Final Report

Evaluating the Benefits of Light Rail Transit

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Abstract

This study evaluated the impact of the Expo light rail transit (LRT) line, which began service in south Los Angeles in 2012, on the travel and activity patterns of both long-term residents and those who moved to the area after service began. Findings support the implementation of Senate Bill 375 (SB 375) by evaluating the potential of transit investments for promoting compact, transit-oriented development goals of reducing vehicle miles traveled (VMT) and increasing active travel. Based on a quasi-experimental, longitudinal research design, results for longer-term residents indicate that living within walking distance (1 kilometer) of the line was associated with a reduction of 11 household VMT per day, a change likely due to their reduction in average car trip length. Living near the line was not associated with a significant increase in walking or bicycling trips. Residents who moved to the area after service began tended to be younger and had higher rental rates and income; those within walking distance of a station drove 8-10 more VMT per day and took longer car trips compared to longer-term households near a station but had rail ridership rates which were more than double that of longer-term households near a station.

Executive Summary

BACKGROUND. This study comprises the first experimental-control, before-and-after evaluation of a light rail transit (LRT) line investment in California on the vehicle behavior and co-benefits for nearby residents. It supports the implementation of Senate Bill 375 (SB 375) by evaluating the potential of transit infrastructure investments for promoting compact, transit-oriented development goals of reducing vehicle miles traveled (VMT) and increasing active travel (walking and biking). The research informs ARB's objectives by promoting improved livability across California, the reduction of vehicle emissions through the use of alternative transportation modes, and by evaluating the extent to which small-area land use policies in areas of high policy relevance for SB 375 (such as infill development, transit-oriented land uses, and transportation infrastructure) can enhance California's environment by encouraging reductions in VMT.

OBJECTIVES AND METHODS. The objectives of the research was to assess the impact of Expo service on nearby private vehicle travel, transit ridership, and physical activity. The research funded by this contract represent the final data collection and analysis phase of a multi-year evaluation of the impact of the Expo LRT Line which began service in south Los Angeles in 2012 on the travel and activity patterns of longer-term residents who lived near the line before service began and new residents who moved to the area after service began. The study's research design mimicked classical controlled experiments to conduct a longitudinal evaluation of the travel impacts of LRT through the use of the 7-day survey protocol. Results of this three-phase study (including longer-term resident surveys conducted before service began and twice after service began) provide insights into whether potential travel changes persist over time and the magnitude of changes at two points in time after the start of service, and allow us to compare impacts for long-term residents and new residents.

RESULTS. The Expo Line was associated with a reduction of 11 household VMT per day for longer-term residents (who lived in the area before the line opened) living within walking distance (1 kilometer) of the line relative to control households located further away. Decreased VMT was consistently statistically significant in both post-opening surveys, and this decrease was likely due to a reduction in average car trip length among longer-term residents near the line. Living near the line was not, however, associated with a significant increase in walking or bicycling trips. Residents who moved to the area after service began tended to be younger and had higher rental rates and income; those within walking distance of a station drove 8-10 more miles per day compared to longer-term households near a station and took longer car trips compared to longer-term households near a station but had rail ridership rates which were more than double that of longer-term households near a station.

CONCLUSIONS. The observed reduction in VMT among long-term residents is consistent with the policy goal of investing in transit infrastructure and promoting nearby compact, transit-oriented development in order to reduce vehicle travel. The patterns of residents who moved to the area after service began, however, raise concerns that even though new residents to LRT corridors may tend to have higher rail transit ridership than longer-term residents, they may also have higher household VMT. This study focused on the impacts of LRT for a largely low-income

neighborhood in south Los Angeles comprised primarily African-Americans and Hispanics, and further research is needed to determine whether the effects of LRT found in this study will hold for neighborhoods of different socio-demographic compositions and built environmental characteristics. Future research is needed to extend, clarify and validate the findings of the current study, and should include comparison longitudinal studies of LRT impacts, assessments of gentrification processes and residential displacement within rail transit corridors, and documentation of the land use and development changes associated with light rail investments.

1. INTRODUCTION

1.1. Project Objectives

The objectives of the research was:

1. To assess the impact of Expo service on nearby private vehicle travel, transit ridership, and physical activity;
2. To identify neighborhood factors which could enhance the potential positive effects of transit proximity on bus ridership and walking; and,
3. To demonstrate methods for evaluating the sustainability, travel, and community impacts of major transportation projects.

ARB funding supported post-processing and analysis of survey data from Phase 2 (Fall 2012, after the Expo line opened in April, 2012) and Phase 3 (Fall 2013, after the Expo line opened). Data collection for Phases 1 (September 2011-February 2012, before the Expo line opened) and 2 were supported by the University of California Transportation Center, the University of California Sustainable Transportation Program, and the Haynes Foundation. The research funded by ARB was organized to accomplish four Phase 3 tasks.

The first task was conducted before Phase 3 data collection began in order to identify and assess early potential changes in travel behavior of nearby residents in the months after Expo service began. During this process, we generated measures of nearby built environment and land use factors to assess their influence on travel patterns. We assessed the role that household attitudes and perceptions (reported in the baseline survey) played in the likelihood that households will change their travel patterns in response to the new LRT line. We also investigated the characteristics of new residents to the study area and assessed how their travel patterns differed from longer-term residents.

The second task was to recruit households from the core sample from Phases 1 and 2 to participate in the survey in Fall 2013. We also recruited and surveyed 'new resident' households, which included follow-up with Phase 2 'new resident' households and recruitment of additional households who moved to the area since Expo service began. Households in the core sample of long-term residents from Phases 1 and 2 completed the full 7-day survey protocol for all household members 12 years and older including a trip and vehicle log (trips by mode, vehicle miles traveled, minutes walking and biking), and a subset of these households completed a third wave of supplemental physical activity and location monitoring using GPS loggers and accelerometers. Households in the new resident sample from Phase 2 completed a modified three-day survey protocol which collected data comparable to the core sample.

The third task involved post processing, conducting quality control, and cleaning the Phase 3 survey data. The fourth task was to combine the data assembled in the earlier project phases and in Phase 3 in order to implement cross-sectional and longitudinal analysis to assess the impact of Expo service on nearby private vehicle travel, transit ridership, and physical activity and to identify neighborhood factors which could enhance the potential positive effects of transit proximity on bus ridership and walking.

1.2. Policy and Planning Context and Background

This research provides critical insights into the co-benefits of transportation infrastructure investments and land use planning for compact, transit-oriented communities by evaluating the impacts of a new light rail transit (LRT) line on changes to household vehicle, transit, and non-motorized "active" travel. Since World War II, zoning and development practices in the United States have resulted in disconnected street networks and single-use and low-density built environments which have been associated with greater automobile usage and lower levels of walking, biking and usage of public transit.[1, 2] Associated physical inactivity remains an important public health problem with serious implications for obesity and associated co-morbidities.[3]

A growing body of evidence suggests that vehicle miles traveled and physical activity is associated with neighborhood built environment factors such as levels of land use mix, residential density and street connectivity.[1, 4-8] The relationship between public transit and physical activity has been poorly understood,[9, 10] but recent evidence suggests that people who walk to and from public transit obtain significantly more daily physical activity than those who do not.[11-14] Although those who live in more walkable areas (those with higher diversity and safety from crime) may be more likely to use transit,[15] some evidence suggests that regardless of neighborhood walkability, transit commuters have more moderate physical activity and walk to more nearby destinations than non-transit commuters. In these ways, investments in transit infrastructure and service could support decreased vehicle miles traveled, increased transit usage, physical activity, and improved health.[7, 8, 16, 17]

California Senate Bill 375 mandates regional targets for the reduction of greenhouse gas (GHG) emissions from passenger vehicles and requires Metropolitan Planning Organizations (MPOs) in California to develop and integrate Sustainable Communities Strategies (SCS) into their Regional Transportation Plan (RTP). The Southern California Association of Governments (SCAG) recently adopted the region's 2012-2035 RTP and SCS which promote greater integration of transportation, land use, housing, and environmental planning to reduce VMT and associated greenhouse gas (GHG) emissions. This plan calls for substantial investments in public transportation and directs substantial development and densification along light rail and subway corridors. It designates High-Quality Transit Areas (HQTA), which are "within one-half mile of a well-serviced transit stop, and includes transit corridors with minimum 15-minute or less service frequency during peak commute hours." The 2012 RTP assumes that 53 percent of new employment growth areas and 51 percent of new housing developed between 2008 and 2035 will be within HQTAs.[18]

Cities, including Los Angeles, California, are making substantial investments in designing and expanding light rail transit (LRT) systems and promoting nearby transit-oriented development in order to make neighborhoods more compact, mixed-use, and transit accessible in hopes of reducing vehicle travel and associated air pollution.[19, 20] The Los Angeles Planning Department continues to encourage development and densification along light rail and subway corridors

through updates to community plans and zoning codes targeted to increase density around light rail and subway nodes.

Consistent with these goals, Los Angeles County voters approved Measure R in 2008, a half-cent sales tax increase that is projected to generate $40 billion in transportation funding over 30 years. Forty percent of Measure R funds will support transit capital projects, and another 25 percent of the funds will support transit operations. The Los Angeles Metropolitan Transportation Authority's (Metro) long-range plan commits funds to six new LRT lines scheduled to open between now and 2019.[21] In total, those six lines will increase the Los Angeles MTA rail network from 73 miles to approximately 120 miles, making it larger than the current Washington Metro system.

1.3. Challenges to Assessing the Impact of LRT

1.3.1 The Need for Spatially-resolved Behavior Data near LRT

Planning decisions about the magnitude and nature of behavior changes associated with LRT investments are largely based on regional averages from cross-sectional travel surveys which provide few insights into the impact of improvements to the built environment on the behavior of lower-income and racially-diverse communities along major transit corridors.[19] The areas of policy focus – transit-oriented developments, locations with moderate to high densities, or activity centers – often have limited data in regional surveys. An earlier literature focused on thresholds for transit ridership,[22] but current data have insufficient spatial detail near stations to accurately assess impacts of compact, transit-oriented development and transit investments on travel and walking.

1.3.2 The Need for Longitudinal Studies of the Impact of LRT on Behavior

Another major limitation in the existing literature is the lack of longitudinal studies on the relationship of the built environment and physical activity. Most research in this area consists of cross sectional studies, making it difficult to assess causal relationships.[23] In particular, pre-post longitudinal studies of the impacts of LRT investments are needed in order to overcome concerns over the influence of household residential selection on travel behavior. This approach would collect travel behavior data on households near the new LRT investments service before service began and after service began in order to assess changes in behavior of nearby residents associated with the LRT service. This is important because observed effects of LRT service in cross sectional studies may reflect the fact that individuals who are predisposed to being more physically active and prefer more compact, mixed-use areas with transit service tend to locate near transit stations.[24]

Before/after tests of travel and activity changes associated with new LRT service are almost absent in the literature, meaning that the robust quasi-experimental research designs which mimic controlled experiments and which have become common in other fields (i.e. labor policy, education, health care) have been rare in transportation. To our knowledge, only two pre-post

studies have longitudinally examined the effect of a new LRT service on the physical activity and travel of residents living near transit stations. The first used a pre-post study design to examine the impact of a new LRT line in 2005 on 51 residents from a low-income, mixed ethnicity neighborhood in Salt Lake City, Utah. They found that the new station was associated with increased transit ridership, moderate physical activity, perceived walkability, and neighborhood satisfaction.[25-27] The second available pre-post LRT study, which examined outcomes for 500 residents near a new station in Charlotte, North Carolina in 2007-2008, found that the use of LRT to commute to work was associated with a reduction in Body Mass Index (BMI) and reduced odds of becoming obese over time. The results suggest that LRT may help some overcome barriers to engaging in daily utilitarian exercise.[28]

1.3.3 The Need for Monitoring Impacts of LRT Over Time

Previous studies provide limited insight into the appropriate length of time to wait before collecting follow-up travel and activity data after the start of LRT service. The evaluation study of the LRT line in Salt Lake City administered its 'post' about 9 to 11 months after the start of LRT service, and the evaluation study of the LRT line in Charlotte administered its 'post' about 6 to 8 months after the start of LRT service.[25, 28] The study protocol for an evaluation of the travel behavior impacts of the Cambridgeshire Guided Busway, which opened in 2011 (pre-post longitudinal results are not yet available), proposed using repeat questionnaires annually over time to assess the travel behavior impacts of the busway. This approach could help minimize the influence of seasonal variations in travel behavior.[29] Repeat follow-up measurements at multiple intervals over time (for instance at 6 to 8 months and 18 to 20 months, during the same season) could provide insights into the long-term impacts of LRT investments.

1.3.4 The Need to Understand the Role of Residential Sorting near LRT

Longitudinal before-after travel surveys near LRT (such as the current study) will extend previous cross-sectional studies by examining whether nearby (or "treatment") and comparison (or "control") households lower their automobile usage and increase their transit usage and walking after the start of LRT service, but we expect the aggregate, long-term impacts of LRT will also be influenced by the behavior of residents who relocated from outside the area to live near LRT because they prefer to live in more dense, mixed-use, and transit-accessible areas.[24, 30-32] Understanding the influence of LRT on both existing and new nearby residents is important for evaluating the impact of LRT on aggregate travel patterns, particularly if the travel patterns and associated values and preferences of new residents differ substantially from existing residents.

1.3.5 The Value Residents Place on Living Near LRT

Although substantial literature has examined the revealed preference of households to live near LRT based on hedonic analysis of home values in proximity to LRT,[33-35] few studies have used survey techniques to more directly characterize the role that personal values and attributes play in a household relocating to live near transit and potential implications on whether LRT will impact behavior. Survey-based stated preference surveys can help account for the role of

preferences and attitudes in residential choice in ways that may not be reflected in revealed preference studies of housing market data. Most stated preference studies in the travel behavior literature have used the method to understand household travel mode choice,[36, 37] but few studies have used this method to assess residential preferences to live near LRT or walkable communities.[38, 39] Furthermore, few comparative studies exist which assess household willingness to pay to live close to LRT using both hedonic-based revealed preference results with stated preference methods.[40]

1.3.6 The Need to Understand the Role of Attitudes and Perceptions in Travel Behavior

Travel behavior is a complex phenomenon that is affected not only by characteristics of the built environment and socio-economics but also by social and psychological factors.[41, 42] These underlying psychological and social decision processes that guide individual travel behavior have been largely ignored in the travel behavior literature.[43, 44] This is a shortcoming, as research has shown that individuals in homogeneous socio-economic groups may behave differently depending on their perceptions, attitudes, and preferences.[45-48] Understanding and modeling this behavior requires a robust methodological approach that takes all of these aspects into account. Several researchers have identified the need for a more robust theory-based approach to travel behavior research – one that builds on findings from the fields of transportation, geography, and microeconomics by incorporating insights and theoretical frameworks from social and environmental psychology.[43, 44, 49]

While some recent travel behavior research has begun to explore the role of attitudes and perceptions in travel behavior and decision making,[26, 50, 51] the attitudinal questions in travel surveys are often introduced in an ad hoc fashion – based on factors that the researchers feel are relevant, but lacking a theoretical framework. According to van Acker et al. (2010), almost none of the empirical travel behavior studies that attempt to account for spatial, socio-economic, and socio-psychological aspects present a theoretical framework that relates these factors to travel behavioral outcomes, such as vehicle miles traveled or walking trips.[43]

1.3.7 The Need for Methodological Innovations in Travel and Activity Surveys

The use of innovative and less expensive methods of travel data collection, including web-based surveys and portable GPS location tracking, provide valuable tools for collecting the high temporal and spatial resolution needed to more adequately evaluate policies, infrastructure investments, and service improvements.[52-55] Transportation planning has long relied on travel forecasting models and cross-sectional (regression-based) hypothesis tests in part due to the expense associated with travel diary surveys. These surveys typically use recall interviews or diaries, and research has raised methodological concerns about recall, reliability, and compliance.[56] Previous research using GPS-based location tracking indicates that respondents to traditional regional travel surveys tend to under-report trips, a challenge which could impair our ability to evaluate the impact of LRT on behavior.[54, 57-59] Gaps in trip and activity information on traditional travel surveys can be extensive and systematically correlated with individual and household trip characteristics.

Several regional travel surveys have tracked travel activities by equipping passenger vehicles with Global Positioning Systems (GPS) devices [52, 57] and recent cohort studies demonstrate that portable GPS loggers and GPS-enabled cell phones are valuable tools for monitoring subject locations in travel behavior and air pollution exposure studies and can lessen respondent reporting burden and enable data collection over longer periods.[60, 61] GPS location tracking can provide a nearly continuous location database and highly-resolved enhanced insights into the environmental exposures associated with health outcomes across 'activity spaces' occupied over the course of the day.[54, 62-65] These studies found that using GPS to collect activity data offers several advantages including near-continuous tracking, high temporal resolution, and minimum reporting burden for participants. Furthermore, previous research indicates that combining accelerometer-based data collection methods with GPS location tracking can provide substantial information on the location and extent of moderate-vigorous physical activity (MVPA).[66-69]

However, GPS data collection generates large amounts of location data which presents substantial challenges in the processing and classifying of raw GPS data. Our research team has developed and evaluated automated GPS data processing techniques which we will use and refine to process and identify activities, trips and modes from the large volumes of GPS location data.[54, 62, 70]

2. MATERIALS AND METHODS

2.1 Study Area Selection

The Expo Line is a light rail transit line in the Los Angeles metropolitan area that extends south and west from downtown Los Angeles, reaching downtown Santa Monica upon completion. The line is scheduled to be completed in two stages. Phase 1 opened in early 2012, runs 8.7 miles from downtown Los Angeles westward to Culver City, near the junction of the 405 and 10 Freeways. Service began on the eastern portion of the Phase I section on April 28, 2012, and service was extended to Culver City on June 20, 2012. Phase 1 of the Expo line stops at a total of 12 stations, 10 of which were newly constructed. It shares track with the Metro Blue light rail line over 1.2 miles near downtown Los Angeles, and also runs on the same route as the Metro Silver rapid bus and other Metro bus lines over 2.7 miles between the 7th Street/Metro Center station in downtown LA and the Expo Park/USC station (LACMTA, 2012). In addition to downtown LA and Culver City, the Expo line serves the area south and east of the University of Southern California campus as well as the neighborhoods of Exposition Park, Leimert Park, Crenshaw, Jefferson Park, Baldwin Hills and West Adams.

Phase 2 of the Expo Line, which will extend the line into downtown Santa Monica, is currently under construction. According to the Expo Line Construction Authority the line is scheduled to be complete in 2016. Figure 2.1 shows a diagram of the Phase I portion of the line and its location within the LA metro area.

Figure 2.1. Exposition Line Vicinity Map (LACMTA)

The study neighborhoods were chosen around the six westernmost Expo Line Phase 1 stations. The six easternmost stations were not chosen because they were also served by either the Blue Line light rail or the Silver Line rapid bus, which provide service of similar characteristics in conjunction with the new Expo Line service. In addition, the Jefferson/USC, Expo Park/USC, and Expo/Vermont stations were excluded because of their proximity to the University of Southern California campus, which has a very different socio-demographic profile than the neighborhoods to the west. Because this area has a high proportion of university students, any travel behavior change, though interesting in its own right, may not be as generalizable as that of residents in other neighborhoods.

The study used a quasi-experimental research design to collect before/after travel and physical activity for households from “experimental” neighborhoods near the Expo Line (within approximately 1 kilometer) and comparable nearby “control” neighborhoods not receiving transit service enhancements. Comparison neighborhoods were chosen from the outer limit of the experimental areas to more than 2 miles in distance from stations. Comparison neighborhoods were chosen from areas with similar characteristics to the experimental areas.The second set of comparison neighborhoods were chosen within a ½ mile radius of the Expo Line National/Palms station, which is the easternmost station of Expo Line Phase 2, and the first stop beyond the Culver City station.

We chose control neighborhoods to be demographically similar, to approximate a treatment-control group design where the treatment group, within 1 kilometer (walking distance) of new stations, got an improvement in access to light rail, and the control group, being more distant, did not benefit as much from the new Expo Line. Characteristics of the treatment and control group neighborhoods are shown in Table 2.1. The treatment and control areas are similar in terms of population density, age and income distribution. The only apparent difference between the two is that the control neighborhoods have a higher proportion of African-American residents, and a larger proportion of Hispanics live in the experimental neighborhoods.

Table 2.1. Characteristics of the Treatment and Control Group Neighborhoods

		Experimental	Control	Source
	Land Area (acres)	3590	5011	2010 Census SF1 Data
	Population Density (Persons/Acre)	21.1	18.1	2010 Census SF1 Data
	Housing Density (HH/Acre)	7.8	7.2	2010 Census SF1 Data
Race and Ethnicity:				
	Hispanic	51.8%	32.7%	2010 Census SF1 Data
	African American	27.7%	46.4%	2010 Census SF1 Data
	White	11.5%	12.5%	2010 Census SF1 Data
	Asian	5.8%	5.3%	2010 Census SF1 Data
	Other	1.0%	0.8%	2010 Census SF1 Data
	Multiple Races	2.1%	2.3%	2010 Census SF1 Data
Age:				2010 Census SF1 Data
	Under 20 Years Old	27.5%	25.4%	2010 Census SF1 Data
	65 Years Old and Older	9.2%	12.0%	2010 Census SF1 Data
Household Income and Benefits (2010 Inflation-adjusted Dollars):				
	Less than $25,000	29.8%	31.9%	ACS 2010 5-year Estimate
	$25,000 to $50,000	26.4%	27.8%	ACS 2010 5-year Estimate
	$50,000 to $74,999	18.5%	17.5%	ACS 2010 5-year Estimate
	$75,000 to $99,999	11.9%	8.1%	ACS 2010 5-year Estimate
	$100,000 or more	13.5%	14.6%	ACS 2010 5-year Estimate

2.2 Advantages of the Research Design

This research design has several advantages, listed below.

- The experimental design includes both treatment and control groups, and the research design examines travel/activities of the same households surveyed in the baseline (before-opening) study. This provided a rare opportunity to compare the same households before and after a major improvement in transportation infrastructure, and also allowed inference about causality and the magnitude of impact, adapting the methods of classic experimental research to this context. See, e.g., Shadish, Cook, and Campbell (2002) for a discussion of experimental research designs in the social sciences.[71]

- The seven-day tracking period used for the core sample will provide exceptional ability to capture travel trends. Travel survey studies of this sort typically track travel for one or two days, staggering the respondents' start days across days of the week to provide subsamples with travel data on each day of the week.[72-74] Longer observation periods provide an opportunity to observe more typical travel patterns, with less sensitivity to idiosyncratic day-to-day variations.

- We obtained data on all household members 12 years old or older for the core sample, allowing analysis of the full household. Because household members can substitute travel within the household – with, for example, one person ceasing to make shopping trips while

another takes on the responsibility for running errands – it is essential to have data for the full household.

- We tracked multiple outcome variables – vehicle mileage, trip counts by mode, and distance traveled, and physical activity (from the GPS and accelerometer data) – allowing an analysis of a broad set of policy questions.

We administered an extensive survey about environmental attitudes, attitudes toward public safety, crime, and victimization, and experiences with victimization and harassment while walking, bicycling, or using transit. This allowed detailed analysis of factors beyond the immediate transportation system, giving insight into more holistic approaches to neighborhood development and how those interact with personal experiences and attitudes to influence travel patterns in response to new infrastructure investment.

2.3 Participant Recruitment and Data Collection

2.3.1 Phase 1 - Before Opening (September 2011-February 2012)

Core Group

The Phase 1 Core sample, which is comprised of experimental and control households that resided in the study area before the Expo Line opened, was recruited in two phases. During the first phase, from September to November of 2011, we obtained addresses from InfoUSA, a marketing information firm, for households in the vicinity of three Expo stations (Crenshaw, Farmdale, and La Brea) and control neighborhoods to the south, including Crenshaw, Leimert Park, Harvard Park and Chesterfield Square. Each household was mailed a letter inviting them to take part in the study.

The study recruitment letter, which was provided in English and Spanish, directed potential participants to visit the project website and/or call a telephone number to contact us. In either case, the respondent was asked to complete an introductory questionnaire that consisted of basic questions about household composition and travel behavior. Participants were not informed of the study's objectives regarding effects of the Expo Line. They were informed in study materials that "the purpose of this study is to examine the effects of local employment, shopping, transportation and neighborhood design on the distance people travel and the types of transportation they use".

Based on responses to the introductory questionnaire, potential participants were separated into three groups: web-based (participants who entered survey components online), paper-based (participants who completed survey components using hard copy materials), and mobile tracking (participants who completed survey components using hard copy materials and also participated in GPS and activity monitoring). Phase 1 households in the web- and paper-based groups that completed the survey materials received a supermarket gift card with a value of $15, and households in mobile tracking group received a $30 gift card for participation.

All participants except those interested in carrying the GPS and activity monitor were mailed a packet that contained all of the materials necessary to complete the study. Those who agreed to carry the GPS and activity monitor (the mobile tracking group) met with a trained researcher and were provided the materials in person during training on how to use and charge tracking devices. The survey instrument included instructions, a 7-day travel log for each household member 12 years old or older, and a mileage log for each household vehicle. Appendix A contains the materials that each participating household in the core sample completed for all household members 12 years of age or older.

For participants who indicated they preferred to complete the study using the website (the web-based group), a password and username were provided. Participants were instructed to log in on the website using the username and password to complete the baseline survey and 7-day travel logs. Responses were captured using a survey form developed with the SurveyGizmo web application. Those who either did not have access to the Internet, or preferred to mail the materials to us, received a paper version of the surveys along with the instructions and 7-day travel log (the paper-based group). A self-addressed postage-paid envelope was provided to facilitate return of the survey instruments and logs. The survey materials included in the paper group packet were identical in content to those available on the web-based survey.

Households in the mobile tracking group were contacted to schedule a convenient time to meet with a trained researcher. At this meeting, the respondent was given instructions, survey materials, travel logs, and vehicle logs. These materials were identical to those received by the paper and the web groups. Participants were also given the two monitoring devices and personalized instruction on how to properly use them. Only the main respondent in each household carried the GPS and physical activity monitor during the survey period. However, the remainder of the survey protocol was the same as the web and paper groups. At the end of the 7-day survey period, participants again met with one of our researchers, who collected all of the survey materials along with the GPS and activity monitors. The responses to the survey were checked by the researcher to ensure they were complete at the time of pick up.

During October, it became apparent that the Expo Line would not open before early 2012. This gave us sufficient time to expand the project area beyond the original boundaries and to include three stations adjacent to the original study stations (Culver City, La Cienega/Jefferson, and Expo/Western). In addition, we selected an area in the vicinity of the Expo Phase 2 National/Palms station as a new control area. A final mailing went out to these, as well as any remaining households in the original project area, during the second week of November.

A total of 304 responses were received during phase 1. Of these, 289 were complete and usable: 117 (40.5%) in control neighborhoods and 172 (59.5%) in experimental neighborhoods. The overall response rate was 1.0% (Table 2.2). This response rate is comparable to the 1.4% response rate for the region's sample from the 2010-2012 California Household Travel Survey (defined as Los Angeles and Ventura County)[75] and the 0.4% response rate for the 2012 Neighborhood Travel and Activity Study (NTAS)[76] of residents of rail transit corridors in Los Angeles, both of which collected travel survey data using a one day protocol. Our comparison of the characteristics of responding households to all households in the study area is limited to the

marketing InfoUSA information we purchased. Compared to all households contacted, the study sample included a slightly lower percentage of households headed by a male (36% vs. 42%), households headed by a younger adult aged 18–39 (21% vs. 27%), and households with an annual income below $30,000 (33% vs. 38%), but these differences were not statistically significant. Overall, response rates did not vary greatly across subgroups. Relative to the sample frame, the following households were slightly underrepresented among respondents: households with a head under 40 years old, households with an annual income under $30,000, households with less than 1 year or more than 10 years tenure in their residence, and households residing in a multi-family dwelling (Table 2.2). This suggests the final sample was representative of the study area population based on observable characteristics.

Table 2.2. Phase 1 Core Sample Response Responses by Household Characteristics

	Sample Frame	Response Rate
Total	27,275	1.0%
Age Category		
18-29	2,002	0.8%
30-39	5,300	0.8%
40-49	6,154	1.0%
50-59	5,504	1.0%
60 plus	8,312	1.1%
Income Category		
under $29,999	10,289	0.9%
$30,000 - $49,999	6,243	1.0%
$50,000 - $69,999	4,545	1.1%
$70,000 plus	6,196	1.0%
Housing Tenure		
1 year or less	4,473	0.9%
2 to 5 years	6,804	1.0%
6 to 10 years	4,377	1.2%
more than 10 years	11,619	0.9%
Owner	12,371	1.0%
Renter	8,318	1.1%
Residential Structure Type		
Single Family Dwelling	18,027	1.3%
Multi-Family Dwelling	8,959	0.9%

2.3.2 Phase 2 - 6 Months After Opening (September 2012-February 2013)

Core Group

In September, 2012, approximately five months after the opening of the Expo Line, we began re-contacting households that completed phase 1. Participants were mailed a letter asking them to reply by phone or email if they were willing to participate in the phase 2 survey. As in phase 1, in order to not affect participant behavior, no mention was made of the Expo Line in the

recruitment materials. To encourage households to participate, study compensation was substantially increased from phase 1. For the phase 2, paper and web respondents were offered $50 grocery gift cards (increased from $15), while mobile tracking group households received $75 cards (increased from $30). Households that did not respond to the initial letter were also contacted by telephone or email using information obtained during the before opening study. Overall, return rate for the after opening study was quite good. A total of 208 households out of 284 (73.2%) returned a usable set of study materials (Table 2.3).

Households completed the phase 2 survey between September and November of 2012. The survey protocol was the same as phase 1, and the study was administered in the same way as before, with respondents completing the study by one of three methods (web, paper, or mobile tracking). Mobile tracking households from the before study were once again enrolled in the mobile tracking group of phase 2 to allow analysis of physical activity and travel pattern changes.

New Resident Group

In order to compare new resident travel behavior to that of established households, we implemented a survey component in phase 2 targeting residents who had moved to the area after phase 1 data collection and after the start of the Expo Line service. In early October, 2012, we purchased an address list of 3,212 residents who had moved to the study area between January and September of 2012. The address list was purchased from InfoUSA, a commercial provider of residential and business marketing information. We mailed these households an invitation postcard in late October 2012, and 110 (or about 3%) of these new residents went to our study website or called to express interest in participation. We mailed a survey packet to each of these participants during the final week of November, with instructions that they should log their trips and vehicle mileage from Tuesday-Thursday during the first week of December. Participants who completed all survey materials were mailed compensation in the form of a $30 supermarket gift card. From this initial recruitment, we received a total of 29 completed surveys (26.3% of packets mailed).

In order to improve response, we conducted a second mailing in early February 2013. The mailing list for this outreach was created from two sources. First, we again purchased a supplemental sample of addresses for residents who had moved to the study area between October to December of 2012. Second, we generated a second list of potential new residents to the area by purchasing a full address list from InfoUSA for all areas targets in the phase 2 study period (January 2013) and comparing this list to our phase 1 full address list to identify the second list of potential new residents. Addresses that matched between 2011 and 2013 but had different names listed were identified as potential new residents. Using these two combined address sources, we identified 11,213 possible new residents. These households were mailed a recruitment postcard in early February of 2013. In order to boost response, we increased the incentive compensation from $30 to $50 for responding households.

This second mailing in February 2013 resulted in 151 responses from potential new resident participants. Each household that expressed interest was mailed a full set of survey materials,

asking them to complete their travel diaries Tuesday through Thursday during the first or second week March 2013. Of the 151 packets mailed, 125 (82.8%) were completed and returned to us in the postage-paid return envelope provided. After removing responses from households that moved before our cutoff date of January 1, 2012, a total of 90 usable responses remained (Table 2.3). This represents a response rate of 59.6 percent of the mailed packets.

The survey instrument used for the new resident sample included the same socio-demographic and travel data as the core before and after samples with several notable modifications. First, the travel diary and vehicle odometer logs were altered to reduce burden on respondents. Each household in the new resident survey was requested to track their travel for three weekdays (Tuesday – Thursday) instead of the full 7-day reporting period for the Core group survey. Second, participants were asked for details about the time and distance of their move, including the zip code of their previous address. Finally, the main respondent in each new resident household was asked to answer 16 questions about various housing and neighborhood characteristics and 4 questions about which modes of travel were important in the choice of their current residence. The full set of survey materials can be found in Appendices A and B.

Unlike the core sample, all new resident surveys were completed in paper form only and were returned in a postage paid return envelope. Other than the initial screening questionnaire, no survey materials were completed online, and mobile tracking devices were not used for the new resident survey.

2.3.3 Phase 3 - 18 Months After Opening (September 2013 – April 2014)

Core Group

The phase 3 after opening survey began in September, 2013, approximately 18 months after the opening of the Expo Line. We contacted 208 households that participated in the phase 2 survey and again offered $50 and $75 incentives to households to encourage participation. The protocol was the same as in previous survey phases, except that all households in the paper and web groups were provided with paper materials only.

This phase of data collection was completed in early December, 2013, and a total of 173 households returned a usable set of study materials. This represented 83% of households who completed the phase 2 after opening survey, and 61% of the households who completed the phase 1 before opening survey. As with the phase 1 survey, phase 2 and 3 surveys began after the start of the school year, and were not conducted during holiday periods in order to capture normal travel patterns. The core group survey instruments, protocol, and administration was the same in all phases of data collection.

New Resident Group

Beginning in October 2013, the 90 households that participated in the phase 2 new resident survey were re-contacted and invited to participate again. Each of these households was mailed the invitation letter along with all of the materials required to complete the study. The survey

protocol was the same as was used in phase 2, and included a household survey and 3-day travel and odometer log. Households were offered a $50 grocery gift card as an incentive to participate. Of the 90 new resident households that participated in phase 2 of the study, 58 (64%) returned useable surveys in phase 3.

New Resident Supplemental Group

In order to increase the overall new resident sample size, a supplemental group of new resident households was recruited in early 2014. We again purchased a list of households that recently moved into the study area from InfoUSA. We drew a random sample of 1,230 addresses from this list, and mailed an invitation postcard to each of these households beginning in April 2014. Households that indicated interest in participating were mailed the full set of survey instruments in April and May 2014. The survey protocol and compensation for this group were the same as those used for households who previously completed the phase 2 and 3 new resident survey. A total of 26 households returned useable responses, yielding a response rate of 2.1 percent based on the initial postcard mailing. Of these, 21 had moved after the January 1, 2012 cutoff date used to define our new resident sample (Table 2.3).

The total combined size of the sample of new resident households that moved to the study area after January 1, 2012 and provided complete responses was 79 (Table 2.3).

Table 2.3. Summary of Responses by Data Collection Phase

	Phase 1			**Phase 2**			**Phase 3**		
	6 Months Before Opening			**6 Months After Opening**			**18 Months After Opening**		
Sample	**Exp.**	**Control**	**Total**	**Exp.**	**Control**	**Total**	**Exp.**	**Control**	**Total**
Core	172	117	289	128	80	208	104	69	173
New Resident	0	0	0	55	35	90	34	24	58
Supp. New Resident	0	0	0	0	0	0	8	13	21
Total	172	117	289	183	115	298	146	106	252

2.3.4 Human Subjects Review and Approval

The study design, recruitment materials, consent procedures, and survey and data collection instruments were approved as exempt status from the UC Irvine's Institutional Review Board (UCI HS#2011-8042).

2.4 Sample Characteristics by Group and Survey Period

2.4.1 Household Residential Locations

Figure 2.2 shows the distribution of the core and new resident samples for the three phases of data collection. Experimental households were located within 1 kilometer of an Expo Line station, and control households were located beyond this distance from a new station. Some new

resident households in the phase 2 collection period were located outside of the primary sampling area because this sample was identified using all new resident addresses from the larger zip codes and was not constrained to the primary sampling area.

2.4.2 Sample Characteristics

Table 2.4 contains descriptive statistics for the households in each of the three waves of data collection, including the number of households in the experimental and control groups, household income, homeownership status, and age structure. While the core sample is comprised of a nearly 40/60 split between experimental and control areas, the new resident sample is comprised of a nearly 60/40 split between experimental and control areas.

Household incomes were similar between the core and new resident samples obtained 6 months after the opening of the Expo Line, although the new residents included fewer very low income (less than $15,000 per year) households. Approximately 11 percent of new resident households were in this lowest income category, compared to 17 and 16 percent for the core sample in the before and after samples respectively. However, the income distributions were quite different for the final sample, taken 18 months after the opening of the line. In this final wave, more than 40 percent of core households had incomes of less than $35,000 per year, compared to 30 percent of new residents. At the upper end of the income range, only 23 percent of core households in phase 3 had annual incomes of $75,000 or more, while 37 percent of new residents in phase 3 fit into this category.

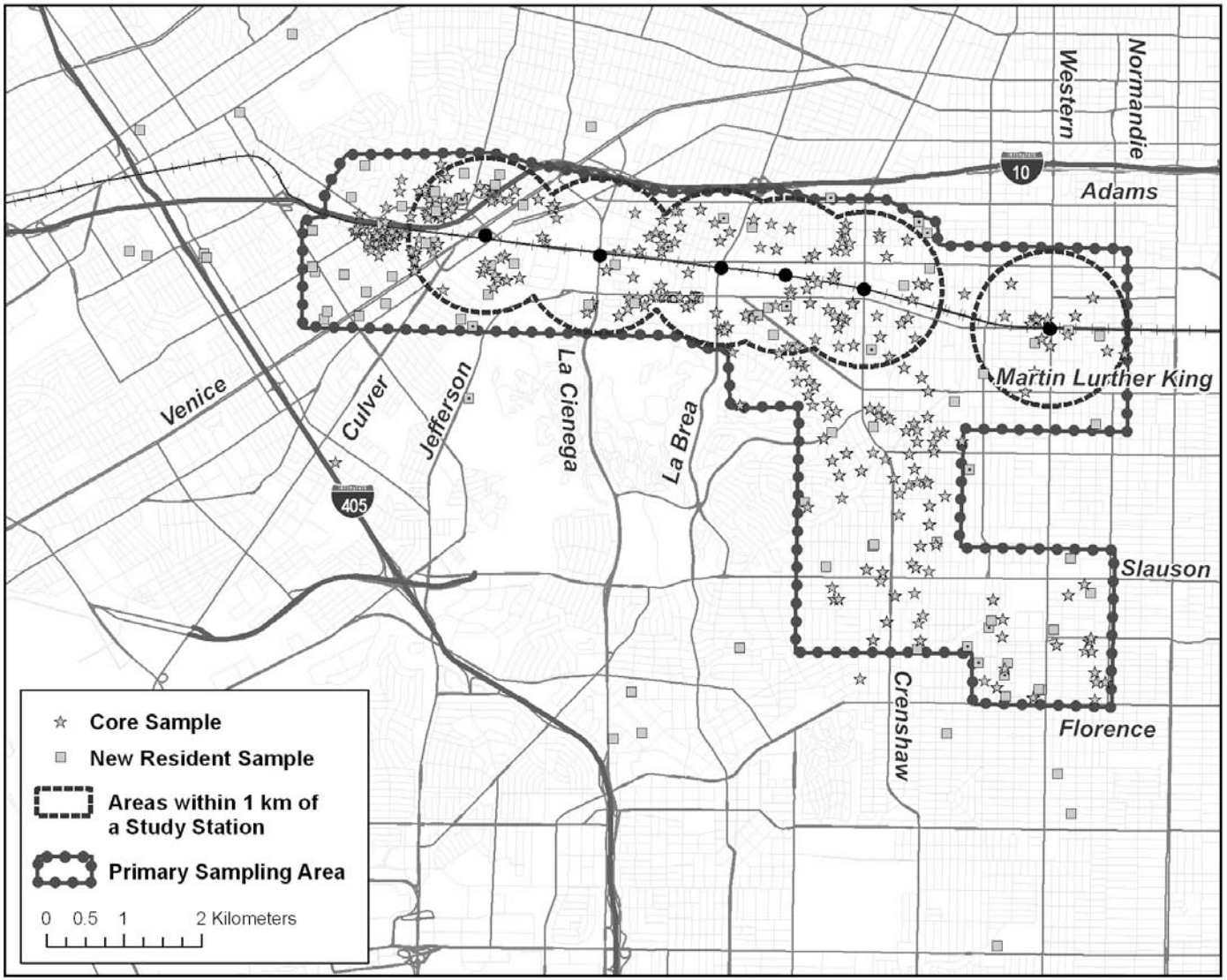

Figure 2.2. Core and New Resident Household Approximate Locations

Table 2.4. Expo Line Core and New Resident Sample Socio-demographic Descriptive Statistics

	Phase 1 6 Months Before Opening		Phase 2 6 Months After Opening				Phase 2 18 Months After Opening			
	Core		Core		New Resident		Core		New Resident	
Study Area	**N**	**percent**	**N**	**percent**	**N**	**percent**	**N**	**percent**	**N**	**percent**
Experimental	117	40.5	80	38.5	35	38.9	69	39.9	32	40.5
Control	172	59.5	128	61.5	55	61.1	104	60.1	47	59.5
Total	289	100	208	100	90	100	173	100	79	100
Household Income										
less than $15k	47	17.3	33	16.1	10	11.4	29	17.1	12	15.8
$15k to $35k	60	22.1	43	21	22	25.3	41	24.1	11	14.5
$35k to $55k	50	18.5	45	22	19	21.8	31	18.2	17	22.4
$55k to $75k	43	15.9	30	14.6	13	14.9	30	17.6	8	10.5
$75k to $100k	38	14	27	13.2	11	12.6	20	11.8	11	14.5
more than $100k	33	12.2	27	13.2	12	13.8	19	11.2	17	22.4
Total	271	100	205	100	87	100	170	100	76	100
Home Ownership										
Rent	148	53.4	113	55.1	24	70.8	88	51.2	56	70.9
Own	124	44.8	89	43.4	63	27	82	47.7	23	29.1
Other	5	1.8	3	1.5	2	2.2	2	1.2	0	0
Total	277	100	201	100	89	100	172	100	83	100
Age										
Under 12	70	12.4	48	12.2	24	13.7	41	12.6	23	15.2
12 to 17	50	8.8	20	5.1	7	4.0	24	7.4	4	2.6
18 to 29	70	12.4	53	13.5	56	32.0	32	9.8	43	28.5
30 to 44	117	20.7	80	20.3	60	34.3	61	18.8	56	37.1
45 to 64	185	32.7	142	36.0	22	12.6	110	33.8	21	13.9
65 and Older	74	13.1	51	12.9	6	3.4	57	17.5	4	2.6
	566	100	394	100	175	100	325	100	151	100
	mean	**Std. Dev.**	**mean**	**Std. Dev.**	**mean**	**Std. Dev.**	**mean**	**Std. Dev.**	**mean**	**Std. Dev.**
Household Size	2.16	1.33	1.88	1.17	2.07	1.01	2.05	1.24	2.04	1.01
No. of Vehicles	1.36	0.87	1.3	0.8	1.34	0.69	1.33	0.91	1.42	0.71
No. of Driving Licenses	1.63	0.81	1.52	0.7	1.53	0.61	1.47	0.83	1.59	0.65

Despite the higher incomes, households that recently moved into the study area were also more likely to be renters. In both phase 2 and 3 samples, more than 70 percent of new residents rented their housing compared to less than 51-55 percent of longer-term residents in the core sample.

Differences are also apparent in the age structure of core and new resident households. Over half of individual surveyed in the core sample were 44 years old or younger, while over 80% of new resident individuals surveyed were 44 years old or younger. So, overall, new resident households tended to be younger, had higher home rental rates, and had higher income than core households. The core and new resident samples were similar in terms of household size, vehicle ownership, and number of household members with driver's licenses.

2.5 Key Measures and Data Post-Processing/Cleaning

2.5.1 Travel and Mileage Logs

Quality control checks were performed on all trip and vehicle mileage log data to ensure that responses were complete and reasonable. Records with missing data or that were outside of reasonable ranges were flagged so they could be identified and appropriately handled in the analysis. In a few cases where responses appeared to be unreasonable due to input error (for example, odometer readings with transposed digits), research staff attempted to correct the values and flagged them as corrected.

2.5.2 Development of Built and Social Environment Measures

Consistent with our previous research,[19, 77, 78] we developed measures of the physical and social environment based on geocoded participant residential locations using ArcGIS 10.0 which reflect factors including neighborhood walkability, residential density, land use mix, and transit accessibility within walking distance. These measures represent the density, diversity, design, and regional accessibility factors that could decrease vehicle travel and encourage walking and more active lifestyles.[4] We used Census 2010 TIGER street segment data to estimate nearby street connectivity based on the number of street intersections within walking distance of residential locations. We estimated nearby land use composition using 2008 parcel-level land use data from the Southern California Association of Governments (SCAG) to account for proximity to nearby commercial uses or mix of commercial and residential uses which may be associated with higher rates of walking. Several standard metrics have been developed in the literature, including the number of street intersections, block size, and dissimilarity indices and entropy indices to measure land use mix.[8, 79] We estimated transit accessibility (to non-Expo lines) based on data obtained from Los Angeles Metro which identifies the point locations of all unique public transportation route stops in the study area in 2011 and 2012 served by Metro. We also developed measures of nearby neighborhood-serving businesses based on 2011 infoUSA firm location data obtained from SCAG since residential proximity to these land uses have been associated with greater walking trips.[53]

3. RESULTS

The research funded by this ARB contract and discussed in this report represents the final data collection and analysis phase of a multi-year evaluation of the Expo LRT Line which began service in south Los Angeles in 2012 on the travel and activity patterns of (1) long-term residents who have lived in the study area since before service began (referred to as the "core" sample) and (2) residents who moved to the study area since service began (referred to as the "new resident" sample). Results are presented below for these two groups separately.

3.1 Longitudinal Analysis of Factors Associated with Travel Changes

Note: The results presented in this section have been adapted from a previous version included in the proceedings of the 2014 Conference of the Association of Collegiate Schools of Planning. (Spears, S., Boarnet, M. G., Houston, D., 2014, "Do Travel Effects of New Light Rail Service Persist? An examination of longer-term impacts of Los Angeles' Expo Line on travel behavior")

3.1.1 Analytical Objectives

We used a quasi-experimental, longitudinal study design to evaluate the impact of the Expo Line on the travel patterns of nearby residents. Using the core sample, we investigated changes in key travel patterns between the phase 1 data before the Expo Line opened and Phases 2 and 3 after the Expo Line service began using descriptive and multivariate analysis of factors associated with potential changes in key outcome variables (the number of trips by travel mode, the duration of trips using active modes, and household vehicle miles traveled).

3.1.2 Analytical Approach

The analysis in this section examines data for the "core" longitudinal Expo sample to assess changes in key travel outcome variables between the Phase 1 data collection period (Fall 2011) before the Expo line opened and Phases 2 and 3 after the Expo line service began (Fall 2012 and Fall 2013). We used a quasi-experimental study design to assess the impact of the Expo Line on the travel behavior of existing residents. We selected experimental neighborhoods within walking distance of new stations (the "experimental" group which received the new service), and comparison neighborhoods with similar built environment and socio-demographic characteristics (the "control" group which did not receive the new service). For the analysis in this section, we define experimental neighborhoods as areas within a 1 kilometer (5/8 mile) radius of the six westernmost stations. This distance corresponds with a home to station walking time of approximately 15 minutes. Other research indicates that ½ and ¾ mile radius circles produce the best fitting models of residence-based transit catchment areas.[80] Households within the 1 kilometer (5/8 mile) radius fall between these two values, and data collected for this study show high correspondence between this catchment area and actual use of the new light rail facilities. Six months after the opening of the Expo Line, more than 26 percent of households within 1 kilometer of a station used light rail, compared to 6 percent of those in the study area who were further away.

In order to evaluate the effect of the opening of the Expo Line, we used several analytical techniques. First, we examined between and within group differences using a series of t-tests. Our hypothesis was that no differences in travel behavior existed between experimental and control households before the opening of the Expo Line, due to the similar demographic and built environmental characteristics of the experimental and control households. After the opening of the new service, we expected to find changes in the behavior of our experimental households, but no impact on travel outcomes for control households, who live beyond a 15 minute walk (1 kilometer) from the new light rail stations. In particular, we hypothesized that experimental households near the new Expo Line service would drive less, travel fewer miles by private vehicle, increase their transit ridership, and increase their use of active travel modes (bicycling and walking). We expected these differences to be significant between the two groups after the opening of the new line. Our quasi-experimental study design helps isolate the impact of the new transit service because we expect the travel patterns of both the control and experimental households to be impacted equally by external factors such as changes in fuel prices and regional economic trends. Next, we compared the means of the change in travel behavior for the control and experimental groups. This difference in means reflects the differential effect of the Expo Line opening on those households within 1 kilometer (5/8 mile) of the stations compared to those further away.

Finally, we conducted a difference-in-differences (DID) analysis of the data. DID is an econometric technique commonly used with quasi-experimental panel data to evaluate the effect of a treatment over time. DID analysis assumes that the differences that arise in the control and experimental groups are due only to the treatment – in this case, the opening of the new light rail line. Defining μ_{it} as the mean of the outcome for group i at time t, the DID estimator is $(\mu_{11} - \mu_{01}) - (\mu_{10} - \mu_{00})$, where "i" = 1 for experimental households and "i" = 0 for control households. This estimator can be evaluated using the following regression model:

$$y_{it} = \beta_0 + \beta_1 X_i + \beta_2 T_t + \beta_3 X_i * T_t + \varepsilon_{it}$$

where y_{it} is the outcome for household i at time t, X_i is a dummy variable where 0 represents the control group and 1 the experimental group, and T_t is a dummy variable that takes the value 0 in the before opening period and 1 for the after opening period. The coefficient β_3 on the interaction between X_i and T_t represents the DID estimator. Note that β_3 takes a value of 1 only for experimental households in the after opening time period. The coefficient β_3 is therefore the effect of the treatment (the Expo Line in this case) on the outcome variable. In addition to the basic DID model, we add household size, income, and number of personal vehicles as control variables to account for the independent effect of changes in these three variables. The full model is then:

$$y_{it} = \beta_0 + \beta_1 X_1 + \beta_2 T_t + \beta_3 X_1 * T_t + \beta_4 X_2 + \beta_5 X_3 + \beta_6 X_4 + \varepsilon_{it}$$

where X_1 is an experimental/control flag, X_2 is household size, X_3 is household income, and X_4 is the number of vehicles available to the household. See, e.g., Card and Krueger (1994) for a discussion of difference-in differences analysis. We use the regression above to obtain DID estimates of the effect of the Expo Line on each of the travel behavior variables.

3.1.3 Sample Characteristics

In total, we obtained usable travel, socio-demographic, and attitude/preference data from 284 households before the opening of the Expo Line (Phase 1), 204 6 months after opening (Phase 2)

and 173 18 months after opening (Phase 3). Retention rate between the first two waves was 72 percent, and 61 percent of households surveyed before the opening completed all three waves of the study. The before and after opening sample are comprised of a 60/40 percent split between experimental and control areas.

Table 3.1 shows descriptive demographic statistics for households that participated in all three waves of the study, divided into experimental and control groups. The experimental and control samples are very similar in most respects throughout the three waves of the study. A greater proportion of household in the control areas had annual incomes below $35,000, with 38 percent on experimental households in the lowest income category compared to approximately 46 percent of control households. Approximately 65 percent of households lived at their current address for more than 5 years at the time of the before opening survey. About 75% had been at their address for more than 5 years at the time of our final survey period, 18 months after the opening of the new line.

Table 3.2 shows travel behavior outcome variables for the households that participated in all three waves of the study. All variables are household daily averages. Vehicle miles traveled was computed from vehicle odometer readings provided on a daily basis for each household vehicle. In order to minimize the impact of long trips on our analysis, individual vehicle daily mileage was censored at a maximum of 200 miles. Our rationale for this cutoff point is that trips beyond this distance likely reflect travel outside of the metropolitan Los Angeles area, and therefore do not reflect typical travel patterns. A total of 32 out of 5377 (0.6%) vehicle-day observations were censored at 200 because of high mileage.

Average household VMT for the sample decreased more than 2 miles per day 6 months after the opening, from a baseline of 26.5 miles, but then increased by more than 3.5 miles per day between the 6 and 18 month point. Similarly, daily car driver trips initially decreased slightly after the opening of the Expo Line, but increased to pre-opening levels at 18 months after opening. Rail trips tripled after the opening of the line and appeared to stabilize, though they accounted for only about 0.2 trips per household per day in both after-opening periods. Bus trips showed a slight declining trend from 0.6 trips per day before opening to 0.5 trips per day 18 months after opening. This trend is not surprising considering that bus routes in the study area were restructured following the opening of the light rail service, and a bus service that ran along the approximate route of the Expo Line was eliminated. Total trips were steady at about 7 per day per household throughout the period. Note that the standard deviations for most travel variables are as large as their corresponding mean values, suggesting high variability in the data.

Table 3.1. Before and After Opening Sample Characteristics, Core Sample

	Phase 1 Before Opening				Phase 2 6 Mo. After Opening				Phase 3 18 Mo. After Opening			
	Experimental		Control		Experimental		Control		Experimental		Control	
	N	%	N	%	N	%	N	%	N	%	N	%
Household Income												
less than $35k	38	37.6%	31	47.7%	38	37.3%	29	43.3%	39	37.9%	31	46.3%
$35k to $75k	39	38.6%	22	33.8%	39	38.2%	26	38.8%	38	36.9%	23	34.3%
more than $75k	24	23.8%	12	18.5%	25	24.5%	12	17.9%	26	25.2%	13	19.4%
Total	101	100.0%	65	100.0%	102	100.0%	67	100.0%	103	100.0%	67	100.0%
Home Ownership												
Rent	53	51.0%	39	60.0%	53	51.5%	37	56.9%	52	51.0%	36	52.9%
Own	51	49.0%	26	40.0%	50	48.5%	28	43.1%	50	49.0%	32	47.1%
Total	104	100.0%	65	100.0%	103	100.0%	65	100.0%	102	100.0%	68	100.0%
Housing Tenure												
Less than 1 year	5	5.1%	3	4.8%	1	1.1%	0	0.0%	3	2.9%	4	5.8%
1 to 5 years	32	32.7%	18	29.0%	31	32.6%	22	33.3%	22	21.6%	14	20.3%
5 years or more	61	62.2%	41	66.1%	63	66.3%	44	66.7%	77	75.5%	51	73.9%
Total	98	100.0%	62	100.0%	95	100.0%	66	100.0%	102	100.0%	69	100.0%
	mean	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**
Household Size	2.01	1.28	2.18	1.18	1.87	1.18	1.88	1.20	1.97	1.24	2.17	1.22
Number of Vehicles	1.23	0.78	1.38	0.85	1.26	0.79	1.32	0.76	1.31	0.83	1.36	1.03
Licensed Drivers	1.50	0.65	1.63	0.81	1.41	0.57	1.57	0.80	1.43	0.77	1.54	0.90
Age												
Under 12 years old	0.24	0.61	0.24	0.55	0.23	0.60	0.24	0.55	0.26	0.67	0.20	0.50
12 to 17 years old	0.15	0.52	0.19	0.40	0.12	0.45	0.07	0.26	0.11	0.39	0.19	0.46
18 to 64 years old	1.27	0.87	1.31	0.94	1.26	0.85	1.32	0.98	1.14	0.86	1.28	1.03
65 years old or older	0.27	0.58	0.25	0.50	0.26	0.54	0.25	0.50	0.34	0.62	0.32	0.58
male	0.60	0.77	0.59	0.74	0.62	0.73	0.56	0.68	0.57	0.76	0.54	0.68
female	1.05	0.58	1.12	0.76	1.02	0.59	1.09	0.75	1.02	0.57	1.19	0.86

Table 3.2. Travel Outcome Descriptive Statistics

Variable	Survey Period	N	Min.	Max.	Mean	S.D.
VMT	Before opening (Phase 1)	166	.00	139.00	26.53	25.79
	6 mo. after opening (Phase 2)	166	.00	127.00	24.25	22.34
	18 mo. after opening (Phase 3)	169	.00	218.00	27.83	29.90
Car trips	Before opening (Phase 1)	172	.00	13.29	3.34	2.97
	6 mo. after opening (Phase 2)	169	.00	11.71	3.17	2.75
	18 mo. after opening (Phase 3)	169	.00	16.57	3.53	3.33
Bus trips	Before opening (Phase 1)	172	.00	12.00	.59	1.36
	6 mo. after opening (Phase 2)	171	.00	6.57	.55	1.12
	18 mo. after opening (Phase 3)	172	.00	8.57	.46	1.10
Rail trips	Before opening (Phase 1)	172	.00	2.00	.06	.24
	6 mo. after opening (Phase 2)	171	.00	3.57	.18	.52
	18 mo. after opening (Phase 3)	173	.00	3.86	.22	.64
Walk trips	Before opening (Phase 1)	172	.00	13.71	1.38	1.91
	6 mo. after opening (Phase 2)	170	.00	9.57	1.50	1.91
	18 mo. after opening (Phase 3)	171	.00	14.00	1.48	2.07
Bike trips	Before opening (Phase 1)	172	.00	4.00	.19	.63
	6 mo. after opening (Phase 2)	171	.00	7.71	.28	.99
	18 mo. after opening (Phase 3)	173	.00	3.43	.22	.57
Transit Trips	Before opening (Phase 1)	172	.00	12.00	.65	1.45
	6 mo. after opening (Phase 2)	171	.00	6.86	.73	1.44
	18 mo. after opening (Phase 3)	172	.00	9.00	.68	1.48
Total trips	Before opening (Phase 1)	172	.86	42.00	6.64	5.59
	6 mo. after opening (Phase 2)	168	.57	33.86	6.68	5.24
	18 mo. after opening (Phase 3)	166	.57	35.43	6.94	5.76

3.1.4 Impacts on Travel Outcomes

Table 3.3 shows the between-group differences for travel in the experimental and control households 6 months before and 6 and 18 months after the opening of the Expo Line. Before the Expo Line opened, there were no statistically significant differences in travel between the experimental and control households, with one exception. Households in the experimental areas made significantly more walking trips. Six months after the opening of the line however, there were several significant differences between households within 1 kilometer of a new station and those further away. First, experimental households traveled 6 fewer vehicle miles per day compared to control households. Experimental households, within 1 kilometer of a new station, also had more than six times as many rail transit trips (0.26 versus 0.04 per day), continued to walk more, and bicycled more compared to control households. The increase in active (bicycle and walk) travel is notable, since the experimental households were located within walking distance of the new rail service, while control households were not.

At 18 months after the opening of the Expo Line, differences in VMT and train trips remained significant (Table 3.3). Though VMT increased for both groups between the 6 month and 18 month survey periods, the difference in household VMT increased from 6.1 to 9.4 miles per day. Though the gap between train trips between groups decreased somewhat between 6 and 18 months, experimental households took 0.2 additional daily rail trips, significantly higher than control households. Train usage increased slightly in both groups compared to 6 months after the opening. However, the differences in active travel decreased in the period from 6 to 18 months after opening. Though active trip rates remained slightly higher for experimental households, no significant differences between groups existed in the final wave of the study. Figures 3.1 and 3.2 graphically represent differences across groups in VMT and train trips.

As a second test of the Expo line's travel impact, we developed difference-in-differences (DID) regression models for all travel outcome variables. Table 3.4 shows the results of the DID analysis. To evaluate the impact of light rail over time, DID estimates were obtained for each of the after opening time periods (6 and 18 months after opening). For VMT, the "treatment" effect on households within 1 kilometer of the line was a reduction of 7.7 miles per day, though this change was not statistically significant. Note, we conducted a supplemental difference-in-differences model developed for the 6 month before and after opening data only, using a balanced panel of those who responded in the first two waves. The results for this larger supplemental sample ($N = 205$) show a significant VMT decrease ($\beta = -9.10$, $p = 0.03$) for experimental households.

Eighteen months after opening, households close to Expo Line stations drove nearly 11 fewer miles per day. This difference was significant at the 0.05 level. Among the other travel outcomes, the only significant change was in train use. At both 6 and 18 months after opening, the effect of the new line on households living within 1 kilometer was an increase of approximately 0.2 train trips per day.

Table 3.3. Before and After-Opening Between Groups Differences, Experimental Versus Control Group

		Phase 1 Before Opening					Phase 2 6 Mo. After Opening					Phase 3 18 Mo. After Opening				
Variable	**Study Group**	**N**	**Mean**	**Mean Diff.**	**t**	**Sig.**	**N**	**Mean**	**Mean Diff.**	**t**	**Sig.**	**N**	**Mean**	**Mean Diff.**	**t**	**Sig.**
VMT	Experimental	100	26.49	-0.10	-0.03		102	21.89	-6.12	-1.73	°	101	24.07	-9.36	-2.01	*
	Control	66	26.59				64	28.01				68	33.43			
Car driver trips	Experimental	105	3.30	-0.09	-0.20		103	3.08	-0.23	-0.51		100	3.41	-0.29	-0.57	
	Control	67	3.39				66	3.31				69	3.70			
Bus trips	Experimental	105	0.63	0.11	0.51		104	0.55	0.00	0.01		103	0.44	-0.06	-0.35	
	Control	67	0.52				67	0.55				69	0.50			
Train trips	Experimental	105	0.06	0.00	0.05		104	0.26	0.22	3.29	**	104	0.30	0.21	2.49	*
	Control	67	0.06				67	0.04				69	0.09			
Total Transit Trips	Experimental	105	0.69	0.11	0.49		104	0.82	0.23	1.06		103	0.74	0.15	0.66	
	Control	67	0.58				67	0.59				69	0.59			
Walk trips	Experimental	105	1.63	0.64	2.42	*	103	1.71	0.54	1.99	*	103	1.58	0.24	0.73	
	Control	67	0.99				67	1.17				68	1.34			
Bicycle trips	Experimental	105	0.18	-0.02	-0.14		104	0.38	0.25	1.98	*	104	0.24	0.04	0.43	
	Control	67	0.20				67	0.13				69	0.20			
Total Trips	Experimental	105	6.86	0.57	0.66		102	6.98	0.77	0.93		98	6.86	-0.22	-0.25	
	Control	67	6.29				66	6.21				68	7.08			

Significance codes: ** < 0.01, * < 0.05, ° < 0.10

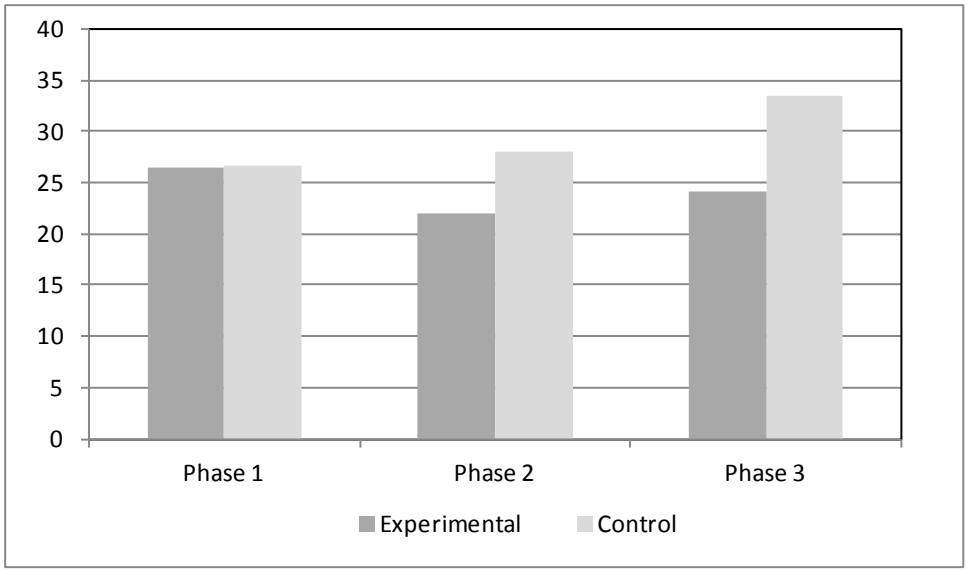

Figure 3.1. VMT, Before and After-Opening by Group

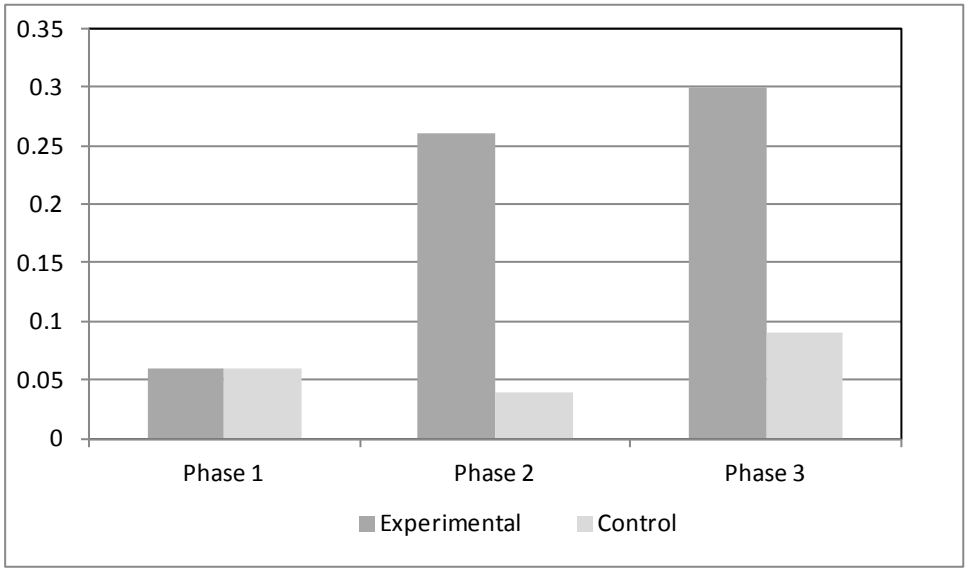

Figure 3.2. Train trips, Before and After-Opening by Group

Table 3.4. Differences-in-Differences Estimation Results

Travel Outcome	DID Est. 6 mo. After opening	S.E.	t	Sig.	DID Est. 18 mo. After opening	S.E.	t	Sig.	Model Adj. R-sq.
VMT	-7.69	5.08	-1.52		-10.90	5.04	-2.16	*	0.29
Car Driver Trips	-0.16	0.55	-0.29		-0.25	0.55	-0.45		0.35
Bus Trips	-0.20	0.23	-0.87		-0.12	0.23	-0.50		0.26
Train Trips	0.20	0.11	1.86	°	0.22	0.11	2.06	*	0.09
Total Transit Trips	0.00	0.00	0.00		0.11	0.28	0.38		0.25
Active Trips	-0.05	0.46	-0.11		-0.36	0.46	-0.79		0.18
Total Trips	-0.33	0.96	-0.35		-0.73	0.96	-0.77		0.41

Significance codes: ** < 0.01, * < 0.05, ° < 0.10

The results indicate that significant changes did take place in the driving behavior of households located in close proximity to the newly opened Expo Line stations. This change could be attributable to the substitution of car trips for train trips, which increased significantly as well. However, even in the after opening period, train trips constitute a small share of overall travel. Rail mode share for the experimental households was only 4.4% 18 months after the opening of the Expo Line stations. It seems unlikely therefore that substitution of rail for car travel could completely account for the change in VMT. An alternate hypothesis could be that a combination of mode substitution and changes in car use are responsible for the VMT drop in experimental households. To test this, we examined changes in average car trip length for the two groups before and after the Expo Line opening (Table 3.5). Average trip length was calculated by dividing total VMT by total car driver trips for each household. Independent sample t-tests were then computed to compare the experimental and control trip lengths in the before and after opening periods.

Table 3.5 shows the total number of households with valid observations in each wave of the study, along with the number and percentage of households that drove at least once during that wave. For control households, the percentage of households that drove increased slightly from 85 to 87 percent over the three survey periods. In contrast, the percentage of households in the experimental areas that drove declined from over 86 percent to 83 percent. With regard to difference in trip length, the average trip of control households was longer than that of experimental households in all three observation periods. However, the difference in trip length was significant in the 18 month after opening sample (-3.9, p=0.069). Considering all households, and coding households with no car trips as having a mean car trip length of zero, a similar pattern exists. Households within 1 kilometer of the new light rail stations drove an average of 3.75 fewer miles per car trip. While not conclusive, these results give some indication that the opening of the Expo Line affected car use in the expected manner. Households within 1 kilometer of the new stations reduced their trip lengths compared to households further away.

In order to gain more insight into possible effects of train ridership changes, we also examined differences in travel behavior between households that used the train and those that did not (Table 3.6). The results show that average driving trip length declined over time for households

that used the train while non-train household trip length remained relatively constant. Before the opening of the line, train user households drove an average of 11 miles per car trip, approximately 1 mile per day more than non-train users. This could be expected, due to the fact that the few households that used the train at before the Expo Line opened would have had to travel outside of their neighborhood to reach a station. Six months after the opening of the new light rail line, average car trip length for rail users dropped to less than 8 miles. At the final observation period 18 months after the opening of the line, households that used the train averaged slightly more than 4 miles per car trip, compared to 10 miles per trip for non-train users. In addition, the difference in VMT between train users and others in the final period is 11.3 miles. These results add further evidence that the opening of the Expo Light Rail line had a significant impact on travel behavior among residents living within 1 kilometer of the new stations, resulting in shorter car trips and fewer vehicle miles traveled.

Table 3.5. Independent Sample T-test Comparison of Average Vehicle Trip Lengths

Survey Period	Group	Total Households	House-holds w/ Car Trips	Percent with Car Trips	Mean Trip Length	S.D.	Mean Diff.	t	Sig.
Before Opening (Phase 1)	experimental	105	91	86.7	10.37	11.80	-3.35	-1.03	
	control	67	57	85.1	13.72	22.10			
6 Months After Opening (Phase 2)	experimental	103	89	86.4	9.22	10.11	-1.93	-1.04	
	control	66	57	86.4	11.15	11.52			
18 Months After Opening (Phase 3)	experimental	100	83	83.0	8.69	9.04	-3.90	-1.84	°
	control	69	60	87.0	12.59	14.31			

Significance codes: ** < 0.01, * < 0.05, ° < 0.10

Table 3.6. Comparison of Train-user and Non-user Household Travel

	Phase 1 6 Months Before Opening					Phase 2 6 Months After Opening					Phase 3 18 Months After Opening				
	Train Users (n = 16, 9.3%)		Non-train Users (n =156, 90.7%)			Train Users (n = 32, 18.7%)		Non-train Users (n =139, 81.3%)			Train Users (n = 35, 20.3%)		Non-train Users (n = 138, 79.7%)		
Travel Outcome	Mean	S.D.	Mean	S.D.	Sig.	Mean	S.D.	Mean	S.D.	Sig.	Mean	S.D.	Mean	S.D.	Sig.
Household VMT	15.05	38.29	27.60	24.32	°	18.97	23.92	25.28	21.92		18.70	22.78	30.04	31.05	°
Car Trip Length	11.12	36.87	9.87	12.59		7.80	11.32	8.72	10.32		4.14	4.52	9.81	12.22	***
Driver Trips	0.96	1.94	3.58	2.96	***	2.06	2.95	3.43	2.65	*	2.39	2.79	3.81	3.41	*
Walk Trips	1.82	1.02	1.34	1.98		3.40	2.67	1.07	1.39	***	2.63	2.79	1.20	1.75	**
Bicycle Trips	0.37	0.88	0.17	0.60		0.65	1.27	0.20	0.89	*	0.16	0.33	0.24	0.62	
Total Trips	6.81	3.32	6.63	5.78		10.42	7.16	5.83	4.30	**	8.64	6.52	6.53	5.50	°
Cars Available	0.75	0.86	1.34	0.78	**	1.09	1.03	1.32	0.70		1.09	1.29	1.39	0.78	°
Household Size	1.88	1.03	2.10	1.26		2.19	1.38	1.81	1.14		2.20	1.41	2.01	1.19	

Significance codes: ***<0.001, ** < 0.01, * < 0.05, ° < 0.10

3.2 Comparison of New Residents vs. Long-Term Residents

3.2.1 Analytical Objectives

Previous studies suggest the aggregate impact of a compact, transit-oriented development or transit investment on the travel of nearby residents is influenced by the behavior of residents who relocated from outside the area to live near LRT because they prefer to live in denser, mixed-use, and transit-accessible areas.[24, 30-32] We analyzed households in the new resident sample collected in phases 2 and 3 to compare the influence of LRT on both long-term and new nearby residents and to assess potential differences in travel patterns between new residents and long-term residents. We also investigated the value that residents place on living near transit to help assess the role of residential preferences to live near LRT or walkable communities.[38, 39]

3.2.2 Sample Characteristics, New Resident Households versus Core Households

As reported in section 2.4, households in the new resident sample tended to be younger, had a higher rate of renting their homes, and had higher income than households in the core sample. The core and new resident samples were similar in terms of household size, vehicle ownership, and number of household members with driver's licenses.

3.2.3 Travel Patterns, New Resident Households versus Core Households

For all samples, we obtained a comprehensive set of travel outcomes from travel diaries and vehicle odometer logs. For the core sample, diaries and logs were completed for seven consecutive days, though the participants' start and end day of the week varied. For the new resident sample, we collected the same data, but over a three day period. New resident households always recorded their travel between Tuesday, Wednesday and Thursday. Therefore, in the following comparisons of the travel patterns between new resident households with those of core households, we restrict the core household travel data they reported for Tuesday, Wednesday and Thursday. Table 3 summarizes the mean number of trips taken by mode for each sample group. Summary data from the California Household Travel Survey (CHTS) is listed for comparison.

The CHTS data include all of Los Angeles County, California, which contains not only the dense urban core of the city of Los Angeles, but also smaller cities, suburban neighborhoods, and a considerable rural area. Therefore, it is not surprising that the samples from the Expo study area, which is moderately dense and urban, show higher transit usage, lower daily personal vehicle trips, and slightly higher active travel (walk and bicycle) usage (Table 3.7). The overall vehicle miles traveled (VMT) for core households was lower than the CHTS sample (26-29 miles vs. 35 miles) and the VMT for the new resident households was similar to the CHTS sample (34-36 miles vs. 35 miles).

Table 3.7. Mean daily trip counts and VMT for Expo Samples and CHTS

All Households			**Phase 1 6 Months Before Opening**		**Phase 2 6 Months After Opening**				**Phase 3 18 Months After Opening**			
	LA County CHTS		**Core**		**Core**		**New Resident**		**Core**		**New Resident**	
	(n = 8,219)		**(n = 284)**		**(n = 207)**		**(n = 90)**		**(n = 173)**		**(n = 78)**	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Personal Vehicle (driver + passenger)	6.39	6.61	4.22	4.00	4.03	3.73	3.73	2.43	4.38	4.37	3.86	2.64
Bus	0.33	1.43	0.60	1.63	0.64	1.44	0.50	1.23	0.43	1.15	0.52	1.35
Rail transit	0.07	0.59	0.09	0.37	0.19	0.57	0.28	0.72	0.16	0.49	0.21	0.56
Walk	1.36	3.24	1.50	3.20	1.60	1.98	1.78	2.03	1.40	2.12	1.29	1.55
Bike	0.11	0.72	0.16	0.62	0.29	1.19	0.08	0.26	0.24	0.69	0.22	0.71
Other	0.11	0.63	0.35	3.25	0.03	0.26	0.02	0.14	0.02	0.17	0.00	0.00
Total trips	8.37	7.88	6.98	6.69	6.82	5.11	6.43	3.20	6.76	5.37	6.18	3.46
VMT	35.15	46.15	25.84	26.15	26.46	28.52	33.87	36.08	28.94	33.48	35.65	37.01

Table 3.8 shows transportation mode choice split in each of the samples. Personal vehicle use was 12-19 percentage points lower for all Expo samples compared to the CHTS sample of Los Angeles County. Bus use was nearly twice the LA County rate for all Expo samples. Although the before-opening rail use rate of 0.9% was nearly equal to LA County as a whole (0.8%), the after-opening rate for the core and new residents were 3 to 5 times higher. In addition, residents in the study households tended to have a higher percentage of walking and bicycling trips compared to the county as a whole. Again, this may be expected since the study neighborhoods are located in a relatively dense residential setting with a mix of land uses.

3.2.4 Travel Comparisons for Core and New Residents in Experimental Areas

One of the goals of this research was to evaluate differences in travel between core sample households that were established in the study neighborhoods before the opening of the Expo Line and new resident households who moved in afterward. This comparison is important in the context of residential self-selection given previous researcher suggests people choose their residential location at least partially based on their travel preferences, and that these preferences must be taken into account when evaluating the true effect of land use patterns and transportation infrastructure on travel. We therefore expect that households that move into residences close to the new Expo stations would use light rail more than those who chose their residence before the line existed. We might also expect new resident households close to stations to drive less, based on their preference to be located in an area with greater public transportation access.

In order to examine differences between new resident and core households, we conducted several comparisons of the demographic characteristics and travel patterns. Table 3.9 shows demographics for the core and new resident households that reside in the experimental neighborhoods within 1 kilometer of Expo Line stations. Although the household income levels for the full sample of new resident households and core households were similar (or slightly higher for new residents), new resident households in experimental neighborhoods tended to have lower incomes than core households in experimental neighborhoods. Homeownership patterns in experimental areas were similar to the overall samples for both groups, with approximately ¾ of new resident households renting compared to about ½ of core households.

A slightly higher percentage of new resident experimental households indicated that they typically use the train for their commute, and a higher percentage of new resident experimental households also indicated that they commute by car. This pattern suggest that new resident experimental households vary their commute mode more often than core experimental households. This difference was larger in the final wave of the study. However, this difference may reflect differences in employment levels between the groups as much as it does travel preferences. While nearly 80 percent of main respondents in both groups reported being employed 6 months after the opening of the Expo Line, only about 67 percent of core main respondents in the experimental area reported being employed at the time of the final survey, compared to 97 percent of new resident main respondents in the experimental area. In terms of household size, composition, and vehicle ownership, both groups appear similar, though new resident experimental households tended to have fewer children between the ages of 12 and 17 in their households.

Table 3.8. Mode Split Comparison for Expo Samples and CHTS

			6 Months Before Opening 6 Months Before Opening		6 Months After Opening 6 Months After Opening				18 Months After Opening 18 Months After Opening			
	LA County CHTS		Core		Core		New Resident		Core		New Resident	
	(n=8219)		(n = 284)		(n = 207)		(n = 90)		(n = 173)		(n = 78)	
Mode	**Trip Count**	**Percent**	**Trip Count**	**Percent**	**Trip Count**	**Percent**	**Trip Count**	**Percent**	**Trip Count**	**Percent**	**Trip Count**	**Percent**
Personal Vehicle (driver + pass)	52526	76.4	8595	63.2	6042	61.6	980	57.6	5292	64.6	892	62.5
Bus	2714	3.9	1076	7.9	815	8.3	128	7.5	555	6.8	121	8.5
Rail transit	580	0.8	126	0.9	275	2.8	71	4.2	263	3.2	48	3.4
Walk	11137	16.2	2864	21.0	2193	22.4	483	28.4	1772	21.6	303	21.2
Bike	898	1.3	289	2.1	380	3.9	20	1.2	271	3.3	51	3.6
Other	900	1.3	657	4.8	106	1.1	18	1.1	44	0.5	13	0.9
Total trips	68755	100.0	13607	100.0	9811	100.0	1700	100.0	8197	100.0	1428	100.0

Table 3.9. Demographic Comparison for Experimental Households

	6 Months After Opening				18 Months After Opening			
	Core (N=128)		New Resident (N=35)		Core (N=104)		New Resident (N=32)	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Household Income								
less than $15k	22	17.5	3	8.8	20	19.4	5	16.1
$15k to $35k	22	17.5	13	38.2	19	18.4	9	29.0
$35k to $55k	29	23.0	8	23.5	17	16.5	6	19.4
$55k to $75k	15	11.9	3	8.8	21	20.4	2	6.5
$75k to $100k	20	15.9	3	8.8	13	12.6	5	16.1
more than $100k	18	14.3	4	11.8	13	12.6	4	12.9
Total	126	100	34	100	103	100	31	100
Home Ownership								
Rent	70	55.6	26	74.3	52	50.5	25	78.1
Own	55	43.7	8	22.9	50	48.5	7	21.9
Other	1	0.8	1	2.9	1	1.0	0	0.0
Total	126	100	35	100	103	100	32	100
Employment Status								
Employed	101	78.9	28	80.0	70	67.3	30	96.8
Not Employed	27	21.1	7	20.0	34	32.7	1	3.2
Total	128	100	35	100	104	100	31	100
Typical Commute by Train								
Yes	13	10.2	5	14.3	12	11.5	6	19.4
No	115	89.8	30	85.7	92	88.5	25	80.6
Total	128	100	35	100	104	100	31	100
Typical Commute by Car								
Yes	76	59.4	23	65.7	53	51.0	21	67.7
No	52	40.6	12	34.3	51	49.0	10	32.3
Total	128	100	35	100	104	100	31	100
	mean	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**	**mean**	**S.D.**
Household Size	1.85	1.15	1.89	0.83	1.97	1.24	2.06	1.11
Under 12 years old	0.23	0.6	0.24	0.56	0.26	0.67	0.28	0.68
12-17 years old	0.12	0.45	0.03	0.17	0.11	0.39	0	0
18 years old or older	1.51	0.7	1.63	0.6	1.61	0.83	1.78	0.71
Number of Vehicles	1.27	0.79	1.41	0.56	1.31	0.83	1.34	0.65
Number of Driving Licenses	1.44	0.62	1.56	0.5	1.43	0.77	1.61	0.72

Examining differences in travel outcomes between the core and new resident experimental households shows several significant differences (Table 3.10). First, as expected, new resident households tended to use the train more frequently than core households. In each wave of the study, new resident households made approximately 0.2 more rail trips per day. At 18 months after opening of the Expo Line, new resident experimental household rail trip rates were more than double that of core experimental households. This difference was statistically significant at the 0.10 level. These differences are consistent with the notion that households moving to areas near the stations are doing so at least partly due to a preference for rail access.

The other area where a significant difference exists between the core and new resident experimental households is in personal vehicle use, though the difference is not what might be expected. In both waves, new resident households drove more miles and took longer car trips than core households. Though the expectation was that new resident households close to stations might drive less than core experimental households, this unexpected pattern may be partially due to employment levels, or demographic differences between the two groups, though the underlying causes are not entirely clear based on available data.

Table 3.10. Travel Outcome Comparison for Experimental Households

	6 Months After Opening					**18 Months After Opening**				
	Core		**New Resident**			**Core**		**New Resident**		
	(n = 128)		**(n =33)**			**(n = 104)**		**(n = 31)**		
	Mean	**S.D.**	**Mean**	**S.D.**	**Sig.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Sig.**
VMT	23.36	25.28	31.43	33.4	*	25.17	25.92	34.38	35.76	
Car Driver	3.41	2.97	2.97	1.87		3.74	3.52	3.03	2.04	
Car Passenger	0.59	1.18	0.38	0.54		0.53	1.04	0.75	1.09	
Bus	0.61	1.44	0.31	0.94		0.39	0.99	0.54	1.71	
Rail transit	0.28	0.57	0.48	1.03		0.21	0.59	0.43	0.81	°
Walk	1.78	1.98	1.99	1.92		1.42	2.17	1.19	1.43	
Bike	0.38	1.19	0.12	0.49		0.25	0.68	0.29	0.96	
Total trips	7.05	5.11	6.25	3.01		6.58	4.77	6.06	3.77	
Avg. Car Trip Length	7.60	11.61	16.61	29.63	**	7.53	10.72	11.89	2.18	°

Significance: ** < 0.01, * < 0.05, ° < 0.10

3.2.5 New Resident Housing Preferences and Move Characteristics

New residents were asked a series of supplemental questions about the move to their current address. These included the distance between their old and current residence, and the housing, transportation, and neighborhood characteristics that were important factors in their choice of where to live.

Figure 3.1 shows move distance for the 111 new resident sample households, including both new resident households who participated in the phase 2 data collection period and the supplemental

sample of new resident households who participated in the phase 3 data collection period. Approximately 2/3 of households moved less than 10 miles to their current address and more than 1/3 moved 5 miles or less. Approximately 16 percent moved from locations more than 100 miles away.

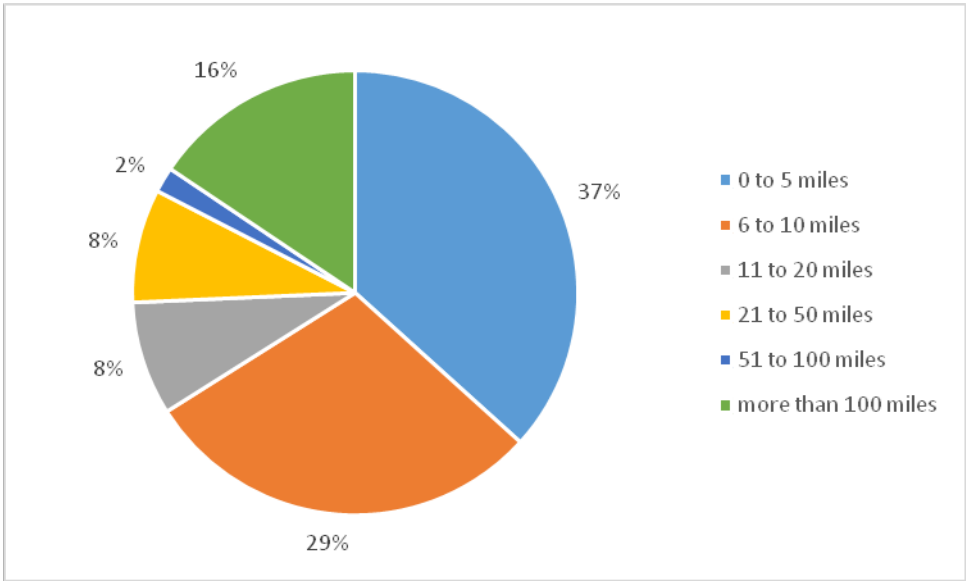

Figure 3.3. Move Distance for Expo New Resident Sample

The main respondent in each new resident household was asked to rank the importance of a number of factors related to the decision to move to their current residence. Each item was rated on a scale of 1 (not important at all) to 7 (extremely important). Table 3.12 shows the results. The dominant attribute was housing affordability (6.5 out of 7.0). Low crime (5.6) was next in importance, followed by housing quality (5.3). Neighborhood visual attractiveness, commute time, and access to shops and services were next in the ranking, and all were rated at approximately 5.2 out of 7 for importance. Least important attributes were generally related to amenities for children, including school quality (2.9), distance to school or daycare (2.3), and child care access (1.9). Access to transit, both generally (4.2) and rail specifically (4.0) ranked in the lower half in importance, and both were rated below highway access (4.6) in importance.

Statistically significant differences in the rankings between experimental and control households were only apparent in two categories. New resident households in the experimental group ranked access to the rail transit system higher compared to households in the control group (4.5 vs 3.7). New resident households in the experimental group also ranked access to childcare higher compared to households in the control group (2.3 vs 1.7).

Table 3.12. Housing Characteristic Importance Ranking for New Residents

	All Households			Experimental Households			Control Households			
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**	**Sig.**
Housing affordability	109	6.50	1.015	42	6.60	0.89	67	6.43	1.09	
Low crime	107	5.63	1.377	42	5.45	1.40	65	5.74	1.36	
A particular type/quality of housing in the neighborhood	109	5.30	1.572	43	5.14	1.61	66	5.41	1.55	
Access to shops and services (grocery stores, etc.)	110	5.18	1.621	43	5.14	1.61	67	5.21	1.64	
Short commute to your workplace or school	109	5.17	2.007	43	5.23	1.97	66	5.12	2.04	
Visual attractiveness of the neighborhood	109	5.17	1.351	43	4.93	1.40	66	5.32	1.30	
Access to open space (parks, beaches, mountains, etc)	108	4.71	1.697	43	4.58	1.69	65	4.80	1.71	
Lower traffic noise or safety from traffic	109	4.70	1.681	43	4.60	1.61	66	4.76	1.74	
Access to highways, generally	86	4.64	1.814	29	4.52	1.70	57	4.70	1.88	
Access to public transit, generally	108	4.41	2.114	43	4.58	2.05	65	4.29	2.16	
Near to family and friends	109	4.17	2.124	43	4.00	2.10	66	4.27	2.15	
Access to the rail transit system (Metro subway or light rail)	109	4.01	2.162	43	4.49	2.11	66	3.70	2.16	°
Short commute to work/school for other household adult	106	3.99	2.467	41	3.66	2.59	65	4.20	2.39	
Wanted to live near certain kinds of people/households (families with children, ethnic or cultural group, etc)	109	3.71	2.118	43	3.63	1.99	66	3.76	2.21	
Familiarity with the neighborhood	108	3.67	2.082	43	3.77	2.08	65	3.60	2.10	
Quality of the public schools	108	2.92	2.337	43	3.02	2.40	65	2.85	2.31	
Short trip to school/daycare for children in your household	103	2.25	2.252	41	2.12	2.16	62	2.34	2.33	
Access to child care	107	1.93	1.941	43	2.33	2.20	64	1.66	1.71	°
Wanted to move in with someone in the neighborhood	107	1.75	1.549	43	1.91	1.63	64	1.64	1.50	

All items measured on a scale of 1 (not important at all) to 7 (extremely important)

Significance codes indicates statistically significant difference in the mean for experimental vs. control households: ** < 0.01, * < 0.05, ° < 0.10

Main respondents in the new resident survey were also asked to indicate which travel modes were important in the decision to move to their current residential location. Respondents indicated as many travel modes as they wished for the following purposes: their personal commute, commute of others in the household, trips to school or day care, and access to shops and services.

Table 3.13 shows the percentage of respondents that indicated a given travel mode as important for each purpose. For each journey type, personal vehicle was selected as important more often than any other travel mode. Bus and train were more often listed as important for commute trips than for school or shopping trips. Interestingly, more than 60 percent of respondents listed walking as an important mode for access to shops and services, and nearly 30 percent indicated walking was important for their personal commute. This could indicate a preference among new residents for living within walking distance to a mix of land uses, despite the importance placed on car accessibility.

Table 3.13. Modes Indicated as Important in the Choice of Housing by Purpose (%)

	Personal Commute	**Other HH Member Commute**	**School/Day Care**	**Access to Shops/Services**
Walk	30.0	19.1	8.2	64.5
Bike	13.5	8.2	1.8	20.0
Bus	32.7	35.5	7.3	22.7
Train	30.0	24.5	5.5	18.2
Personal Vehicle	76.1	47.3	17.3	86.4
None / NA	10.9	36.4	73.6	1.8

4. DISCUSSION

Results of longitudinal analysis for the core sample represent the first before-after evaluation of a major rail transit investment in California, and one of the few studies of the before and after effects of light rail on travel behavior. It adds to our understanding of two highly relevant policy questions: does light rail reduce car use, and does it increase the number of active travel trips for households that live close to the line?

On the question of VMT change, the answer appears to be that the new line has had a significant impact over the 18 months since service began. Based on our difference-in-differences analysis of the “core” sample of long-term residents, households within walking distance (1 kilometer) of the new stations decreased their vehicle miles traveled by nearly 8 miles per day 6 months after the opening of the line, and 11 miles per day 18 months after the opening, compared to control households located further away. At 18 months after opening, daily mileage for households close to the line was approximately 25 percent lower than that of control households. This change appears to have resulted primarily from differences in car trip lengths. Average car trip length declined in each wave for the households within walking distance of new light rail stations, resulting in a difference of nearly 4 miles per trip at 18 months after the opening of the Expo

Line. Although we have consistently identified this pattern based on collected data for the core sample, our survey results do not contain sufficient information to fully explain why this pattern occurred. Our results also indicate that train user households, which predominantly reside within walking distance of stations, had average car trip lengths that were only 40 percent of the length for households that did not make any rail trips. These results are consistent with at least one study which estimated that transit availability can have an indirect impact on VMT that is larger than, and independent of, a potential increase in transit use.[81]

The case that the Expo Line impacted physical activity is less clear based on trip log data. Although comparisons of daily mean walk and bicycle trips indicate some increased active travel among households close to the line, control households also increased the number of walking trips over the study period. At the 18 month after opening time period, no significant difference existed between the two groups in terms of walking or bicycling trips.

Results of analysis for the new resident sample provide useful insights into whether proximity to the Expo Line was an important consideration when deciding to move to the area. Respondents ranked access to rail transit as only moderately important in their location decision, and that low housing cost, low crime, and housing quality were more important in their decision. Interestingly, about two-thirds indicated that being able to walk to shops and services was an important factor they considered.

Results also provide insights into whether new residents differ in terms of socio-demographic characteristics and travel patterns from longer-term residents. The new and long-term samples had similar household size, vehicle ownership, and number of household members with driver's licenses, but new residents tended to be younger, had higher home rental rates, and had higher income. In terms of travel behavior, new resident households within walking distance of an Expo station drove 8-10 more miles per day and took longer car trips than long-term households within walking distance of a station. Interestingly, new resident households near a station had household rail trip rates which were more than double that of core households near a station. These patterns suggest that new residents may differ in important ways from long-term residents and that policies should be tailored to maximize their potential for transit ridership and also to maximize the importance they tend to place on neighborhood walkability. These patterns also raise concerns that although new households to rail corridors may be more likely to take rail transit, they may have greater overall vehicle miles traveled and associated greenhouse gas emissions compared to longer-term households.

The current study has several important limitations. First, only 1% of households contacted in the study area responded to the survey, but this response rate is comparable to the response rate for two recent major travel surveys in the region.[75, 76] Analysis of responses based on observable characteristics for subgroups suggests the final sample was largely representative of the study area population. Second, residents of neighborhoods examined are largely low-income and non-white, primarily African-Americans and Hispanics. While understanding the travel impacts and equity of new transportation investments for these groups is an important and understudied area,[82] more research is needed to determine whether the effects of light rail found in the Expo Line study will hold for neighborhoods of different socio-demographic compositions. The same

caveat holds for neighborhoods that differ in terms of built environmental characteristics. While the study areas we investigated are typical of many in the city of Los Angeles (moderate residential density and corridor-oriented commercial areas), the lack of other similar longitudinal studies with a larger sample size makes generalization difficult. Third, it was beyond the scope of the analysis to fully investigate the role that residential self-selection may play in the observed patterns– particularly whether impacts of the line could be due to households moving to the study area to suit their travel and activity preferences.[83] Our study design and findings, however, improve upon previous cross sectional studies on the impact of rail transit by using a longitudinal survey to examine impacts of a new light rail line on longer-term residents and a comparable survey of residents who moved to the area after the new service began.

Overall, the results shown here provide some important insights into the effect of light rail investment on vehicle miles traveled, and by proxy, transportation-related pollution and greenhouse gas emissions. Understanding and quantifying these impacts are crucial if cities are to move forward effectively and efficiently toward a sustainable future. The research methods and evaluation techniques described provide a prototype that can be adapted and improved to answer important questions about the impact of any number of neighborhood-based interventions designed to improve quality of life and decrease the environmental impact of development.

The research benefits ARB's objectives by promoting improved livability across California, the reduction of vehicle emissions through the use of alternative transportation modes, and by evaluating the extent to which small-area land use policies in areas of high policy relevance for SB 375 (such as infill development, transit-oriented land uses, and transportation infrastructure) can enhance California's environment by encouraging reductions in VMT.

5. Summary and Conclusions

The research funded by this ARB contract and discussed in this report represents the final data collection and analysis phase of a multi-year evaluation of the Expo LRT Line which began service in south Los Angeles in 2012 on the travel and activity patterns of long-term residents who have lived in the study area since before service began (referred to as the "core" sample) and residents who moved to the study area since service began (referred to as the "new resident" sample).

The study's quasi-experimental, longitudinal research design enabled us to assess the impact of the line for long-term residents (the "core" sample) and results indicate the line had a significant and policy-relevant impact. For this core sample, the Expo Line was associated with a reduction of 11 household vehicle miles traveled per day 18 months after the opening (relative to control households located further away). This change appears to have resulted primarily from a reduction in average car trip length among households within walking distance of the new stations. At the 18 month after service began, households near the line were not significantly different than control households in terms of walking and bicycling trips.

Residents who moved to the study area after the Expo Line service began tended to be younger, had higher home rental rates, and had higher income than longer-term households, but they were similar in terms of household size, vehicle ownership, and number of household drivers. Although new residents indicated that car accessibility remained important, about two-thirds indicated that being able to walk to shops and services was an important factor in their decision. In terms of travel behavior, new resident households within walking distance of an Expo station drove 8-10 more miles per day compared to longer-term households and took longer car trips compared to longer-term households near a station. Interestingly, these new resident households had rail trip rates which were more than double that of longer-term households near a station.

6. RECOMMENDATIONS

The Expo Line Study is the most comprehensive evaluation of a new light rail transit line on travel behavior and physical activity, and the following future research is needed to extend, clarify and validate the findings of the current study:

- Additional longitudinal evaluations of the impacts of light rail transit and other infrastructure and land use changes on travel behavior
- Greater incorporation of psycho-social, attitudinal, and neighbourhood preference factors in studies of behavior change associated with local land use and transit investments
- Assessments of gentrification processes and residential displacement within rail corridors
- Investigation of land use and development changes associated with light rail investments

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Appendix A. Expo Line Core Sample Study Survey Materials

Appendix A-1: Expo Line Study – Baseline Survey

UNIVERSITY OF CALIFORNIA, IRVINE

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Neighborhood Travel and Activity Study

Neighborhood Travel and Activity Study
Study Information Sheet

You are being asked to participate in a research study about household travel. The purpose of this study is to examine the effects of local employment, shopping, transportation and neighborhood design on the distance people travel and the types of transportation they use.

The research procedures involve the following:

- Survey – After you review this information sheet, you will begin the study's baseline survey which will ask you to answer questions about your household composition, transportation resources, and about your neighborhood. This section should take less than 30 minutes to complete.
- One Week Travel Log – Next, we ask that your household keep a trip log for everyone over 12 years old for one week starting ***on the designated day on your instruction letter***. On the log, you will count the number of trips you take by each travel mode (car, bus, train, etc.) and the number of minutes you spend walking or bicycling each day. We will also ask you to record the mileage for each of your vehicles from the vehicle's odometer at the beginning and end of each day.
- Log Entry and Final Survey – At the end of the seven-day collection period, we will ask one adult from your household to enter the Trip and Vehicle Log information on our website and to answer a few additional questions about each person and vehicle. This step will take less than 30 minutes to complete.
- Activity and location tracking – If you choose to carry a lightweight Global Positioning Systems (GPS) device and a lightweight activity monitor during the seven-day collection period, the research manager will drop off the device, explain how it works, and answer any questions. At the end of the seven-day period, the research manager will pick up the device.

We do not anticipate that you will experience any physical or emotional discomfort as a result of this study. However, we will ask you for personal information about you and other members of your household. We realize the release of your personal and travel information could make you uncomfortable. We will minimize the risk of disclosure through secure data collection, storage, and analysis procedures that protect sensitive information and participant privacy.

There are no direct benefits to you from participation in the study. However, this study may provide insights about the impacts of urban design and planning policies on travel. These insights could help guide policies designed to reduce transportation-related air pollution and energy use in urban areas.

Participation in this study is voluntary and there is no cost to you for participating. You may refuse to participate or discontinue your involvement at any time without penalty. You may choose to skip a question or a study procedure.

As an incentive to participate, you will receive a local supermarket gift card worth $15 after you

complete the study. Households which also carry two lightweight devices which measure activity and locations will receive an additional $15 (a total gift card value of $30). We will repeat data collection in early 2012. Households which also participate in phase 2 will receive a second gift card upon completion.

If you are interested in participating, we will ask you to complete an initial questionnaire which asks eight questions about your household which we will use to select 600 households that are representative of your neighborhood as a whole.

All research data collected will be stored securely and confidentially. The household identification number (HID) provided on your invitation postcard will be used to track your information in a way that cannot be readily associated with you. The link between your identifying information (name, phone number, and residential address) and your HID will be stored in the UCI research facility in a restricted-access locked cabinet that is separate from the cabinet where the research data are stored. Data with subject identifiers will not be released. All research data will be maintained in a secure location at UCI. Only authorized researchers will have access to the data for research purposes.

The research team and authorized UCI personnel may have access to your study records to protect your safety and welfare. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed by these entities without your separate consent, except as specifically required by law.

If you have any comments, concerns, or questions regarding the conduct of this research please contact us:

- If you prefer English, please contact Steve Spears, Research Field Manager
  University of California, Irvine, 323-364-4824 or ntas@uci.edu
- If you prefer Spanish, please contact Carolina Sarmiento, Research Field Manager
  University of California, Irvine, 323-570-4824 or ntas@uci.edu

In addition, you may contact Dr. Douglas Houston, Principal Investigator, Department of Planning, Policy and Design, University of California, Irvine. Phone: 949-824-1870. Email: houston@uci.edu

If you are unable to reach the researchers listed at the top of the form and have general questions, or you have concerns or complaints about the research, or questions about your rights as a research subject, please contact UCI's Office of Research Administration by phone, (949) 824-6662, by e-mail at IRB@rgs.uci.edu or at University Tower - 4199 Campus Drive, Suite 300, Irvine, CA 92697-7600.

Do all members of your household over 12 years old understand the study goals and agree to participate? □ Yes □ No

If you agree to participate, please enter the Household Identification Number (HID) from your invitation letter:

Information About Your Household

How long have you lived in your current home?
□ less than 1 year
□ 1 to 5 years
□ 6 to 10 years
□ more than 10 years
□ all of my life

Do you own or rent your residence?
□ Own
□ Rent
□ Don't know
□ Other. If other, please describe:_____

Is your housing unit provided to you at a reduced rent through a government or non-profit program?
□ Yes
□ No
□ Don't know

If you receive assistance, which best describes the rent assistance you currently receive?
□ I receive a housing voucher which pays all or part of my rent (e.g., though a section 8 or a housing voucher program)
□ I reside in a unit provided at reduced rent in a building owned or financially assisted by the government
□ I reside in a unit provided at reduced rent in a building owned or managed by a non-profit organization
□ Other

What is your average annual household income?
□ Less than $15,000
□ $15,001 to $35,000
□ $35,001 to $55,000
□ $55,001 to $75,000
□ $75,001 to $100,000
□ More than $100,000

What is your race or ethnicity?
□ Asian/Pacific Islander
□ Black/African-American
□ White/Caucasian
□ Hispanic
□ Native American/Alaska Native
□ Other/Multi-Racial

How long have you lived in the United States?
□ less than 1 year
□ 1 to 5 years
□ 6 to 10 years
□ more than 10 years
□ all of my life

Information About Your Household's Vehicles

Section Two: Information about the cars and other vehicles that you or other household members have in your home.

Number of cars that are available to persons living in my home, including me, on most days:

□ 0
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7
□ more than 7

Number of motorcycles in your household:

□ none
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7
□ more than 7

Number of bicycles in your household:

□ 0
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7
□ more than 7

How many members of your household have a driver's license?

□ 0
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7
□ more than 7

About Your Typical Weekday Travel

Now think about your travel on a typical weekday (Monday through Friday). Please answer the following questions about how you travel to your work on a typical weekday:

On a typical workday, I travel to work by (check all that apply):
□ Car
□ Bus
□ Train
□ Bicycle
□ Walking
□ Other
□ I work at home
□ I am not employed

If you drive to work, where do you park your car while at work?
□ On the street
□ Parking lot or parking garage at my workplace
□ Parking lot or parking garage not part of my workplace, but nearby
□ Other
□ I do not drive to work

On a typical workday, do you carpool to work with other people?
□ Yes
□ No

During a typical work week, do you work at home?
□ Yes
□ No

How many days per week do you usually work at home?
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7

On the days that you work at home, do you work part of the day or a full day?
□ All day
□ Part of the day

Your Thoughts About Transportation and Your Neighborhood

In this section, you will be asked your opinion on a range to transportation topics. Please select the answer that most closely reflects your feeling or experience.

Please read each of the following statements and indicate how much you agree or disagree with each of them.

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately agree	Strongly agree
I can get things done while riding the bus or train that I can't do in my car.	○	○	○	○	○	○	○
Driving is stressful for me.	○	○	○	○	○	○	○
Traffic makes walking and bicycling in my neighborhood difficult.	○	○	○	○	○	○	○
Reducing car use is beneficial to the environment.	○	○	○	○	○	○	○
My friends and family would support me if I decided to use my car less.	○	○	○	○	○	○	○
Much of my travel is is done to meet the needs of others in my household.	○	○	○	○	○	○	○
I feel restricted because I don't have access to a car often enough.	○	○	○	○	○	○	○
The bus and train schedules are convenient for me.	○	○	○	○	○	○	○
There are plenty of places to shop within walking distance of my home.	○	○	○	○	○	○	○
I am uncomfortable on a crowded bus or train.	○	○	○	○	○	○	○
I don't like to waste natural resources or energy.	○	○	○	○	○	○	○
My car is an important part of who I am.	○	○	○	○	○	○	○
My life keeps me on the move all of the time.	○	○	○	○	○	○	○
To protect the environment, I try to use my car as little as possible.	○	○	○	○	○	○	○
I have physical limitations that make getting around difficult.	○	○	○	○	○	○	○
Increasing use of public transit is beneficial to the environment.	○	○	○	○	○	○	○

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately agree	Strongly agree
I don't know enough about public transit in my neighborhood to use it.	○	○	○	○	○	○	○
There are enough places in my neighborhood where I can go for recreation or entertainment.	○	○	○	○	○	○	○
Using the bus or train takes too long compared to going by car.	○	○	○	○	○	○	○
Protecting the environment is important to me.	○	○	○	○	○	○	○
The bus and train take me where I need to go.	○	○	○	○	○	○	○
I like the privacy of riding in a car compared to other ways of traveling.	○	○	○	○	○	○	○
Taking the bus or train could save me money compared to driving a car.	○	○	○	○	○	○	○
I enjoy walking or bicycling near my home.	○	○	○	○	○	○	○
My family and friends would support me if I used public transit for environmental reasons.	○	○	○	○	○	○	○
I feel pressed for time in my daily travels.	○	○	○	○	○	○	○
I can get most of my personal business (like banking, laundry, etc.) done within walking distance of my home.	○	○	○	○	○	○	○
I try to minimize my impact on the environment by taking the bus or train whenever I can.	○	○	○	○	○	○	○
Privacy is a problem on the bus or train.	○	○	○	○	○	○	○
It is/would be difficult to get everything done without a car.	○	○	○	○	○	○	○
My close friends and family are concerned about the environment.	○	○	○	○	○	○	○
Noise and pollution from cars and trucks is a problem in my neighborhood.	○	○	○	○	○	○	○
There are good restaurants within walking distance of my home.	○	○	○	○	○	○	○
People who are important to me worry about my safety when I use public transit.	○	○	○	○	○	○	○

Your Thoughts About Safety and Transportation

The following section includes questions about safety and security concerns you might have in your neighborhood and when you use transit. Please select only one answer for each of the questions below.

Please indicate how safe you feel when...

	completely unafraid	unafraid	somewhat unafraid	neither	somewhat afraid	afraid	extremely afraid
walking in your neighborhood during the day.	○	○	○	○	○	○	○
walking in your neighborhood at night.	○	○	○	○	○	○	○
where you get on and off of the train/bus during the day.	○	○	○	○	○	○	○
where you get on and off of the train/bus at night.	○	○	○	○	○	○	○
while riding on the train/bus during the day.	○	○	○	○	○	○	○
while riding on the train/bus at night.	○	○	○	○	○	○	○

Have you ever had a problem with personal safety while walking in your neighborhood?
□ No
□ Yes, during the day only
□ Yes, at night only
□ Yes, during the day and at night

Have you ever had a problem with personal safety where you get on and off the bus or train?
□ No
□ Yes, during the day only
□ Yes, at night only
□ Yes, during the day and at night

Have you ever had a problem with personal safety while riding the bus or train?
□ No
□ Yes, during the day only
□ Yes, at night only
□ Yes, during the day and at night

If you have had a personal safety problem when using public transit, what was it?
□ none
□ harassment
□ robbery
□ physical attack
□ more than one of the above

How often do you use public transit?
□ hardly ever
□ few times a year
□ few times a month
□ few time a week
□ almost every day

	very unlikely	unlikely	somewhat unlikely	neither	somewhat likely	likely	very likely
How likely are you to reduce or avoid using public transit because of safety and security concerns?	○	○	○	○	○	○	○
How likely are you to change the time or route of a trip by public transit because of safety and security concerns?	○	○	○	○	○	○	○
How likely are you to drive a car as often as possible because of safety and security concerns?	○	○	○	○	○	○	○

Thank You!

Thank you for completing this portion of the study. Your response is very important to us. If you have not already done so, the next step is to fill out the one-week travel and mileage logs for your household. Please try to be as accurate as possible with your responses. The quality of this study depends on the getting the best possible information from you and your neighbors. You are an important member of the study team!

Appendix A-2: Individual Demographic Survey and 7-Day Travel Log

Please enter the following information for the person whose trips are recorded on this log.

First Name: _____

What is this person's gender?
□ Male □ Female

How old is this person?
_____ years

Is this person employed?
□ No □ Yes, part time □ Yes, full time

Is this person a student?
□ No.
□ Yes, in a college or university.
□ Yes, in high school.
□ Yes, in another type of school.

If they are a student, do they attend school full time or part time?
□ Part time □ Full time

What is the highest level of education this person has completed?
□ 12th grade or less
□ Graduated high school or equivalent
□ Some college, no degree
□ Associate degree
□ Bachelor's degree
□ Post-graduate degree

What is this person's height? _____feet _____ inches

What is this person's weight? _____ pounds

Overall, how would you describe this person's current health?
□ Excellent
□ Good
□ Fair
□ Poor

Appendix A2: Trip Log

Neighborhood Travel and Activity Study **Travel Log**

Person Name:

	Car Driver	Car Pass-enger	Motor-cycle/ Scooter	Bus	Train	Bicycle		Walk		Other	Notes? Problems? Please describe below.
						# of Trips	Total Minutes	# of Trips	Total Minutes		
Monday											
Tuesday											
Wednesday											
Thursday											
Friday											
Saturday											
Sunday											

Instructions

- Count each trip you take during each day
- Include walk/bike trips over 5 minutes
- Count trips you take for recreation or exercise
- Log the total minutes you walk or bicycle each day
- Count each trip mode as a separate trip (car, walk, etc)

Suggestions

- Carry and complete the log as you travel
- Or you can complete the log at the end of each day
- Note any problems each day (forgot to fill out one day)
- See the back of this log for examples

Appendix A3: Vehicle Mileage Log

Neighborhood Travel and Activity Study

Vehicle Mileage Log

Vehicle Year: _____

Make (Ford, Honda, etc): _____

Model (Focus, Accord, etc): _____

	Start	End
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		
Sunday		

Instructions

- Place one log in each vehicle in a visible location
- Enter vehicle year, make, and model
- Log mileage at the start and end of each day
- Obtain mileage from the *odometer* near the speedometer

Appendix B. Expo Line New Resident Sample Study Survey Materials

Neighborhood Travel and Activity Study
University of California, Irvine

Study Information Sheet

You are being asked to participate in a research study about household travel. The purpose of this study is to examine the effects of local employment, shopping, transportation and neighborhood design on the distance people travel and the types of transportation they use.

The research procedures involve the following:

Survey – After you review this information sheet, you will begin the study's baseline survey which will ask you to answer questions about your household composition, transportation resources, and about your neighborhood. This section should take less than 30 minutes to complete.

Three Day Travel Logs – Next, we ask that your household keep a trip log for everyone over 18 years old for three days **starting on Tuesday.** On the log, you will count the number of trips you take by each travel mode (car, bus, train, etc.) and the number of minutes you spend walking or bicycling each day. We will also ask you to record the mileage for each of your vehicles from the vehicle's odometer at the beginning and end of each day.

We do not anticipate that you will experience any physical or emotional discomfort as a result of this study. However, we will ask you for personal information about you and other members of your household. We realize the release of your personal and travel information could make you uncomfortable. We will minimize the risk of disclosure through secure data collection, storage, and analysis procedures that protect sensitive information and participant privacy.

There are no direct benefits to you from participation in the study. However, this study may provide insights about the impacts of urban design and planning policies on travel. These insights could help guide policies designed to reduce transportation-related air pollution and energy use in urban areas.

Participation in this study is voluntary and there is no cost to you for participating. You may refuse to participate or discontinue your involvement at any time without penalty. You may choose to skip a question or a study procedure.

As an incentive to participate, you will receive a local supermarket gift card worth $50 after you complete the study. One gift card will be given per household.

All research data collected will be stored securely and confidentially. The household identification number (HID) provided on your invitation postcard will be used to track your information in a way that cannot be readily associated with you. The link between your identifying information (name, phone number, and residential address) and your HID will be stored in the UCI research facility in a restricted-access locked cabinet that is separate from the cabinet where the research data are stored. Data with subject identifiers will not be released. All research data will be maintained in a secure location at UCI. Only authorized researchers will have access to the data for research purposes.

The research team and authorized UCI personnel may have access to your study records to protect your safety and welfare. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed by these entities without your separate consent, except as specifically required by law.

If you have any comments, concerns, or questions regarding the conduct of this research please contact:

Steven Spears Research Field Manager
University of California, Irvine, 323-364-4824 or ntas@uci.edu

In addition, you may contact Dr. Douglas Houston, Principal Investigator, Department of Planning, Policy and Design, University of California, Irvine. Phone: 949-824-1870. Email: houston@uci.edu.

If you are unable to reach the researchers listed at the top of the form and have general questions, or you have concerns or complaints about the research, or questions about your rights as a research subject, please contact UCI's Office of Research Administration by phone, (949) 824-6662, by e-mail at IRB@rgs.uci.edu or at University Tower, 4199 Campus Drive, Suite 300, Irvine, CA 92697-7600.

Neighborhood Travel and Activity Study – Baseline Survey

Part 1 - Information About Your Household

Housing and Neighborhood Preferences

1. When did you move to your current address?

Month _____

Year _____

1a. In what city was your previous residence? _____

1b. What was your previous zip code? _____

1c. About how far away is your new home from your old home?
- □ 5 miles or less
- □ From 6 to 10 miles
- □ From 11 to 20 miles
- □ From 21 to 50 miles
- □ From 51 to 100 miles
- □ More than 100 miles

1d. When people move, they choose a new house or apartment and also choose a new neighborhood. Please think back to when you lived in your previous home. When you starting looking for a new place to live, how important were the following factors to you?

	1 Not Important at all	2	3	4	5	6	7 Extremely Important
Housing affordability	○	○	○	○	○	○	○
Short commute to *your* workplace or school	○	○	○	○	○	○	○
Short commute to work or school for *other adult household members*	○	○	○	○	○	○	○
Short trip to school or daycare *for children in your household*	○	○	○	○	○	○	○
Access to shops and services (grocery stores, shopping malls, etc.)	○	○	○	○	○	○	○

	1 Not Important at all	2	3	4	5	6	7 Extremely Important
Access to highways, generally	○	○	○	○	○	○	○
Access to public transit, generally	○	○	○	○	○	○	○
Access to the rail transit systems (Metro subway or light rail)	○	○	○	○	○	○	○
A particular type or quality of housing available in the neighborhood	○	○	○	○	○	○	○
Quality of the public schools	○	○	○	○	○	○	○
Wanted to live near certain kinds of people/households (other families with children, ethnic or cultural group, etc)	○	○	○	○	○	○	○
Visual attractiveness of the neighborhood	○	○	○	○	○	○	○
Low crime	○	○	○	○	○	○	○
Access to open space (parks, beaches, mountains, etc)	○	○	○	○	○	○	○
Lower traffic noise or safety from traffic	○	○	○	○	○	○	○
Near to family and friends	○	○	○	○	○	○	○
Wanted to move in with someone already living in the neighborhood	○	○	○	○	○	○	○
Familiarity with the neighborhood	○	○	○	○	○	○	○
Access to child care	○	○	○	○	○	○	○

1e. For *your* personal commute to school or work, which transportation modes were important considerations in deciding where to live? (Please select all that apply)

□ Walking □ Bicycle □ Bus □ Train □ Personal Vehicle (Car, Truck, etc) □ None/Not Applicable

1f. For the commute of *other adult household members* to school or work, which transportation modes were important considerations in deciding where to live (Please select all that apply)

□ Walking □ Bicycle □ Bus □ Train □ Car □ None/Not Applicable

1g. For the trip to school or day care for *children in your household*, which transportation modes were important considerations in deciding where to live? (Please select all that apply)

□ Walking □ Bicycle □ Bus □ Train □ Car □ None/Not Applicable

1h. For *access to shops or services*, which transportation modes were important considerations in deciding where to live? (Please select all that apply)

□ Walking □ Bicycle □ Bus □ Train □ Car □ None/Not Applicable

Current Housing and Household Characteristics

2. Do you own or rent your current residence?

□ Own
□ Rent
□ Don't know
□ Other. If other, please describe: _____

3. If you RENT the current home:

a) Is your housing unit provided to you at a reduced rent through a government or non-profit program?

□ Yes □ No □ Don't know

b) If you receive assistance, which best describes the rent assistance you currently receive?

□ I receive a housing voucher which pays all or part of my rent (e.g., through a section 8 or a housing voucher program)
□ I reside in a unit provided at reduced rent in a building owned or financially assisted by the government
□ I reside in a unit provided at reduced rent in a building owned or managed by a non-profit organization
□ Other

4. What is the housing type of your current home?
□ Detached single family house
□ Duplex or triplex
□ Row-house or townhouse
□ Apartment or condominium
□ Mobile home or trailer
□ Other (Specify) _____

5. What is your average annual household income?
□ Less than $15,000
□ $15,001 to $35,000
□ $35,001 to $55,000
□ $55,001 to $75,000
□ $75,001 to $100,000
□ More than $100,000

6. How many people in your household are in the following age groups ?

0 to 5 years old _____
6 to 11 years old _____
12 to 15 years old _____
16 to 17 years old _____
18 years old or older _____

Information About Your Household's Vehicles

7. Number of cars that are available to persons living in my home, including me, on most days:
□ 0
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ more than 6

8. Number of motorcycles in your household:
□ none
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ more than 6

9. How many members of your household have a driver's license?

□ 0
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ more than 6

Part 2 - About Your Typical Weekday Travel

Now think about your travel on a typical weekday (Monday through Friday). Please answer the following questions about how you travel to your work on a typical weekday:

10. On a typical workday, I travel to work by (check all that apply):
□ Car
□ Bus
□ Train
□ Bicycle
□ Walking
□ Other
□ I work at home
□ I am not employed *(please skip to Question 12)*

10. During a typical work week, do you work at home?
□ Yes
□ No (please skip to question 12)

10a. How many days per week do you usually work at home?
□ 1
□ 2
□ 3
□ 4
□ 5
□ 6
□ 7

10b. On the days that you work at home, do you work part of the day or a full day?
□ All day
□ Part of the day

11. How often do you use public transit?
□ hardly ever
□ few times a year
□ few times a month
□ few time a week
□ almost every day

12a. During the past 2 weeks, how many days did you use public transit (bus or rail)?
□ 0 days □ 1-3 days □ 4-6 days □ 7-9 days □ 10 days or more

12b. Please estimate the average time it takes to walk from your home to the nearest public transit stop (bus or rail):
□ Less than 5 minutes
□ 5 to 10 minutes
□ 10 to 15 minutes
□ 15 to 30 minutes
□ More than 30 minutes

Part 3 - Your Thoughts About Transportation and Your Neighborhood

In this section, you will be asked your opinion on a range to transportation topics. Please select the answer that most closely reflects your feeling or experience.

Please read each of the following statements and indicate how much you agree or disagree with each of them.

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately agree	Strongly agree
I can get things done while riding the bus or train that I can't do in my car.	○	○	○	○	○	○	○
Driving is stressful for me.	○	○	○	○	○	○	○
Traffic makes walking and bicycling in my neighborhood difficult.	○	○	○	○	○	○	○
Reducing car use is beneficial to the environment.	○	○	○	○	○	○	○
My friends and family would support me if I decided to use my car less.	○	○	○	○	○	○	○
Much of my travel is is done to meet the needs of others in my household.	○	○	○	○	○	○	○
I feel restricted because I don't have access to a car often enough.	○	○	○	○	○	○	○
The bus and train schedules are convenient for me.	○	○	○	○	○	○	○
There are plenty of places to shop within walking distance of my home.	○	○	○	○	○	○	○
I am uncomfortable on a crowded bus or train.	○	○	○	○	○	○	○
I don't like to waste natural resources or energy.	○	○	○	○	○	○	○
My car is an important part of who I am.	○	○	○	○	○	○	○
My life keeps me on the move all of the time.	○	○	○	○	○	○	○
To protect the environment, I try to use my car as little as possible.	○	○	○	○	○	○	○
I have physical limitations that make getting around difficult.	○	○	○	○	○	○	○
Increasing use of public transit is beneficial to the environment.	○	○	○	○	○	○	○

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately agree	Strongly agree
I don't know enough about public transit in my neighborhood to use it.	○	○	○	○	○	○	○
There are enough places in my neighborhood where I can go for recreation or entertainment.	○	○	○	○	○	○	○
Using the bus or train takes too long compared to going by car.	○	○	○	○	○	○	○
Protecting the environment is important to me.	○	○	○	○	○	○	○
The bus and train take me where I need to go.	○	○	○	○	○	○	○
I like the privacy of riding in a car compared to other ways of traveling.	○	○	○	○	○	○	○
Taking the bus or train could save me money compared to driving a car.	○	○	○	○	○	○	○
I enjoy walking or bicycling near my home.	○	○	○	○	○	○	○
My family and friends would support me if I used public transit for environmental reasons.	○	○	○	○	○	○	○
I feel pressed for time in my daily travels.	○	○	○	○	○	○	○
I can get most of my personal business (like banking, laundry, etc.) done within walking distance of my home.	○	○	○	○	○	○	○
I try to minimize my impact on the environment by taking the bus or train whenever I can.	○	○	○	○	○	○	○
Privacy is a problem on the bus or train.	○	○	○	○	○	○	○
It is/would be difficult to get everything done without a car.	○	○	○	○	○	○	○
My close friends and family are concerned about the environment.	○	○	○	○	○	○	○
Noise and pollution from cars and trucks is a problem in my neighborhood.	○	○	○	○	○	○	○
There are good restaurants within walking distance of my home.	○	○	○	○	○	○	○
People who are important to me worry about my safety when I use public transit.	○	○	○	○	○	○	○

Part 4 - Your Thoughts About Safety and Transportation

The following section includes questions about safety and security concerns you might have in your neighborhood and when you use transit. Please select only one answer for each of the questions below.

Please indicate how safe you feel when...

	completely unafraid	unafraid	somewhat unafraid	neither	somewhat afraid	afraid	extremely afraid
walking in your neighborhood during the day.	○	○	○	○	○	○	○
walking in your neighborhood at night.	○	○	○	○	○	○	○
where you get on and off of the train/bus during the day.	○	○	○	○	○	○	○
where you get on and off of the train/bus at night.	○	○	○	○	○	○	○
while riding on the train/bus during the day.	○	○	○	○	○	○	○
while riding on the train/bus at night.	○	○	○	○	○	○	○

Thank You!

Thank you for completing this portion of the study. Your response is very important to us. If you have not already done so, the next step is to fill out the three day travel and mileage logs for your household. Please try to be as accurate as possible with your responses. The quality of this study depends on the getting the best possible information from you and your neighbors. You are an important member of the study team!

Neighborhood Travel and Activity Study **Travel Log**

Person Name:

	Car Driver	Car Pass-enger	Motor-cycle/ Scooter	Bus	Train	Bicycle		Walk		Other	Notes? Problems? Please describe below.
						# of Trips	Total Minutes	# of Trips	Total Minutes		
Tuesday											
Wednesday											
Thursday											

Instructions

- Count each trip you take during each day
- Include walk/bike trips over 5 minutes
- Count trips you take for recreation or exercise
- Log the total minutes you walk or bicycle each day
- Count each trip mode as a separate trip (car, walk, etc)

Suggestions

- Carry and complete the log as you travel
- Or you can complete the log at the end of each day
- Note any problems each day (forgot to fill out one day)
- See the back of this log for examples

Neighborhood Travel and Activity Study

Vehicle Mileage Log

Vehicle Year: _____

Make (Ford, Honda, etc): _____

Model (Focus, Accord, etc): _____

	Start	End
Tuesday		
Wednesday		
Thursday		

Instructions

- Place one log in each vehicle in a visible location
- Enter vehicle year, make, and model
- Log mileage at the start and end of each day
- Obtain mileage from the *odometer* near the speedometer on the instrument panel

Please enter the following information for the person whose trips are recorded on this log.
First Name: _____

What is this person's gender?

☐ Male ☐ Female

How old is this person?

_____ years

Is this person employed?

☐ No ☐ Yes, part time ☐ Yes, full time

Is this person a student?

☐ No.

☐ Yes, in a college or university.

☐ Yes, in high school.

☐ Yes, in another type of school.

If they are a student, do they attend school full time or part time?

☐ Part time ☐ Full time

What is the highest level of education this person has completed?

☐ 12th grade or less

☐ Graduated high school or equivalent

☐ Some college, no degree

☐ Associate degree

☐ Bachelor's degree

☐ Post-graduate degree

What is this person's height? _____feet _____ inches

What is this person's weight? _____ pounds

(continued on reverse side)

Overall, how would you describe this person's current health?

☐ Excellent

☐ Good

☐ Fair

☐ Poor

What is this person's race or ethnicity?

☐ Asian/Pacific Islander

☐ Black/African-American

☐ White/Caucasian

☐ Hispanic

☐ Native American/Alaska Native

☐ Other/Multi-Racial

How long has this person lived in the United States?

☐less than 1 year

☐ 1 to 5 years

☐ 6 to 10 years

☐ more than 10 years

☐ all of his/her life

Appendix C. Phase 1 Mobile Tracking Device Training Materials

NEIGHBORHOOD TRAVEL AND ACTIVITY STUDY (NTAS)

UNIVERSITY OF CALIFORNIA, IRVINE

Instructions for the Activity Level Meter

This small activity level meter records general movement and allows us to get a good idea of your overall activity level (low, moderate, high, etc.). We will **not** be able to tell what kind of specific activity is happening, so your privacy is absolutely protected.

You will need to use a belt which you have received to wear this meter. At first, the belt may feel slightly awkward, but after a few minutes, you will probably get used to it and not notice it as much.

Activity Level Meter: right above your **right** hipbone, snug again your body.

GPS: You can wear your location tracking device on your own belt with the pocket you have received.

It is **extremely** important for our study that you wear the meter properly. Please follow these instructions carefully:

- Wear the meter attached to the belt around your waist, just above your **right** hipbone. You can wear it either underneath or on top of your clothing.
- Wear the meter so the logo "ActiGraph" on the front of the meter is straight up.
- Wear the meter **snug** against your body. If you have to, you can adjust the belt by pulling the end of the strap to make it tighter. Or, to loosen the belt, push more of the strap through the loop. **Wear the belt tight enough so that the meter does not move when you are being active.**
- Please **put it on first thing in the morning** -- either just after you get out of bed or just after you shower or take a bath in the morning.
- **Do not submerge the meter in water** (swimming, bathing, etc.)
- Keep the activity meter on all day (unless swimming or in the water).
- At night, **take it off right before you go to bed**. You should be wearing the meter for *at least 12 hours every day*.
- Do not let anyone else wear it.
- No need to charge it.
- The time period during which you will wear the meter is:
  from _____ to _____.
- If you cannot wear it during the above time period, please call **(323) 364-4824** for English or **(323) 570-4824** for Spanish as soon as possible

There is no "ON" or "OFF" switch that you need to worry about turning on or off every day. The activity meter runs on a battery and is programmed to run continuously without you needing to turn it on. Please do not try to open the activity meter.

NEIGHBORHOOD TRAVEL AND ACTIVITY STUDY (NTAS)

UNIVERSITY OF CALIFORNIA, IRVINE

Instructions for the Global Positioning System (GPS) Device

This device is used to record your locations and travel patterns.
The switch on its left side has three positions: "OFF", "NAV" and "LOG".

"LOG" Position

"OFF" Position

Before You Leave In the Morning

- Disconnect GPS from power cord
- Switch to "LOG" position
- Place GPS in carrying bag or connect to belt clip
- Carry the GPS with you at all times during the day until you end your day

Every Night: Charge GPS

- Switch to "OFF" position
- Connect GPS and Power Adapter and plug Power Adapter into electrical socket

Note Any Problems on the Trip Log

For example, note any of the following:

- If you forget to take the devices with you
- If you forgot to switch to "LOG" during the day
- If you switched to "OFF" for privacy
- If you forgot to charge the GPS device

During the day, you do not have to change any settings on the devices.

Appearance

1. Power jack (mini USB type)
2. Mode switch (OFF/NAV/LOG)
3. Battery status LED (Red/Green)
4. *Bluetooth* status LED (Blue)
5. GPS status LED (Orange)
6. Internal antenna