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Access to Public Transportation and its Effect on Older Adult Ridership in Two American Cities

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Abstract: In the upcoming years, the population of older individuals (those 60 and older) will increase, posing a challenge for urban designers and operators of the transportation system to offer travel options that support autonomy. This study investigates links between older persons who take fixed-route public transit and their neighborhood's foot access to buses and trains in order to better understand the challenges older adults face while using public transportation. Distance between a trip's origin or destination and a transit stop or station is tested in this study to see if it affects how frequently people use the transit system. The frequency of older adults using public transportation is regressed against explanatory variables such as demographic and socioeconomic variables, access and mobility indicators, and neighbourhood features using data from a survey of older persons in California and New York. Results reveal that self-reported walking distance to transportation has a statistically significant impact on predicting transit passenger frequency in San José, California, but not in Buffalo, New York. Compared to non-drivers, drivers are more sensitive to walking distance. Simulations predict that in San José, every five minutes of perceived walking time to transit reduces the frequency of transit ridership by 5% for nondrivers and by 25% for drivers. If they are male, non-white, and low income, older persons are more likely to use public transportation.

1 Introduction

When older adults (age 60 and above) have inadequate access to transportation, they tend toexperience lower levels of physical activity, reduced independence, and greater health risks. Incoming years, a noteworthy challenge for planners and policymakers will be to expand mobility on and access to public transit for the growing population of older adults in the United States.Although the private automobile remains the primary travel mode for a majority of older adults, capturing 90 percent of travel (Federal Highway Administration 2001), public transitcan provide autonomous travel for those who cannot drive or choose not to drive. Variousstudies conducted since the mid-1990s by the Surface Transportation Policy Project (STPP),the American Association of Retired Persons (AARP), the American Public TransportationAssociation (APTA), and other policy organizations and researchers have arrived at the sameconclusion: the United States is ill-prepared to provide adequate transportation for the rapidly growing number of older adults (Millar 2005).

onventional wisdom suggests that if older adults do not drive, or are not driven by others, they will use other modes of transportation—riding transit and walking—more frequently. However, use of alternatives to driving has declined in recent years among older adults (Col- lia *et al.* 2003; Wallace and Franc 1999). ăe most frequent mode of travel for older adults is driving or being driven, followed by walking; riding public transit is the third most frequent choice (Rosenbloom and Waldorf 2001). Consequently, less than two percent of daily intracity travel by older adults in the United States occurs on public transit (Burkhardt 2003; Burkhardt *et al.* 2002; Collia *et al.* 2003). It is a worthwhile pursuit, then, to identify barriers that older adults face in using fixed-route public transit as the population of older adults in the United States is projected to reach approximately 70 million by 2030 (U.S. Bureau of Census 1996). Transit agencies that have taken action to tailor their service in recent years to meet the needs of older adults and riders with disabilities have, indeed, experienced ridership increases (Hess *et al.* 2002; Rosenbloom and Fielding 1998)

ăis study takes as its central premise the assertion that there are great accessibility and mobility gains to be realized for older adults—and, indeed, for riders and potential riders of all ages—by identifying barriers to riding fixed-route public transit. Introducing interventions in public transit systems that remove or reduce those barriers can make transit riding more convenient for older adults. Public transit systems are already established in U.S. metropolitan areas and already receive public subsidies, making public transit a better choice for serving older adults than privately funded dedicated van services, which are expensive to establish and operate and may not comply with the requirements of the Americans with Disabilities Act (ADA).

To investigate potential barriers, this research explores the relationship between older adults (both those who do and do not ride fixed-route public transit) and their neighborhood walk- ing access to buses and trains. ăe hypothesis is that for older adults age 60 and above, the distance between an origin or destination and a transit stop or station is a significant factor in predicting ridership (Neilson and Fowler 1972). Various other characteristics that influence the decision to ride transit—including physical capacity, housing type and living arrangements, and income—are used in the analysis as well.

ăis article employs data from a survey of older adults in California and New York to de- termine how frequently older adults ride public transit. Given that access to public transit by foot is a critical component of a trip, a particular focus of inquiry in this article is proximity as a predictor of ridership frequency. ăe remainder of this article is structured as follows: relevant literature is reviewed to help develop a framework for conceptualizing the relationship between transit ridership and various explanatory variables, including proximity to transit stations; orig- inal survey data is introduced, and survey responses are combined with environmental data from other sources; the theoretical model is then implemented by undertaking regression analysis; observations and recommendations are presented at the conclusion.

Within scholarly literature in the areas of transportation planning, policy, and design—especial- ly research that seeks to improve and increase access to transportation—limited attention has been focused exclusively on older adults (Cunningham and Michael 2004; Frank and Engelke 2001; Frank *et al.* 2003; Ory *et al.* 2003; Rosenbloom 2003; Wallace and Franc 1999). ăis is likely because most published works about travel behavior focus on travel (and especially commuting) for working-age adults. However, researchers who investigate access and mobility for older adults (Bailey 2004; Burkhardt *et al.* 2002; Millar 2005; O'Gara 2002; Rosenbloom 2003) noted that older adults experience poorer quality of life when that access is limited (Peel *et al.* 2002).

In addition, public health researchers have in recent years turned to evaluating the built environment in order to quantify the influence of various characteristics on physical activity (Frank and Engelke 2001; Handy *et al.* 2002). ăe known health benefits for older adults of physical activity (Rowe and Kahn 1998; Singh 2002) suggest that age-sensitive urban design and public policy can promote active living (Humpel *et al.* 2002; Owen *et al.* 2004).

Access

ăe decision to ride public transit is based on a complex set of abilities and circumstances, in- cluding personal mobility, availability of alternatives, cost of service, safety in getting from ori- gin to stop and stop to destination (Hess *et al.* 2004), travel barriers along pedestrian paths, andother factors.

Older adults who are able to travel on their own can manage their access and mobility in their communities with a certain level of independence; however, those who depend on others for rides experience a significant loss of mobility (Straight 1997). Older adults hampered by mobility limitations oĕen see the easily accessible areas for activities like shopping and socializ- ing shrink to a “footprint” that may be as small as 2.6 square km (one square mile) surrounding their homes (O’Gara 2002). ăis is especially true for the increasing number of older adults who live alone and do not have a spouse or other family member to act as driver. In fact, a person may travel more frequently if they live with another person upon whom they can rely for travel assistance. Nevertheless, older adults choose walking for a greater share of daily travel than their younger counterparts (Collia *et al.* 2003).

A short, comfortable walk from an origin or destination to a transit station or bus stop is a rule of thumb for multimodal urban planning. Urban planners typically assume that people of all ages will comfortably walk approximately 400 meters (one-quarter mile) to reach transit stops or stations (Southworth and Ben-Joseph 2003; Untermann 1984); as walking distance to public transit increases, people are less likely to use it if they have other travel alternatives (Zhao *et al.* 2003). Convenient access to public transit is a foundation for neighborhood planning for

pedestrians and transit-oriented design, and (to a lesser extent) for neotraditional neighbor- hood design and New Urbanism.

Riding transit requires a passenger to possess sufficient mobility for travel—by walking some or all of the way—between origins, destinations, and transit stops. ăe presence of side- walks and pedestrian pathways increases the potential number of trips (Kitamura *et al.* 1997) and the likelihood of walking (Corti *et al.* 1996; Hess *et al.* 1997, 1999; Parsons Brinckerhoff Quade and Douglas 1993). ăe quality of a pedestrian environment is a strong predictor of walking behavior and travel (Cervero and Kockelman 1997), and the presence of sidewalks on the shortest route to a destination tends to increase the likelihood of travel on foot (Rodriguez and Joonwon 2003). Conversely, difficult walking conditions reduce the likelihood of walking in lieu of driving (Loukopoulos and Gärling 2005). In various studies of walking behavior and commercial districts (Handy 1996a,b; Handy and Cliĕon 2001; Handy *et al.* 1998; King *et al.* 2003; Patterson and Chapman 2004), neighborhood design characteristics—including high traffic volumes on streets (Wilcox *et al.* 2003) and the safety of streets and sidewalks (Booth *et al.* 2000)—influence the decision to walk for neighborhood errands.√

Consequently, people are more active in neighborhoods with higher population density, mixed residential and commercial land uses, street connectivity, and multimodal accessibility (Handy *et al.* 2002; Saelens *et al.* 2003). Higher residential densities have been shown to de- crease automobile mode share (Schimek 1996), and greater pedestrian access increases public transit mode share and decreases solo driving (Hsiao *et al.* 1997).

Personal mobility is requisite for walking access to public transit. A 1999 study conducted in Baltimore determined that older adults' ability to walk three blocks is the strongest predictor of travel frequency (Ketron, Division of the Bionetics Corporation 1999).[4] Pedestrian infras- tructure located along a travel route from home to a transit station may lessen the burden of walking for older adults (Burkhardt 2003; Straight 1997). Desirable pedestrian infrastructure includes sidewalks, curb ramps, street lighting, street crossings, and resting places.[5] Older adults can be inconvenienced and discomfited by having to wait for bus service without shelter from inclement weather (Cozens *et al.* 2004; Patterson 1985). Comfort is critical for older adult transit passengers, as trips on public transit are estimated to take more than twice as much time on average than automobile trips between the same origin and destination (Rosenbloom andMorris 1998).

Older pedestrians may encounter additional challenges while navigating urban streetscapes: steep grades, high curbs, excessive numbers of stairs, and dangerous entrances onto busy road- ways to cross streets or board buses (Iwarsson and Ståhl 1999). Oĕen, the challenge of nav- igating an urban streetscape is

magnified by diminished vision, hearing, or other sensory loss associated with the natural aging process (Walter *et al.* 2004). A lack of pedestrian-friendly zones within automobile-dominated cityscapes can present insurmountable physical obstacles for older adults (Iwarsson and Ståhl 1999). In addition, many older adults simply live too far from existing transit routes to have reasonable access (Rosenbloom 2003).

Travel Patterns and Destinations

Previous research has investigated the degree to which urban density (population or house- holds per unit of land area) influences travel mode decisions. Various studies have found that lower densities increase auto ownership, auto mode choice for trips, and per capita distance trav- eled (Beesley and Kain 1964; Cheslow and Neels 1980; Holtzclaw *et al.* 2002; Kitamura *et al.* 2001). In addition, mixed residential and commercial land uses can encourage lower rates of au- tomobile ownership (Hess and Ong 2002), and traditional built-environment features (street network, building type, land use mix) can reduce non-work travel (but not necessarily overall travel) (Cervero and Kockelman 1997). Higher densities, in which there is less spatial sepa- ration of origins and destinations and more travelers, support public transit more than lowerdensities do.

Transit service is oĕen oriented toward commuters traveling to and from homes and of- fices during peak travel hours. Unfortunately, travel conditions during these hours—including congestion, fast-moving traffic, and crowded buses—are the very conditions that older adults may seek to avoid. ăe greatest share of transit ridership by older adults takes place in areas of concentrated population with efficient urban infrastructure (Evans 2001, 1999).

Many older adults who use public transit prefer to avoid travel during peak commuting hours and at night (Banister and Bowling 2003). Based on interviews with 1,000 subjects, a study in the United Kingdom predictably found that older adults are more active outside the home during daylight hours than aĕer dark (Alsnih and Hensher 2003). As a result, they per- form much of their travel during the midday and on weekends (Collia *et al.* 2003). During these off-peak times, fixed-route transit service tends to be less frequent than it is during week- day peak hours (Glasgow and Blakeley 2000; Hayden *et al.* 2004; Nelson 2002; Taylor *et al.* 2000).

2 Research Method

Description of Study Areas

ăis study focuses on Buffalo, situated in western New York State along the eastern shores of Lake Erie, and on San José, California, located in the Silicon Valley south of the San FranciscoBay region. Both are medium-sized metropolitan regions, but they provide several juxtaposi-tions for comparative study. Buffalo is a former industrial region in the Northeast Rust Belt, while San José is a growing city with a technology-based economy located on the West Coast. ăe population of Buffalo, the second largest city in New York State, is

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292,600, and 13.5 percent of residents are age 65 or older (U.S. Bureau of Census 2000). Buffalo is the tenth"oldest" region among U.S. metropolitan areas with 500,000 or more residents (Tan 2006).[6]ăecity of San José is nearly three times as large as Buffalo, with a population of almost 900,000.

With older adults comprising only 10 percent of the city's population, San José is a "younger" city than Buffalo. ăe average population density of Buffalo is 38 percent higher than that ofSan José.[7]

Evidence of a difference in urban form between Buffalo and San José can be found in the evolution of housing development (see Table 1). San José has nearly twice as many housing units as Buffalo, and the proportion of single-unit-detached housing units in San José is nearly twice that of Buffalo. ăe age of housing suggests urban structure, as U.S. housing through- out the twentieth century generally was built on increasingly larger lot sizes in neighborhoods with greater accommodation (in public rights-of-way and on private property) for automo- biles. ăat is, earlier decades were characterized by pre-automobile development and higher densities, while later development is characterized by a number of features that reduce walka- bility—including lower development densities, large lot sizes, wider streets, off-street parking, garages, and driveways. Table 1 also shows that 86 percent of all housing units in Buffalo were built prior to 1960, while in San José only 21 percent of all housing units were built prior to 1960. Growth in Buffalo peaked in the 1950s (Hess 2005a), but San José has a greater percent- age of housing units built in recent decades, reflecting the city's growth throughout the 1970s, 1980s, and 1990s. Buffalo possesses new, lower-density residential environments similar to

Table 1: Age and Type of Housing Units

	Buffalo, NY	San José, CA
Total housing units	14,5574	28,1706
Share single-unit, detached	30%	58%
Year structure built		
1990 or later	2%	12%
1980 to 1989	2%	15%
1970 to 1979	4%	28%
1960 to 1969	6%	24%
1940 to 1959	28%	16%

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1939 or earlier	58%	5%

Source: 2000 U.S. Census, Summary File 3

those found in San José, but in Buffalo they are located in suburban municipalities (outside the study area for this research), while in San José they are located within the boundaries of theregion's central city.

Table 2 summarizes sociodemographic characteristics of the two study sites. Older adults in Buffalo constitute a greater share of the population than they do in San José. Buffalo has higher shares of older adults in poverty, and San José has higher shares of older adults with disabilities. San José has a smaller share of white older adults than Buffalo; in Buffalo, African Americans constitute the largest racial group of older adults aĕer whites, and in San José, Asian/Pacific

Islanders constitute the largest racial group of older adults aĕer whites. ăe share of older adult

householders without access to vehicles is more than twice as high in Buffalo as it is in San José. Between 1990 and 2000, the share of older adults decreased faster than the population loss rate in Buffalo, and the share of older adults increased faster than the population growth rate in SanJosé.

Table 2: Sociodemographic Profiles of Older Adults in Study Areas

	Buffalo, NY	San José, CA
All Persons	292,648	893,889
1990–2000 change	-11%	14%
With disability	43%	30%
Below poverty	26%	9%
Older Adults (age 65+)	39,524	72,625
1990–2000 change	-19%	29%
With disability	48%	86%
Below poverty	13%	6%
Share of population	13.5%	8.1%
Age Distribution of Older Adults		
Younger (65–74)	51%	57%
Older (75–84)	37%	32%
Oldest (85 and above)	12%	11%

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Race of Older Adults		
White	70%	63%
African American	28%	2%
Asian/Pacific Islander	<1%	26%
Other	<1%	9%
Ethnicity of Older Adults		
Hispanic/Latino	2%	16%
Older Adult Households	27,159	38,638
Share of all households	22%	14%
Zero vehicles	38%	17%
One or more vehicle	62%	83%

Source: 1990 and 2000 U.S. Census, Summary files 1 and 3.

ăroughout Erie County (Buffalo), traditional fixed-route transit service is provided by the Niagara Frontier Transportation Authority (NFTA), which operates a 9.7-kilometer light rail route, 55 fixed bus routes, and a paratransit service. ăe Santa Clara Valley Transportation Authority (San José) operates 68 kilometers of light rail on three routes, 82 bus routes, and a paratransit service.

Data and Analysis

ăis study uses data from a survey of older adults conducted in Buffalo, New York, and San José, California in late 2005 and early 2006. ăe purpose of the survey was to collect information about barriers—perceived and objective—older adults encounter when using public transit.

A single-stage simple random name and address list of adults age 60 or over was generated from the client databases of the Erie County Department of Senior Services and the Office on Aging for the city of San José. In Buffalo, 400 questionnaires were mailed and 171 completed surveys were returned, a response rate of 43 percent; in San José, 900 surveys were mailed and 286 were returned, a response rate of 32 percent. ăe client databases of the agencies in Buffalo and San José include names and addresses of individuals who have at some point used an agency service—this could include persons with infrequent contact, such as those who have registered to receive a senior discount card, or frequent contact, such as participating in services or meal programs at senior centers. Although demographic data for agency clients is unavailable, it is likely that clients of senior services organizations have lower incomes than older adults not registered with such organizations. ăe survey was confidential and anonymous; names and street addresses were not recorded.[8]

Table 3 provides demographic profiles of survey respondents in the two study sites. ăe mean ages are 76 and 77 years and the age distribution shows greater shares in San José in the two older categories than in Buffalo. ăe racial distribution of survey respondents in Buffalo includes a smaller share of African Americans and a larger share of whites than the racial dis- tribution reported in the U.S. Census, while the racial distribution of respondents in San José includes fewer whites and more Asian/Pacific Islanders than the racial distribution in the U.S. Census. Although the U.S. Census reports higher poverty rates in Buffalo than in San José, there is a greater share of respondents in San José with an average household monthly income less than $1,000 than in Buffalo. A greater share of respondents in Buffalo than in San José live alone, perhaps reflecting higher housing costs in California than in upstate New York. ăe housing arrangements of older adults are important because a challenge in coming years will be to provide travel options to the large number of older adults who live in single-family detached homes (Coughlin and Lacombe 1997) in low-density, sprawling areas (Frey 2003; Rosenbloom 2003) that are typically poorly served by public transit. ăe share of respondents with drivers licenses is greater in Buffalo than in San José. Similar shares of respondents in the two cities report that they use assistive devices (such as canes, walkers, wheelchairs, or power scooters) and approximately 70 to 80 percent can walk to a nearby bus stop.

Not included in the table is survey respondents' assessment of the difficulty they experience in getting to public transit due to hot or cold weather (Peck 2009). About 35 percent of the pooled respondents stay home because of the temperature (*always* 4.2 percent, *sometimes* 31.1 percent); about 27.5 percenthave difficulty getting to transit when it is too hot and 36.5 percent have difficulty when it is too cold. In general, the largestweather barriers to public

transit appear to be snow or ice and rain. In Erie County, snow is a barrier for 60.3 percent of respondents

Table 3: Demographic Profiles of Study Respondents

Characteristic	Buffalo, NY	San José, CA
Observations	*175*	*286*
Demographic Characteristics		

Age range	60–96	60–97
Mean age	76	77
Age distribution	60–69: 16% 70–79: 54% 80+: 30%	60–69: 12% 70–79: 51% 80+: 37%
Race and Ethnicity	93% white 7% African American <1% other	31% white 3% African American 50% Asian 13% Latino/a 3% other
Sex	67% female 33% male	59% female 41% male
Average Household Monthly Income		
23% < $1,000 77% > $1,000	41% < $1,000 59% > $1,000	
Access and Mobility Characteristics		
Living Arrangements	51% live alone 49% live with others	31% live alone 69% live with others
Driving	81% have driver's license	59% have driver's license
19% lack driver's license licensed 63% never licensed	41% lack driver's license 37% previously 35% previously licensed 65% never licensed	
Use of Assistive Device	9% rely upon 19% do not use	15% rely upon 85% do not use
Access 54% do not leave house more than 5 times per week	55 % do not leave house more than 5 times per week	
Transit Access transit stop	71% can walk to transit stop 29% walking to transit stop is very difficult or impossible	80% can walk to

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 “Assistive device” refers to cane, walker, wheelchair, or power scooter.
20% walking to transit stop is very difficult or impossible

(*always* 15.7 percent, *sometimes* 44.6 percent). In San José, rain is a barrier for 55.6 percent of respondents (*always* 11.9 percent, *sometimes* 43.7 percent), and darkness is a barrier for 53.1 percent of respondents (*always* 13.6 percent, *sometimes* 39.5 percent).[9]

Walking to the Bus

Research about walking is scant because data about walking behavior are not collected oĕen (Transportation Research Record and Institute of Medicine 2005) and most researchers esti- mate walking access in the absence of robust data about revealed pedestrian behavior. However, the survey asked respondents in Buffalo and San José to report their transit ridership behavior and the distance from their home to the nearest bus or rail stop. Findings suggest that Buffalo has a greater share of respondents than San José who are non-transit riders, and San José has a greater share of respondents than Buffalo who are frequent or infrequent transit riders (see Table 4).

Table 4: Transit Ridership Frequency and Proximity

Characteristic	Buffalo, NY	San José, CA
Transit Ridership		
Frequent transit riders	25%	36%
Infrequent transit riders	35%	30%
Non-transit riders	40%	34%
Perceived Walking Time to Transit in Minutes, Mean (Range)		
Frequent transit riders	8.3 (2–30)	10.6 (0–45)
Infrequent transit riders	7.7 (2–45)	12.5 (2–60)
Non-transit riders	8.0 (1–40)	12.4 (0–80)

Note: In the last year, frequent transit riders rode one time or more per month, infrequent transit riders rode one time or more per year but less than one time per month, and non-riders did not ride transit.

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In Buffalo, the perceived walking time to transit is 8.3 minutes for frequent transit riders,
7.7 minutes for infrequent transit riders, and 8.0 minutes for non-transit riders. In San José, the perceived walking times to transit for infrequent transit riders and for non-transit riders are similar (about 12.5 minutes) and are greater than the perceived time reported by frequent transit riders (10.6 minutes). In general, perceived walking time to transit in San José is about 30 to 55 percent greater than perceived walking time to transit in Buffalo.U⁰ A two-sample *t*-test for the difference of means assuming unequal variance suggests that in Buffalo, the difference in proximity to transit for those who ride transit *Ěequently* and *never* is statistically significant at the 0.90 level, and in San José, the difference in proximity to transit for those who ride transit *Ěequently* and *never* (and also *Ěequently* and *inĚequently*) is statistically significant at the 0.90 level.

Multivariate regression analysis makes it possible to investigate the association between per- ceived walking distance and the decision to ride transit or transit riding frequency.UU In the

U⁰ Previous research identified two likely explanations for the observation that perceived walking time lengthens as ridership frequency decreases: (a) actual proximity decreases as distance between home and transit stops for nonriders (presumed to reside in less-dense and more single-use urban environments) increases; and (b) to a lesser degree, those who do not walk tend to overestimate walking distances. ăis is not surprising, as people tend to misestimate distances around their homes (Golledge and Stimson 1997; Lloyd 1997).

UU To specify an appropriate model to test relationships between the key variables of interest, a scattergram is used to plot the values of the dependent variable (*transit ridership Ěequency*) as a function of the independent variable (*perceived distance to nearest station*). As walking distance to transit increases, ridership frequency decreases. A

linear multivariate relationship, the dependent variable *R* (representing the annual number of rides on public transit)UY is a function of four vectors of independent variables. ăe four inte- grated vectors include a vector of personal characteristics and self-capacity measures, a vector of variables that describe access and mobility, a vector of perceived barriers to riding transit, and a vector

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of variables that describe neighborhood characteristics. ǟus, the model estimates the importance of demographic and socioeconomic characteristics, access and mobility, perception of ease of access, and neighborhood characteristics in transit ridership frequency.

Estimation of transit ridership frequency is assumed to be dependent on the ability to drive. ăe model includes an independent variable *drive*, a dichotomous variable indicating whether or not the respondent possesses a driver's license and has driven a car in the last month. ǟis overcomes a frequent problem with self-reported driving behavior data in surveys of older adults: survey respondents who possess driver's licenses generally do not classify themselves as nondrivers, even if they have not driven a vehicle for a long time. A second set of models is cre- ated using binary logistic regression in which the dependent variable is a dichotomous variable indicating whether or not the respondent has taken a transit ride at least once in the previous year and the same independent variables as the linear regression. Table 5 provides a list of two dependent variables and 18 independent variables in four vectors, along with operational defi- nitions and data sources.

Table 5: Variable Definitions

Variable (Data Source)	Operational Definition
Dependent Variables	
transitridefreq (survey)	Number of times in last 12 months respondent has traveled (roundtrip) on public transportation expressed as continuous vari-able
transitride (survey)	Dichotomous variable; 0 = respondent did not ride transit in previous 12 months: 1 = respondent rode transit one or more times inprevious 12 months
Independent Variables	
buffalosanjosé dummy(survey)	Dichotomous variable; 0 = survey respondent in Buffalo, 1 = survey respondent in San José

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Personal Characteristics and Capacity

age (survey)	Age of respondent expressed as continuous variable
sex (survey)	Sex of respondent expressed as dichotomous variable: 0 = male, 1 = female

Continued on next page

variable transformation for *walking distance* is contemplated but not undertaken, since the relationship between walking distance and transit ridership is pronouncedly linear.

UY Survey respondents were asked to report the average number of times per week they rode transit during the previous month. A "ride" on public transit refers to roundtrip travel. Responses are used to calculate an average monthly ridership, which is multiplied by 12 to yield an average annual ridership.

Variable (Data Source)

Operational Definition

race (survey) Race of respondent expressed as dichotomous variable: 0 = white or

Caucasian, 1 = all other races

income (survey) Average monthly household income of respondent expressed as cate-

gorical variable: 0 = $500 or less, 1 = $501 to $1,000, 2 = $1,001 to $2,000, 3 = $2,001 to $4,000, 4 = $4,001 or more

cane (survey) Categorical variable describing how frequently responded uses a cane:

0 = never, 1 = rarely, 2 = sometimes, 3 = always

wheelchair (survey) Categorical variable describing how frequently responded uses a

wheelchair: 0 = never, 1 = rarely, 2 = sometimes, 3 = always

Perceived Barriers

knowledge (survey) Categorical response to the statement "I am concerned that I will not

know where I am going on the bus, light rail, or subway": 0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree

transfer (survey) Categorical response to the statement "I am less likely to ride public

transit if I have to transfer to a second bus or light rail train during my trip": 0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree

physicalbarriers (survey) Categorical response to the question "Do any of the following present

difficulties in getting to public transit? (a) crossing busy streets, (b) lack of sidewalks, (c) distance is too far"; 0 = no, 1 = yes , composite variable created by equally responses for (a), (b), and (c)

compositeperception(survey)

Access and Mobility

Categorical response to three statements: (a) "Service on public tran- sit is generally reliable” (b) “Public transit can generally get me where I need to go” (c) “I generally feel safe using public transit”; 0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree, composite vari- able created by equally weighting responses to (a), (b), and (c)

drive (survey)	Driving expressed as dichotomous variable: 0 = respondent did not drive a car in the last month, 1 = respondent possesses driver’s licenseand drove a car in the last month
leavehouse (survey)	Categorical response to the following: “How oŏen do you go out in a typical week? going out mean leaving your apartment, house, or yard to go someplace else”; 0 = rarely or never, 1 = one or two times per week, 2 = three to five times per week, 3 = more than five times perweek
livealone (survey)	Living arrangement of respondent expressed as dichotomous vari- able: 0 = live with spouse, partner, children, friend(s), relatives(s), personal or medical assistant, 1 = live alone
housetype (survey)	Dwelling type expressed as dichotomous variable: 0 = detached house, 1 = apartment or condominium
Neighborhood Characteristics	

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ariable (Data Source)	Operational Definition
walkdist (survey)	Time in minutes to walk from respondent’s home to nearest bus stop or rail station expressed as a continuous variable
%sĐome (U.S. Census)	Share (expressed as percentage) of dwellings classified as single-familyhome in respondent’s home zip code
busstops (NFTA, VTA)	Number of bus stops for all bus routes in zip code expressed as con-

tinuous variable

busservice (NFTA, VTA) Number of buses on all routes (according to current bus schedules)

serving zip code during a 24-hour period on a typical weekday ex-pressed as a continuous variable

Note: NFTA denotes Niagara Frontier Transportation Authority; VTA denotes Santa Clara ValleyTransportation Authority

ăe "personal characteristics and capacity" vector includes self-reported age, sex, race, and income from the survey. Also included is the respondent's reliance on a cane or wheelchair. ăe vector of "perceived barriers to transit access" includes variables measuring the respondent's fa- miliarity with the transit system, the degree to which a transfer on the transit trip to another bus or route is perceived as a barrier, and two composite variables that use survey responses to describe how physical barriers and perception of transit influence the decision to ride public transit. ăe "access and mobility" vector measures driving and licensure, frequency of leav- ing home, whether the respondent lives alone or lives with others, and dwelling type. ăe final vector, "neighborhood characteristics," describes environmental attributes, including perceived walking distance (from the survey), and share of nearby homes that are single-family (from the U.S. Census). ăe number of daily bus runs (all bus routes combined) and the number of busstops is summed for each ZIP code. ăe transit service supply measures (coupled with the shareof nearby dwelling units that are single-family homes) serve as a proxy for urban density and im-prove upon previous research by not assuming that transit service frequency is homogeneous.Uy Table 6 reports the statistical mean, maximum, minimum, and standard deviation for the dependent and independent variables. Note that an identical share (65 percent) of respondentsin the two cities rode transit one or more times in the last year, and transit riders in San José rode with greater frequency than riders in Buffalo.

Findings

Table 7 presents the results of regression analysis, performed according to the plan outlinedusing SPSS.

ăe positive/negative signs of estimated regression coefficients of statistically significant independent variables are in anticipated directions, confirming hypothesized relationships be- tween dependent and independent variables. ăe binary logistic models have lower r^2 values than the linear regression models. Among the linear regression models, the San José model is the most parsimonious, followed by the pooled model and, finally, the Buffalo model.

Uƴ Bus service is quantified rather than rail service because older adults ride buses a greater percentage of the time, and buses provide a mobility function throughout Buffalo's and San José's neighborhoods that light rail does not, as light rail is oriented toward commuting to the central city.

Variable Characteristics

Variable	Buffalo, NY		San José, CA	
	mean	min, max (st. dev)	mean	min, max (st. dev)
Dependent variables				
transridefreq	35	0, 250 (74)	64	0, 250 (95)
transitride	0.65	0,1 (0.48)	0.65	0,1 (0.48)
Independent variables				
buffalosanjosé dummy	0.64	0,1 (0.48)	0.64	0, 1 (0.48)
Personal Characteristics and Capacity				
age	74	62, 98 (7)	77	60, 95 (7)
sex	0.56	0, 1 (0.50)	0.69	0, 1 (0.46)
race	0.72	0, 1 (0.45)	0.27	0, 1 (0.45)
income	2.75	1, 5 (0.95)	2.83	1, 5 (1.18)
cane	0.67	0, 3 (1.03)	0.72	0, 3 (0.99)
wheelchair	0.1	0, 3 (0.36)	0.15	0, 3 (0.40)
Perceived Barriers				
knowledge	1.32	0, 3 (0.83)	1.64	0, 3 (0.74)
transfer	1.67	0, 3 (0.80)	1.8	0, 3 (0.73)

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			5	
physicalbarriers	0.79	0, 1 (0.29)	0.67	0, 1 (0.33)
compositeperception	2.58	0, 1 (0.46)	1.95	0, 3 (0.39)
Access and Mobility				
drive	0.64	0, 1 (0.48)	0.52	0, 1 (0.40)
leavehouse	2.35	0, 3 (0.79)	2.37	0, 3 (0.76)
livealone	0.26	0, 1 (0.44)	0.54	0, 1 (0.50)
housetype	0.71	0, 1 (0.46)	0.69	0, 1 (0.46)
Neighborhood Characteristics				
walkdist	7.64	2, 45 (6.39)	11.96	0, 80 (10.10)
%sÐome	56.36	5, 90 (17.44)	37.51	0, 80 (18.33)
busstops	123	69, 224 (44)	86	10, 184 (43)
busservice	267	22, 661 (119)	268	0, 632 (184)

In Model 1, a pooled linear regression for Buffalo and San José, the adjusted r^2 suggests that independent variables explain 38 percent of the variation in transit ridership frequency among respondents in Buffalo. Nine variables (including the constant) are statistically significant at the 0.90 level or greater: respondents ride transit more frequently if they have lower incomes, do not drive, are not members of the white racial group, have shorter perceived walking time to transit, are more comfortable in their knowledge of the transit system, walk with a cane, or use a wheelchair. In addition, a survey respondent's location in Buffalo or San José is statistically significant in the pooled model. Model 2, the linear egression for Buffalo, has an adjusted

Table 7a: Mo

Variable	Model 1 *Buffalo + San José*	Model 2 *Buffalo*	Model 3 *San José*
Dep. variable	transitridefreq	transitridefreq	transitridefreq
Independent variables			

		.291	
	+7.609	3.638	
	−6.576	−14.537	−3.34
physicalbarriers	−11.039	−32.312	−11.249
compositeperception	7.214	−1.246	17.075
Access and Mobility			
drive	−79.061	−68.739	−85.410
leavehouse	8.659	+20.844	1.471
livealone	6.983	−1.567	18.319
housetype	−11.807	12.468	−20.119
Neighborhood Characteristics			
walkdist	– 1.062	– 0.692	– 1.087
%sĐome	0.152	– 0.11	0.067
busstops	0.048	0.088	0.098
busservice	0.01	0.069	0.001
Model Characteristics:	*Model 1*	*Model 2*	*Model 3*
n	307	109	198
df	19	18	18
r^2	0.42	0.38	0.46
adj. r^2	0.38	0.25	0.40

* $p < 0.10$, significant at the 0.10 level
** $p < 0.05$, significant at the 0.05 level
*** $p < 0.01$, significant at the 0.01 level

r^2 value of 0.25 and produces two independent variables (besides the constant) significant atthe 0.95 level or higher. Survey respondents ride transit more frequently if they are nondrivers

7b: Model Results (Models 4–6)

Variable	Model 4 *Buffalo + San José*	Model 5 *Buffalo*	Model 6 *San José*
Dep. variable	transitride	transitride	transitride
Independent variables			
constant	+4.287	– 1.848	+9.876

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buffalosanjosé dummy	0.619		
Personal Characteristics			
age	− 0.044	0.01	− 0.080
sex	0.201	0.93	0.076
race	−0.253	−0.261	0.042
income	−0.233	0.016	−0.084
cane	−0.014	−0.164	−0.001
wheelchair	−0.237	−1.638	0.466
Perceived Barriers			
knowledge	−0.728	−0.680	−0.888
transfer	−0.102	0.056	−0.289
physicalbarriers	−0.311	−0.386	−0.695
compositeperception	0.54	−0.01	0.768
Access and Mobility			
drive	−1.346	−1.057	−1.489
leavehouse	0.288	+0.851.371	−0.128
livealone housetype	+0.529 0.221		0.122
%sĐome	0.009	0.377	0.211
Neighborhood Characteristics			
Walkdist	−0.017	0.018 0.014	−0.021 0.001
Busstops	0.001	0.004	+0.013
busservice	0.001	0.001	+0.004
Model Characteristics:	*Model 1*	*Model 2*	*Model 3*
n	307	109	198
df	19	18	18
Cox & Snell r^2	0.19	0.24	0.26
Nagelkerke r^2			0.33

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* $p < 0.10$, significant at the 0.10 level
** $p < 0.05$, significant at the 0.05 level
*** $p < 0.01$, significant at the 0.01 level
0.26 N 0.33

and if they leave home more frequently. Model 3, linear regression for San José, is the mostparsimonious of all models, with an adjusted r^2 value of 0.40. Survey respondents ride transit

more frequently if they are male, have lower incomes, are nonwhite, do not drive, have shorter perceived walking time to transit, and are more comfortable in their knowledge of the transitsystem.

ăe second set of models, which employs binary logistic regression to assess the indepen- dent variables that explain whether or not a respondent has used public transit one or more times in the last year, have lower r^2 values than the linear regression models. In Model 4, a pooled analysis for Buffalo and San José, riding transit (or not riding transit) is influenced— represented by statistically significant estimated coefficients in the regression equation—by younger age, lower income, being a nondriver, living alone, and greater knowledge of the transit system. In Model 5, the statistically significant variables that influence riding transit in Buffalo include being a nondriver, leaving home more oěen, living alone, greater knowledge of the transit system, and not using a wheelchair. Model 6 suggests that, in San José, seven variables (including the constant) have a statistically significant effect on riding transit: younger age, lower income, being a nondriver, greater knowledge of the transit system, and more nearby bus stops and bus service.

Each of the six variables describing personal characteristics and capacity show statistical sig- nificance in at least one of the models; age, race, and income are the most significant measures. In the models in which they are statistically significant, use of a cane increases the frequency with which a respondent uses public transit, and use of a wheelchair reduces the frequency of use. Among the perceived barriers to riding transit, a respondent's knowledge of the transit system has a positive influence on the decision to ride transit or the frequency of riding tran- sit in five of the six models. ăe other independent variables in this vector—the burden of transferring and a composite variable describing physical and perceptual barriers—are not sta- tistically significant in any of the models, but including them improves the performance of the models. Among the access and mobility variables, the *drive* variable is statistically significant in all models, and *leavehouse* and *livealone* are statistically significant in several of the models, but *housetype* is not statistically significant. Of the neighborhood variables, walking distance to transit and the supply of bus service are statistically significant only in the San José linear regression models. ăe share of nearby single-family homes is not statistically significant.

Of the variables of particular interest to this study, perceived walking distance to transit is statistically significant in both the pooled and San José linear models. Greater walking dis- tance to transit reduces the frequency of riding transit. A possible rationale for the limited ex- planatory power of the transit proximity variable in the Buffalo models is that the urban form in Buffalo is relatively homogeneous throughout the city, with a pre-1920s regular grid street structure (Hess 2005b) and uniform transit coverage (Hess 2005a).U⁴ "Old Urbanism" features such as medium to high residential density, uniform street grid, sidewalks, and walkable com- mercial corridors along arterials result in relatively uniform transit accessibility throughout the city. In contrast, San José is characterized by a more varied urban structure, including neigh- borhoods within the municipal boundary having arguably suburban characteristics that reducethe convenience of walking to public transit.

Proximity to transit does not have a statistically significant influence in the binary logistics models, suggesting it does not have broad influence on older

adults' choice to ride public transit,

U⁴ A recent study (Hess and Almeida 2007) of the effect of proximity to public transit on property values in Buf- falo determined that residents place greater value on proximity to transit stops (measured by straight-line distance) than on walking distance to transit stops (measured along a street network).

but it is statistically significant in the linear models, suggesting that it has an influence on the frequency of riding transit. A possible explanation is that older adults with penchants for riding transit choose household locations with greater proximity to transit.

Accessibility is a key descriptor of place within a metropolitan area. In previous research, place within a metropolitan area has been strongly associated with mode choice, and in some cases place is the dominant predictor (Rosenbloom and Waldorf 2001) of transit ridership. ăe survey data in Buffalo and San José, however, suggest that place has less influence on mode

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choice than other variables, especially personal characteristics and capacity. Nevertheless, the associations revealed by this survey data between transit ridership and perceived proximity offera basis for additional research.

ăelinear models are used to predict the variation in transit ridership with walking distance in San José. ăis is accomplished by "solving" the linear regression equation using the variable means reported in Table 6 combined with the estimated intercept and estimated coefficients in Table 7 while varying the walking distance. ăe results are shown in Figure 1: women ride transit two-thirds more frequently than men; for older adults having typical characteristics for all of the explanatory variables, each additional five minutes of walking distance to a transit stop or transit station reduces the frequency of riding transit by nine percent for women and eightpercent for men.

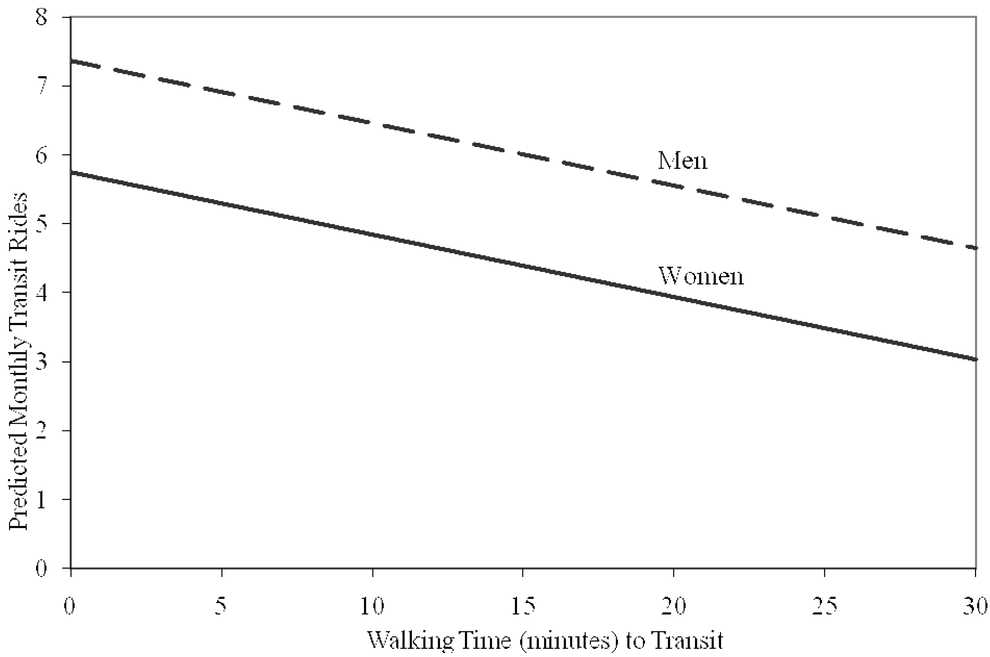

Figure 1: Regression Model Estimation: Variation in Transit Ridership Frequency and Prox-imity

ăe model predicts that a nondriving older adult having typical characteristics and living within a 10-minute walk of transit will ride transit at a rate 83 percent higher than a driving older adult. Model estimations of transit ridership frequency suggest that drivers are more sen- sitive to longer walking distance than nondrivers. In San José, each additional five minutes in

perceived walking distance to transit decreases transit ridership frequency by five percent for nondrivers and by 25 percent for drivers. In San Jose, nonwhite older adults ride transit 56 per- cent more frequently than white older adults, and each additional $1,000 in monthly income reduces ridership frequency by approximately 18 percent.

In Buffalo, men who leave home five times or more per week ride transit nine times asfrequently as men who leave home one or two times per week, and women who leave home fivetimes or more per week ride transit seven times as frequently as women who leave home one ortwo times per week. Men who do not drive ride transit nine times as frequently as men whodrive, and women who do not drive ride transit eight times as frequently as women who drive. ăis study fills a gap in research on proximity to transit by investigating the differential effects that perceived walking distance has on older adults' mode choice. However, the smallsample size limits the power to determine relationships between certain variables. Other po-tential weaknesses of the research include the use of self-reported data, recall bias, and possibleresponse bias. In addition, some older adults walk faster or with greater ease than others andthese differences are masked by the data. ăis study does not control for self-selection among the respondents; that is, the decision to drive a vehicle and the decision to ride transit may influ-ence housing location choice. As mentioned previously, older adults who prefer riding transitmay live in neighborhoods where there is greater service and where walking distances are re-duced.

In Buffalo, a consistently favorable urban structure—including "Old Urbanism" features such as mixed uses, high densities, and walkable streets with sidewalks—may limit the power of dependent variables to explain variation in the independent variable. ăe use of environmental variables at the ZIP code level, rather than in smaller geographic units such as Census block groups, is likely to arbitrarily mask important variations in geographic phenomena.

Future research on this topic should use smaller areal units for the inclusion of geographicalphenomena. A focus on the role that proximity and walking access to transit plays on a trip-by- trip basis would be productive, as trip purposes and characteristics of a trip (weather conditions, traveling with others, carrying parcels) certainly play a role in the decision to use public transit.

Urban planners and transportation managers should be concerned with how those who use public transit view this travel mode choice and whether it accommodates their travel needs. Individual perspectives about the convenience of riding transit are more important than ob- jective measures of transit accessibility, since individual perspectives dictate behavior. Table 8 shows that in Buffalo, 57 percent of respondents who drive agree or strongly agree with the statement "If I were no longer able to drive, it would be difficult for me to use public transit for the majority of my travel needs." In San José, 71 percent of respondents who drive agree or strongly agree with this statement. Note that San José has more new housing built at lower density than does Buffalo (see Table 1). Future research should seek to redress barriers to rid- ing transit for older adults, especially when those barriers include (mis)perceptions that diverge from objective analysis.

ăe suspected barriers that older adults face do not affect transit ridership frequency as strongly as personal characteristics and capacity, whether an older adult does or does not drive, and walking distance to transit. Older adults who seldom or never ride transit may report that they are unfamiliar with the transit system *because* they do not ride transit. A goal of tran- sit marketing and advertising campaigns could be to ensure that *all* older adults have working knowledge of the location of bus stops and routes near their homes or common destinations, so

Perceived Challenge of Transit Dependency

"If I were no longer able to drive, it would be difficult for me to use public transit forthe majority of my travel needs."

	Buffalo, NY	San José, CA
Strongly agree	23%	29%
Agree	34%	42%
Disagree	36%	25%
Strongly disagree	7%	4%

Responses summarized for respondents with a driver's license who drove an automobile within the last month and valid responses for relevant questions. Nondrivers do not have a driver's license or have a driver's license but did not drive during the last month. (For Erie

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County, n = 175; for Santa Clara County, n = 114).

that even nonriders have enough information to help them feel comfortable making an occa- sional transit ride when they lack other means. ăis could be accomplished through informa- tion campaigns targeting older adults and through rider training and buddy programs. Never- theless, transportation planners should be reminded that public transit captures a small share of trips for older adults, and enhancements to access and mobility for older adults should includepublic transit along with other modes of travel.

3 Conclusions

An effective and easy-to-use transit system is an important ingredient for sustainable cities and regions, and convenient access to transit stops and stations makes transit attractive to the largest possible pool of users (Levinson 1992). ăis includes current transit riders—the majority of whom are now transit dependentor downtown commuters (Jones 1985)—as well as new riders, including older adults.

In most North American cities, public transit is not a reasonable substitute for the private vehicle under most circumstances, and this holds true for older adults.Ư[5] While Buffalo and San José have consistent transit coverage, automobile-oriented patterns of development have created places that are difficult to serve with public transit because origins and destinations are dispersed and housing and employment are mismatched. When transit service is provided in low-density areas, infrequent bus service (due to high operating costs) can mean that service does not match the convenience of automobiles. Characteristics that can make transit more convenient for older adults—

including reduced-fare programs, additional bus stops, expanded use of low-floor vehicles,Ư[6] and policies thatallow drivers to deviate from regular transit routes to

Ư[5] For older adults to choose public transit it must be available as an option, and about one-third of respondents to the 1995 Nationwide Personal Transportation Survey reported that public transit is not available in their town or city (Giuliano 1999). ăe U.S. DOT (Federal Highway Administration 2001) reports that only 45 percent of American households have access to public transportation. Access to public transportation is an even greater challenge for older adults who live in nonmetropolitan areas. Half of all adults, particularly in rural areas and small towns, do not have the option of travel by public transportation because service is not available in their area

(Bailey 2004).

U[6] For example, a survey of 225 older adult bus riders in Philadelphia reveals that 65 percent of respondents report difficulty with stepping up onto a bus and negotiating aisles while in motion (Patterson 1985).

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collect passengers closer to their homes and deliver passengers closer to their destinations—do not make a bus network operate more efficiently or with less expense. In this sense, older adults are a challenging submarket to serve, but a submarket that is nonetheless predicted to grow quickly in the coming years. ăe traditional neighborhoods of Buffalo and San José can, how- ever, offer older adults—provided they maintain a minimum level of physical mobility—travel options that support autonomy.

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