban areas in large MSAs in Maryland.[3]

3.2.2. Samples for the neighborhood-level model

We conducted analyses with two samples for the neighborhood-level model. The first sample included all CBGs in Maryland. The second sample included CBGs in the city of Baltimore. We selected Baltimore as a subsample because it has a transit accessibility index, which was used to control for the effect of transit availability and accessibility. Using this variable further validated our model.

3.3. Dependent variables and key predictor variables

3.3.1. Individual-level model

The dependent variable of the individual-level model was the frequency of public transit use in the 30 days before the survey date. The predictor variable was a binary variable of whether the subject was a single parent with a young child. It was recoded from a survey variable measuring the "life cycle classification for the household." If a respondent was the only adult in the household and the youngest child was between 0 and 15 years old, they were coded as 1; otherwise, they were coded as 0.

3.3.2. Neighborhood-level model

The dependent variable of the neighborhood-level model was the number of transit commuters by CBG. The predictor variable was the number of single-parent households with children younger than 18 years, recoded from the survey variable: "family type by presence and age of children under 18 years." We aggregated the number of families led by a single adult, either male or female, with at least one child younger than 18, then divided the sum by the CBG population. We chose different age cutoff scores for children in the models because of the different coding methods for two datasets.

3.4. Control variables

3.4.1. Demographic

We controlled for gender because evidence indicates differences between men and women in transportation mode choice (Taylor et al., 2015). At the individual level, we used the binary variable of "being female;" at the neighborhood level, we calculated the ratio of adult females by dividing the total adult population by the number of females aged 18 or older. Previous research suggests that retirement changes people's social activities such that retired people have a different travel pattern and demand (Van den Berg et al., 2011). Thus, we used a binary variable indicating retirement status in the individual-level model. Because retirement status was unavailable in the ACS data, we used a dummy variable indicating the number of residents aged 65 or older. In addition, two variables of race and ethnicity (i.e., Hispanic, non-Hispanic Black, non-Hispanic White) were included in the individual-level model. In the neighborhood-level model, we only selected the number of Hispanic residents as the control variable because the African American and non-Hispanic Black populations were highly correlated with the number of single-parent families in a CBG ($r > 0.50$). Finally, because parenting duties generate extra travel demand (Lyth-Gollner and Dowling, 2002), we included the number of young children in the household as a covariate in the individual-level model. However, we could not include this variable in the neighborhood-level model due to data unavailability.

3.4.2. Population density

Population density has been demonstrated to be positively related to transit use (Frank and Pivo, 1994). In addition, population density is a proxy for the availability of public transit, because transit services are typically provided in high-density areas in the United States. In this study, we controlled for the population density at both levels. For the individual-level model, the exact value of density was unavailable, so we used a dummy variable indicating high-density areas. High-density areas were defined as areas with a population density greater than 4000 people per square mile, because the average density of U.S. urban areas is about 4500 people per square mile (Ewing et al., 2007).[4]

3.4.3. Household income

Transportation mode choice is closely associated with economic factors such as income (Jara-Díaz, 1998; Mclanahan and Garfinkel, 1989; Quarmby, 1967; Stopher, 1969). Therefore, we controlled for the income variable in both models. The individual-level data provided income information in a categorical format, whereas the neighborhood-level data were numerical. At the individual level, we recoded the annual household income into three levels: less than $50,000, between $50,000 and $150,000, and more than $150,000. For the neighborhood level, we used the logarithmic transformation of the median household income by CBG in the past 12 months.

3.4.4. Transportation

We assumed that public transit use might be affected by other personal or household transportation characteristics. Therefore, in the individual-level model, we included the number of vehicles in the subject's household, use of public transportation as an alternative mode, and frequency of personal vehicle use for travel. At the neighborhood level, the number of available private vehicles was not available. Thus, we used the number of people commuting by vehicle as a control variable. For the neighborhood-level model with the subsample of Baltimore, we included data from the 2017 transit accessibility index based on the total jobs reached by transit within 30 min (http://access.umn.edu/). The transit accessibility index indicates whether the use of transit is related to the proximity to transit facilities.

3.5. Data analysis

Dependent variables (i.e., frequency of public transit use at the individual level and count of transit commuters at the neighborhood level) were

[1] Census block groups (CBGs) are geographical units defined by the U.S. Census Bureau, generally containing between 600 and 3000 people. It is the smallest geographical unit at which the 2017 ACS data are available. A CBG usually covers a contiguous area, which usually consists of several census blocks and is delineated in a census tract in a county. More detailed information about CBGs can be found in the glossary of the U.S. Census Bureau (https://www.census.gov/programs-surveys/geography/about/glossary.html).

[2] MSAs are designated by the U.S. Office of Management and Budget as having at least one urbanized area with a minimum population of 50,000. An MSA usually consists of a core city and its surrounding urban, suburban, and rural areas (Ganti, 2020). A large MSA is defined as having more than 1 million residents and a rail transit system. It was identified through the variable "MSACAT" in the dataset.

[3] Individuals in urban areas were identified through the "HBHUR" variable in the dataset.

[4] The variable was recoded from the variable "HTPPOPDN" in the dataset, which indicates population density (people per square mile). Our threshold point was selected based on the cutoff values of the variable, i.e., 0–99, 100–499, 500–999, 1000–1999, 2000–3999, 4000–9999, 10,000–24,999, and > 24,999. We chose the point closest to 4500, which is 4000.

count variables. Thus, we used negative binomial regression to estimate two models. After excluding data with missing values, we obtained a sample with 1681 people for the individual-level model and a sample with 3800 CBGs for the neighborhood-level model. Both variables had a large proportion of zeros. For the individual-level model, 1438 of 1681 participants did not use any transit in the prior 30 days; for the household-level model, 841 of 3800 CBGs did not have any transit commuters.

To deal with the large number of zeros in the model, we employed zero-inflated negative binomial (ZINB) regression. ZINB is usually used to predict count variables that have an excess of zeros (Mwalili et al., 2008). A ZINB model has two components: a negative binomial regression for a count variable for nonzero observations and binomial logistic regression for the odds of the data value being zero (UCLA Institute for Digital Research and Education, n.d.). ZINB regression can not only illustrate associations between a count variable and independent variables but also reveal the determinants of a zero value for the count variable. An alternative approach that accounts for excess zeros in a count variable is zero-inflated Poisson (ZIP) regression. However, ZINB relaxes the assumption in ZIP that requires a Poisson distribution for the count variable. A likelihood ratio test can assess if a ZINB model fits better than a ZIP model (UCLA Institute for Digital Research and Education, n.d.).

In the first part of the ZINB model, we included independent variables and all control variables in each model; in the second part, we selected several key variables assumed to be relevant to the likelihood of a zero value. We have checked the variance inflation factor (VIF) and correlation coefficients between independent variables for both the individual and neighborhood models. No multicollinearity was detected.[5]

4. Results

4.1. Descriptive results

4.1.1. Individual-level data statistics

Table 1 presents the descriptive results of variables for the individual-level data. Not surprisingly, public transit was not the most popular transportation mode in Maryland. The average number of transit trips in the prior 30 days was 1.1. More than 85% of respondents did not use any transit during this period. More than 95% of the sample reported being frequent car users. Only 11% reported public transportation as an alternative mode for travel. Single parents with young children accounted for 2% of the sample. Women slightly outnumbered men. Participants at retirement age or older accounted for about one third of the sample. About 22% of the respondents lived in an area with a density higher than 4000 people per square mile. The descriptive statistics for the other two subsamples (i.e., large MSAs and urban regions of large MSAs) provide more nuanced information. People living in these regions made more transit trips than the full sample but had fewer vehicles than the average. The number of single parents changed slightly across different samples. Not surprisingly, the percentages of Blacks, Hispanics, and high-income households increased in urban and metropolitan areas, whereas the proportion of nontransit users and frequent car users decreased.

4.1.2. Neighborhood-level data statistics

The neighborhood-level data provided a more representative picture of the state (Table 2). Each CBG had more car commuters than transit commuters. On average, 67 residents were transit commuters in a CBG, whereas 636 residents were car commuters. The average number of single-parent families in each CBG was 91, and the majority of them were led by single mothers. The average percentage of single-parent families in a CBG was 6.09%. The mean density of a block group was 5958 people per square mile. The average median household income was $85,380.

In terms of the demographic characteristics of Baltimore, notable differences were identified compared to the entire state. Although the average number of single-parent families did not change substantially, the number of families headed by single women increased from 70 to 81. The average percentage of single-parent families increased to 10.10%, and the share of families led by single women increased from 4.79% to 8.72%. The number of transit commuters also increased. The count of participants at retirement age or older was half that for the entire state. The population density in Baltimore was double the state average. The average household income for Baltimore was about 60% of the state average.

[5] We chose 2.5 as the threshold for the variance inflation factor (VIF) test, as suggested by Johnston et al. (2018). The threshold for the correlation test was 0.40.

Table 1
Descriptive statistics for individual-level data for three samples in Maryland.

	Full sample		Large MSAs		Urban areas in large MSAs	
	M (*SD*) or %	*n*	*M* (*SD*) or %	*n*	*M* (*SD*) or %	*n*
Frequency of transit use	1.1 (4.8)	2605	1.69 (6.07)	1450	2.05 (6.71)	1114
Number of vehicles in the household	2.3 (1.3)	2608	2.19 (1.27)	1452	2.07 (1.24)	1115
Number of young children	0.09 (0.35)	2608	0.11 (0.38)	1452	0.12 (0.39)	1115
Single parent with young children	1.80	2608	1.86	1452	1.52	1115
Zero transit usage in prior 30 days	86.95	2605	81.79	1450	78.64	1114
Female	53.57	2608	52.89	1452	52.65	1115
Retired	31.17	2608	26.72	1452	26.10	1115
Hispanic	2.76	2607	3.72	1452	4.30	1115
Non-Hispanic Black	10.81	2600	13.59	1450	16.62	1113
Living in a high-density area	22.24	2248	34.35	1307	46.15	973
Transit as an alternative mode	10.46	2075	12.37	1172	14.83	917
Frequent car user	96.17	2557	95.16	1425	94.51	1033
Annual household income		2508		1408		1080
< $50,000	29.35	736	23.30	328	23.70	256
$50,000–$150,000	54.47	1366	56.11	790	54.63	590
> $150,000	16.18	406	20.60	290	21.67	234

4.2. Regression results

4.2.1. Individual-level model

Table 3 presents the results of the individual-level model. The first part of the ZINB regression suggested that being a single parent with young children was positively associated with the frequency of public transit use while holding control variables constant. All control variables except Hispanic race and ethnicity and the number of young children in the household were statistically significant. Females in the sample used less transit. Residents in high-density areas had more public transit use. Compared to those who had the lowest household income, people who lived in higher-income households used more public transit. The number of household

Table 2
Descriptive statistics for neighborhood-level data for two samples in Maryland.

	Maryland	Baltimore
	M (*SD*)	*M* (*SD*)
Number of single-parent families	91 (108)	94 (109)
Number of single-mother families	70 (92)	81 (102)
Number of single-father families	21 (41)	13 (30)
Percentage of single-parent families	6.09 (6.74)	10.10 (10.08)
Percentage of single-mother families	4.79 (6.20)	8.72 (9.69)
Percentage of single-father families	1.30 (2.44)	1.38 (3.14)
Number of transit commuters	67 (92)	76 (71)
Number of car commuters	636 (403)	289 (212)
Ratio of adult females	0.53 (0.07)	0.55 (0.10)
Number of people aged 65 or older	216 (165)	121 (99)
Number of Hispanic residents	146 (267)	47 (98)
Population density	5958/mi^2 (7746)	13,725/mi^2 (9690)
Median household income	$85,380 (42,540)	$52,043 (31,800)
Transit accessibility index (log)		7.59 (0.96)
n of CBGs	3926	653

Table 3
Individual-level model for the association between the frequency of public transit use and single parenthood.

Dependent variable: frequency of transit use	Full sample		Large MSAs		Urban areas in large MSAs	
Independent variable	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Negative binomial						
Single parent with young children	2.0692	*	2.3593	*	2.8474	*
Female	−0.4686	*	−0.3173		−0.4204	a]
Retired	−0.9108	**	−1.0438	**	−1.4186	**
Hispanic	−0.1683		−0.0358		0.0201	
Non-Hispanic Black	0.8595	**	0.6552	*	0.4506	
Number of young children	−0.0612		−0.0237		0.0619	
Living in a high-density area	0.4680	▪	−0.0527		−0.0496	
Annual household income (ref. = less than $50,000)						
$50,000–$150,000	0.8569	*	0.6861		0.5979	
> $150,000	0.8983	*	0.4920		0.4442	
Number of vehicles in the household	−0.2211	**	−0.2589	*	−0.3010	*
Transit as an alternative mode	0.6421	*	0.5293	▪	0.6257	▪
Frequent car user	−1.0954	*	−0.9435	▪	−1.1298	▪
Constant	1.9587	***	2.5185	***	2.8363	***
Inflate						
Single parent with young children	1.0098		1.2428		1.2453	
Retired	0.4127		0.2401		−0.1711	
Annual household income (ref. = less than $50 k)						
$50,000–$150,000	−0.4078		−0.6193		−0.7990	
> $150,000	−1.9105	***	−2.6205	***	−2.9375	**
Living in a high-density area	−1.1777	***	−1.1151	***	−0.9443	*
Number of vehicles in the household	0.2685	*	0.4842	**	0.4229	*
Frequent car user	2.1183	**	1.8313	**	2.7056	▪
Constant	−0.8335		−0.7676		−1.6325	
Observations	1681		996		754	
Nonzero observations	243		197		179	
LR χ^2	76.0		38.6		38.8	
Prob > χ^2	< 0.001		< 0.001		< 0.001	

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.
▪ $p < 0.1$.

vehicles was negatively associated with public transit use. If an individual treated public transportation as an alternative mode, they had more transit use.

The second part of the model was a binomial logistic model, which examined factors associated with the odds of having zero transit use. If an individual had the highest-level household income (more than $150,000), they were less likely to not use transit to travel. Living in a high-density area reduced the likelihood of no transit use, whereas having more vehicles in the household increased the likelihood. Finally, frequent car users were more likely to never use public transit.

The coefficients of independent variables were similar across subsamples. The effect of single parenthood tended to be increasingly influential for residents of large MSAs, urban regions, and urban areas in large MSAs. The number of private cars and car use were consistently associated with transit use. Household income, on the other hand, was not significant for MSA and urban residents.

4.2.2. Neighborhood-level model

Table 4 presents the results of the neighborhood-level model. The result suggest that the number of single-parent households was positively associated with the number of people taking transit to work. When the ratio of females in the CGBs increased, the number of transit commuters increased significantly. Older adults and Hispanics both had a positive effect on the count of transit commuters. CBGs with higher density and higher median income had more transit commuters. Finally, the number of car commuters had no statistically significant association with the number of transit commuters in the CBGs.

The zero-inflated part of the neighborhood-level model indicated that the number of single-parent families had a negative effect on the odds of having zero transit commuters. However, the number of older adults was positively correlated with the odds of having no transit commuters. CBGs with higher density and higher median income were less likely to have no transit commuters. The number of car commuters was negatively associated with the odds of zero transit users, although its effect was very marginal.

The model for Baltimore also presented a significantly positive association between the number of single-parent families and the number of transit commuters, even when controlling for the transit accessibility index for each CBG. Moreover, the number of single-parent families was also significantly associated with the probability of zero transit use, alongside the effect of population density. It should be noted that the coefficient of log (median household income) flipped for the Baltimore sample. In other words, CBGs in Baltimore with lower income had more transit commuters. The transit accessibility index, measured by the log term of total jobs reached by transit within 30 min, had a positive but small association with transit use in Baltimore.

4.3. Model fit

Several tests were conducted to assess model selection and the goodness of model fit. The likelihood ratio chi-square test showed that all models had

Table 4
Neighborhood-level model for the association between the number of single-parent families and the number of transit commuters.

Dependent variable: count of transit commuters	Maryland		Baltimore		Baltimore with transit accessibility index	
Independent variable	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Negative binomial						
Number of single-parent families	0.0019	***	0.0020	***	0.0021	***
Ratio of adult females	1.2862	***	−0.5773		−0.3533	
Number of people aged 65 or older	0.0005	***	0.0009	**	0.0011	**
Number of Hispanic residents	0.0008	***	0.0006	▪	0.0005	
Population density (1000/mile^2)	0.0425	***	0.0204	***	0.0199	***
Log (median household income)	0.2060	***	−0.2628	**	−0.2111	**
Number of car commuters	0.0001		0.0004	▪	0.0003	
Transit accessibility					0.00003	***
Constant	1.9893	***	4.9450	***	4.5030	***
Inflate						
Number of single-parent families	−0.0032	***	−0.0084	*	−0.0084	*
Number of people aged 65 or older	0.0008	**	−0.0008		−0.0008	
Population density (1000/mile^2)	−0.3479	***	−0.1199	**	−0.1198	**
Log (median household income)	−1.3416	***	−0.5477		−0.5441	
Number of car commuters	−0.0004	*	−0.0004		−0.0004	
Constant	6.0445	***	1.0471		1.0338	
Observations	3800		598		598	
Nonzero observations	841		33		33	
LR χ^2	891.15		142.05		155.62	
Prob > χ^2	< 0.001		< 0.001		< 0.001	

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.
▪ $p < 0.1$.

a good fit. A significant likelihood ratio test for $\alpha = 0$ ($p < 0.001$) indicated that both the individual-level and neighborhood-level models outperformed the Poisson model (UCLA Institute for Digital Research and Education, n.d.). Meanwhile, the Vuong test ($p < 0.001$) showed that the ZINB model was preferred to an ordinary negative binomial regression model (UCLA Institute for Digital Research and Education, n.d.).

5. Discussion

Transportation is one of the most crucial challenges for single-parent families. The current literature has highlighted various adverse effects of transportation barriers on single parents and their children. For example, impaired transportation mobility and accessibility may impede single parents from finding steady paid work or participating in the labor market (Blumenberg, 2004, 2016; Pawasarat and Stetzer, 1998; Smart and Klein, 2018). Also, inadequate and unreliable transportation services or the lack of money for public transit can undermine single parents' willingness and ability to be involved with their children's education (Williams and Sánchez, 2013). Moreover, their limited mobility places single parents and their children at higher risk of social exclusion (Cass et al., 2005; Farber et al., 2011; Lucas, 2012; Páez et al., 2010; Pickup and Giuliano, 2016).

In this study, we used Maryland data to examine the association between public transit use and single parenthood at both the individual and neighborhood levels. To validate our models, we further examined the effect of single parenthood across subsamples at both levels. The positive association between single parenthood and transit use was consistently significant across these models. In other words, while holding demographic, socioeconomic, and transportation variables constant, being a single parent was associated with more public transit use. This finding is consistent with previous studies, such as Maciejewska et al. (2019). Specifically, at the individual level, a single parent with a youngest child between 0 and 15 years old made more trips by public transit than someone who had the same demographic characteristics and socioeconomic status.

In subsamples of large MSAs, urban regions, and urban areas in large MSAs, the association between single parenthood and the use of transit became increasingly stronger. This indicates that single parents rely on public transit regardless of the built environment and density.

As shown by the neighborhood-level models, a CBG with more single-parent families had more people commuting by transit while controlling for other variables, including the gender ratio, size of the older adult population, number of racial minorities, density, household median income, and private automobile commuters. The number of single-parent families was consistently significantly associated with the use of transit when controlling for the transit accessibility index in Baltimore. The zero-inflated analyses indicated that the number of single-parent families was negatively associated with the presence of transit commuters.

Our results demonstrate that single parents tend to rely on public transit more. This finding is not surprising because a large proportion of single-parent families experience economic hardship (Brown and Moran, 1997). The individual-level data supported this statement. All single parents with young children in the sample came from low- or moderate-income households. This aligns with the study by Glaeser et al. (2008), which showed a strong correlation between transit use and urban poverty. Therefore, it seems reasonable to interpret single parents' reliance on transit from a financial perspective. However, the regression models revealed a different facet of this phenomenon. First, for the full statewide sample, higher household income was positively associated with transit use at both the individual and neighborhood levels. The result might be heavily skewed by the use of railway transit in Maryland such as commuter trains, which are more preferred by high-income people. In contrast, for neighborhoods in Baltimore where the population living in poverty was more concentrated, higher household income was negatively associated with more transit commuters. Regardless of urban forms and socioeconomic characteristics, the results consistently indicate that single parents used more transit facilities compared to someone else with the same level of income. The number of cars and car use were negatively associated with transit use. However, controlling for these variables did not weaken the effect of single-parent status on transit use.

Another consideration is that single parents may disproportionally reside in transit-rich areas such as urban centers, which could be endogenous with high-frequency transit use. To test this hypothesis, we examined the individual-level model for large MSAs, urban areas, and urban regions in large MSAs, where transit systems are typically better served. The results suggest that the association between single parenthood and transit use consistently held positive regardless of the spatial location and sampling. For neighborhood-level models, we extracted CBGs in Baltimore, the largest city with an extensive transit system in the state, to further examine the association. While controlling for transit accessibility, the use of transit had a positive association with the distribution of single-parent households. Therefore, the result demonstrated consistency and robustness. To expand on this question, we visualized the comparison between the spatial distribution of single-parent families and the pattern of transit accessibility for Baltimore (Fig. 1). These maps show that although transit services are primarily concentrated in the city center, neighborhoods with more single-parent families are dispersed throughout the city, especially in the periphery. This comparison demonstrated that better transit access might not be the main driver of use for single parents. The mechanism underlying their reliance on public transit must involve something beyond income, car access, and availability of transit infrastructure.

The public transit system has been extended and enhanced in many metropolitan areas in recent years, which may make transit services more accessible (Kahn, 2007). Car driving does not necessarily save time compared to public transportation systems (Downs, 2000; Pucher and Renne, 2003). Rail transit, such as light rail, subways, or commuter trains, is more punctual because it is less influenced by traffic congestion, especially during peak hours. Some trips made by single parents are time sensitive, such as picking up children from daycare centers. Transit is also considered safer than driving, reducing the risk of accidents (American Public Transportation Association, 2016). Single parents, who frequently bring their children with them while traveling, may choose transit owing to traffic safety concerns related to driving. More importantly, using a private vehicle imposes substantial extra costs on the household, such as parking, fuel, insurance, repair, and maintenance (Smart and Klein, 2018), which may discourage single parents who have economic distress from using a car. Studies conducted by Battiste (2014) and the Pittsburgh Foundation (2019) noted that some single mothers avoided using cars due to high gasoline prices. This could be another factor that encourages single parents to use transit, because many of them face financial hardship.

The improved reliability and service quality of transit may be another plausible explanation for the mode choice of single parents. Single parents with young children in the household usually made more daily trips and had a more complicated trip chain due to their multiple duties (Primerano et al., 2008; Chlond and Ottmann, 2007). Long-distance travel, for both work purposes and nonwork purposes, likely would be inconvenient and stressful for single parents even if they own a car. This could be a possible reason why single parents tended to use transit more frequently. Similarly, employment opportunities are concentrated in central cities (Anderson and Bogart, 2001). Therefore, neighborhoods proximate to abundant resources are more likely to be urban and dense areas, and public transit is also more available. Single parents residing in such neighborhoods may make more use of these public transportation facilities.

The results of the study shed light on the need for transportation assistance among single parents. Many government agencies, such as the Maryland Department of Human Services, currently provide free vehicles to low-income families, including single-parent households that have economic hardship (Maryland Department of Human Services, n.d.). However, we should consider single parents' unique transportation needs and the various limitations of car driving (e.g., expense of maintaining and operating a private vehicle and barriers to learning to drive and obtaining a license). Moreover, our data suggest that single-parent families are not trivial groups in many areas (see Table 2). In Maryland, a CBG had 91 single-

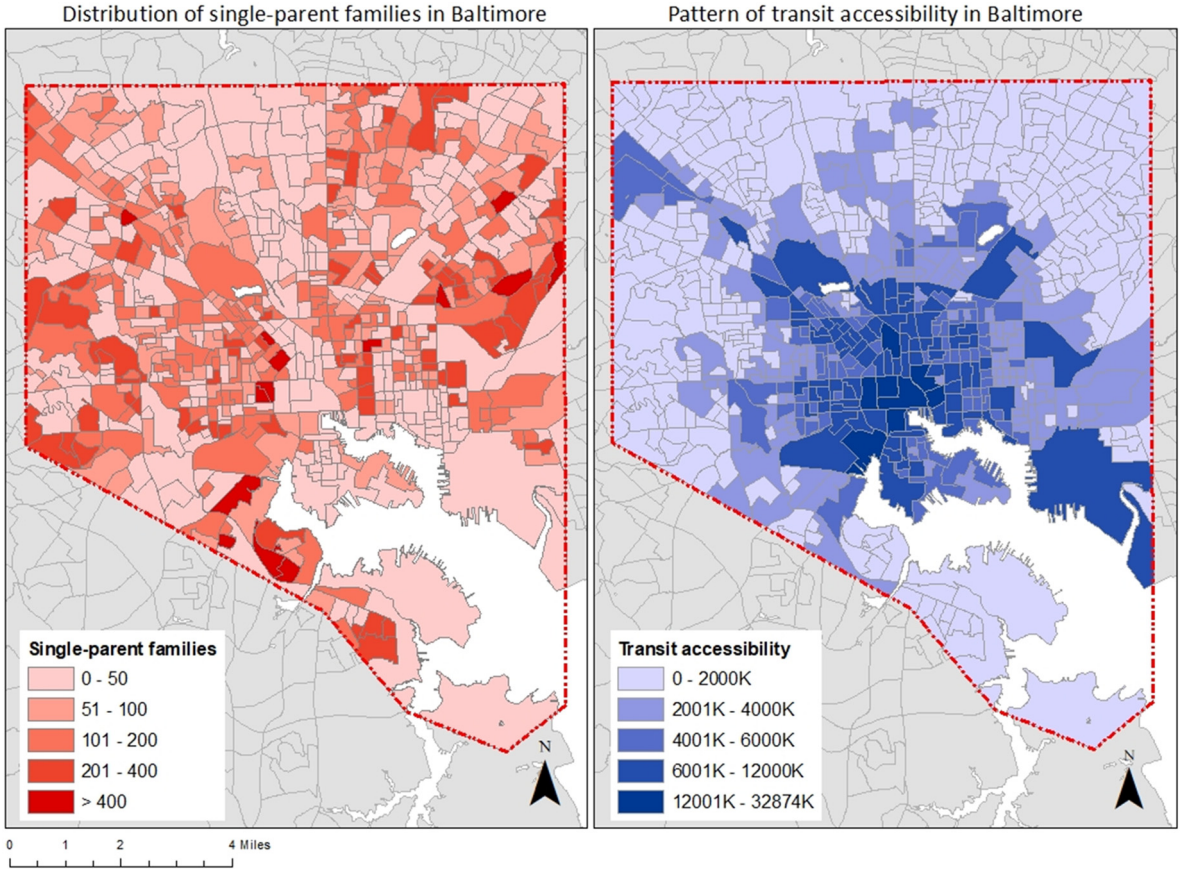

Fig. 1. Comparison between the distribution of single-parent families and transit accessibility in Baltimore.

parent families on average, accounting for 6% of all families. About 10% of CBGs had more than 15% of single-parent families. In Baltimore, more than 25% of CBGs had a 15% or greater share of single-parent families. Therefore, it may not be feasible to offer a free, dependable car to every single parent in need.

Accordingly, this study has specific policy implications that assist single parents in accessing public transportation services. Transit agencies could increase both the number and frequency of transit lines in areas that have a large number or percentage of single-parent families. Transit assistance policies such as ticket discounts or free tickets for low-income single parents or those who do not have a private car would also be helpful, which has been recommended by the Pittsburgh Foundation (2019). Special transportation services targeting childcare trips for single-parent families could relieve time constraints and enhance their willingness to work. Additionally, in areas that lack adequate and reliable transit, subsidizing ride-sharing services might be an innovative solution, as the Pittsburgh Foundation (2019) suggested, such as offering free ride-share trips or fare discounts to eligible single parents. Furthermore, childcare issues related to using transportation services need more attention. For example, providing more space for baby strollers and baby seats in buses, trains, light rails, taxis, and ride-sharing vehicles would attract single parents who travel with their young children.

6. Conclusion

This study examined the association between public transit use and single parents at the individual and neighborhood levels using the 2017 NHTS and ACS. Through ZINB regression, we found that single parents used transit more than the average, and CBGs with more single-parent families had more transit commuters, holding other demographic and socioeconomic variables constant. The association between single parenthood and transit use persisted across subsamples by different geographic sizes and boundaries, including the state, large MSAs, urban areas in large MSAs, and Baltimore.

The results confirm findings in previous studies and offer a new perspective regarding the transportation needs of single-parent families for planning and policies. Unique transportation barriers and time constraints could significantly affect the life quality of single parents. Helping single parents obtain and maintain private vehicles would be a potential approach; however, we cannot ignore the high costs of maintaining a private car, which may impose a heavy financial burden on single-parent families and constrain their mobility. In contrast, good public transit could be a safer, more reliable, and more sustainable transportation mode that benefits not only single-parent families but also society. To sum up, public transit plays an essential role in single parents' daily travel, and it is necessary for policy makers and transportation agencies to consider single parents' unique needs in transportation, including their travel patterns, time constraints, and affordability.

Despite this study's contribution, it is subject to some limitations. First, we focused on the situation in Maryland, which might be different than other regions or the entire country. It is worth investigating nationwide ACS data to confirm our findings. Second, both the individual-level and neighborhood-level models were cross-sectional. It would be of value to examine whether and how transportation mode choices change when a person transitions to single parenthood. In addition, single parents might be underrepresented by the NHTS when comparing the descriptive statistics between the individual-level and neighborhood-level data. Future studies could improve this by collecting more representative household travel data in a specific region. Furthermore, we could not specify the modes of public transit in detail, such as bus, streetcar, light rail, subway, and commuter train. People may have distinct travel patterns if using different transit services. More granular data on travel modes would provide a clearer

picture of single parents' transportation needs. Finally, issues of safety, punctuality, and the sanitation of public transit facilities might affect single parents' use of transit, which should also be investigated in depth.

CRediT authorship contribution statement

Sicheng Wang: Conceptualization, Data processing, Methodology, Writing, Visualization. **Yanfeng Xu:** Conceptualization, Literature review, Writing, Reviewing and Editing, Supervision.

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