ELECTRIC VEHICLE CARSHARING IN A SENIOR ADULT COMMUNITY IN THE SAN FRANCISCO BAY AREA

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ABSTRACT
By the year 2030, the number of people over the age of 65 in the United States is expected to reach 57 million. The Baby Boomer population tends to drive more kilometers annually than previous generations, have wider interests, and will likely be active and healthy well past retirement. This paper examines an electric vehicle (EV) carsharing (short-term vehicle access) service as an alternative to private vehicle ownership for older adults living in a gated community. Research was conducted between Winter 2009 and Spring 2011. The study consisted of in-depth interviews (n=7), four focus groups (n=31), and survey data collection (n=443) with residents of the Rossmoor Senior Adult Community in Walnut Creek, California. Study results indicate that 30% of all survey respondents at Rossmoor are interested in participating in an EV carsharing program in their gated community, while 36% are maybe interested. Eighty-three percent of community-wide survey respondents drive short distances often (i.e., eight kilometers (km) five times a month); 100% of interview respondents plan their trips in advance; and 77% of focus group participants made changes to their driving behavior because of high fuel prices.

Keywords: Carsharing, station cars, shared-use vehicles, electric vehicles, ridesharing, Baby Boomers, older adults, gated retirement community

INTRODUCTION
The older adult population in the United States (U.S.) is quickly growing in size. With the aging Baby Boomer population, the number of drivers 65 years and older is expected to double to 57 million by the year 2030 (1). This growing population combined with public transportation funding and service declines—following the 2008 recession—present a challenge in providing safe, efficient, and economically feasible mobility options for older adults. Many destinations are too far to walk, and alternatives such as taxis are too expensive (2) (3). Often public transit or specialized transportation services are limited. Shared-use vehicle systems, such as carsharing, can provide viable options when combined with other transportation services (e.g., public transit) targeted at older adults.

Carsharing enables a group of people to share a vehicle fleet. Primarily used for short-term trips, carsharing can provide affordable vehicle access for those who do not have a car, want to reduce the number of vehicles in their household, or do not use their vehicle during the day for long time periods. Ideally, carsharing works best in a neighborhood, business, or campus setting where users could walk, bike, share rides, or take public transportation to access the shared-use vehicles.

The Rossmoor Senior Adult Community (Rossmoor) in Walnut Creek, California was selected to understand the potential for EV carsharing in an active senior adult community setting. The authors and Nissan Motor Company conducted this study from December 2009 to May 2011 to determine the feasibility of an EV carsharing pilot program at Rossmoor. The study consisted of seven in-depth household interviews, four focus groups totaling 31 participants, a community-wide survey of 357 residents (paper and online), and a six-question clipboard/short

survey with 86 respondents. A total of 443 Rossmoor residents took part in one of the two study surveys (community-wide and clipboard/short survey); each respondent was unique. It is important to note that the surveys asked the same questions, but the community-wide survey was longer (i.e., 30 minutes to complete vs. five minutes for the clipboard/short survey). Findings from this research provide insights into the feasibility of an EV carsharing program in an older adult community.

This paper includes five sections. First, the authors provide a brief overview of the Rossmoor community. This is followed by a literature review of the history of EVs in a shared-use setting. Next, the study methodology is reviewed. The fourth section presents results of the interviews, focus groups, and surveys (community-wide and clipboard/short). Finally, the authors conclude by summarizing results and discussing the feasibility of an EV carsharing program in a senior adult community.

ROSSMOOR SENIOR ADULT COMMUNITY: OVERVIEW
Rossmoor is a non-profit gated community of approximately 9,500 senior residents in Walnut Creek, California. Founded in 1963, it spans 72.84 kilometers km^2 acres with 6,700 residential units in three cooperatives, 12 condominiums, and one single-family-detached home development consisting of 63 individual homes.

The cost per unit ranges from US$100,000 for cooperatives, US$500,000 for condominiums, and can be over US$1 million for single-family homes. The community offers amenities that cater towards the "active adult" including: hobby shops, 200 clubs, golf courses, tennis courts, hiking trails, open space, and a fitness complex. At least one resident in each household is required to be 55 years of age or older to live at Rossmoor. Thirty-four percent of Rossmoor's population is between the age of 75 and 84 years of age, while 27% is 85 to 94.

Of the 338 community-wide survey respondents who provided their educational background, 21% have a bachelor's degree, 22% a master's degree, and 22% have finished some graduate school. Of the 357 total community-wide survey respondents, 327 answered a question regarding their 2010 household income level. Thirty-one percent had a 2010 household income of US$20,000 to $50,000, 23% US$50,000 to $75,000, and 16% US$75,000 to $100,000.

Rossmoor provides its own transportation services that travel throughout Rossmoor's gated community and the surrounding areas. Residents do not pay per ride; instead costs are covered in a monthly fee that ranges between US$550 and $800 depending on housing type. This fee pays for transportation, facilities management, maintenance, utilities, property taxes (in cooperatives), and building insurance. There are three types of bus transit within Rossmoor: fixed-route bus, dial-a-bus, and paratransit. Fixed-route buses operate on weekdays (8:30am - 6:15pm), while dial-a-bus operates on weekday mornings and evenings up to 10:00pm and from 8:30am to 9:15pm on the weekends. The fixed-route buses have scheduled routes with a 30-minute headway.

LITERATURE REVIEW
Shared-mobility services have been growing in size and popularity since their introduction in 1948. EVs were integrated into station car (shared vehicles available at public transit stations) and carsharing programs in the 1990s, demonstrating the ability to balance the mobility needs of many users with a limited driving range.

Due to logistical and operational challenges, however, EVs began to disappear from shared-mobility systems in the early-2000s. Recently, they have experienced a resurgence.

Building upon lessons learned and notable EV advancements, many carsharing operators anticipate greater potential for EVs in shared-use vehicle systems in the future (4). For example, one potential target group for EV carsharing is the Baby Boomer population, the largest generation in U.S. history (2). EV advancements coupled with the demand for alternative mobility options among the Baby Boomer population present an opportunity that could improve their mobility and travel choices, as well as the negative environmental impacts of transportation. This literature review includes a history of EVs in carsharing worldwide and the need for greater mobility options for older adults.

Early Integration of EVs into Shared-Use Vehicle Systems

Station Car Programs
EVs were a major part of station car programs in the mid-1990s, particularly in the U.S. The station cars provided an easy and convenient way to access a user's home or work from the public transit station, thus relieving the first-and-last mile problem. EVs fit well with station car programs since most trips were short distance.

      The first large-scale station car program, Praxitèle, was launched as an experimental demonstration in 1997 in a suburb of France's Saint-Quentin. Although the EVs were well received by Praxitèle members and suitable for the trips they made, Praxitèle struggled with costs and sustained demand, and it was forced to close in 1999 (7) (8). The CarLink field test, which ran from 1999 to 2000, blended the concepts of carsharing and station cars. It was deployed at the Dublin-Pleasanton Bay Area Rapid Transit (BART) District station and included 12 natural gas Honda Civics. The program was deemed a success from an operational and user perspective (9) (10). CarLink II followed this demonstration. It was deployed from 2001 to 2002 at the Palo Alto Caltrain station in Northern California, with a fleet of 19 ultra low-emission Honda Civics (11). Flexcar took over this program in 2002, but closed it in July 2003 due to financial concerns. Another station car initiative was the BART District-Hertz program, which included two Th!nk city class EVs at the BART Fremont station from 2000 to 2003 (5).

      A hybrid station car/carsharing effort is the Zero-Emission Vehicle Network-Enabled Transport (ZEV·NET) program at the University of California (UC) Irvine, which was deployed in 2001 and continues today as a research program. The current fleet is stationed at the Irvine Transportation Center (ITC)—a commuter rail terminal (12). "UC Riverside (UCR) Intellishare" was a similar project that implemented a station element into its EV carsharing system in 2006. Station cars were located at Riverside's Metrolink train terminal for convenient transport to the UC Riverside campus (13).

      Although EVs were noted as a successful part of station car systems, 60% of all programs ceased in the early 2000s (6). Many closed due to the high cost and low reliability of first-generation EVs, while others cited insurance rates, economic downturn, and decreased customer demand as key operational challenges (14) (6).

Carsharing Programs
EVs also were integral to many carsharing fleets in the 1990s (8). Liselec launched in 1993 in La Rochelle, France. Testing EV use in carsharing, the program was successful and still exists today under the name Yelómobile (15). Yelómobile, now the longest operating EV carsharing project, exists as a one-way program and requires trips to stay within La Rochelle. Thus, trips keep

within the EV's range of 130 km. Unlike other EV carsharing programs struggling with economic sustainability, Yelómobile continues to receive governmental support (16).

Similarly, in 1999, Japan began the project Second Car System (SCS) in the Tama New Town District, Inagi City. Most of its 300 users reported that the service met their travel needs (17). SCS included a reservation system that calculated the charge time needed to complete a planned trip and reserved a vehicle accordingly. In this way, the 160 km EV range did not present an obstacle. After the program began implementing fees, however, many users dropped out. After three years of operation, the program closed.

Toyota Motor Company deployed a carsharing experiment in Japan in the late-1990s, called the Crayon System. The program consisted of 50 vehicles, 13 stations, and 700 members (18). Crayon used advanced ITS technologies including automated reservations, telematics to communicate between the vehicles and system management, and GPS technology to track the cars (19).

Also in Japan, Nissan entered into EV carsharing in 1997, with the Minato-Mirai 21 (MM21) experiment in Yokohama (20) (19). The program's studies began in 1999 and grew to 30 vehicles and seven stations in the Yokohama area. The trials ended in March 2002, and the system transitioned to operators to determine system viability (20). This program spread to Yokohama, Kawasaki, and Tokyo; it was called the Intelligent Transportation System/Carsharing Electric Vehicle (ITS/CEV) City Car System (19). It later became known as Orix Carsharing, comprising roughly 400 vehicles and around 6,000 to 8,000 members. Orix Carsharing discontinued using EVs exclusively and now also uses hybrids and gasoline vehicles (21).

The U.S. also deployed an EV carsharing project called UCR Intellishare, mentioned earlier, which began in 1999 and ended in July 2010 (22). Also a one-way system, Intellishare's fleet was used an average of 100 times/day, each for a relatively short amount of time and distance. With such high use, the EVs had to be well managed so that each had sufficient charge (they had a range of 160 km). If one was depleted, the system would not allow it to be available for use until it finished charging. The limited EV range was not found to be a problem; however, the project was not commercialized since it was created as a test bed (23).

Although most of the EV shared-mobility programs proved to be feasible in terms of driving range and user satisfaction, EVs gradually faded out of these systems. Numerous reasons were cataloged for failure: high costs; high insurance rates; low reliability of the first generation EVs; a preference of hybrid vehicles; decreased user demand and public support; operational barriers (e.g., limited vehicle range, few charging stations); logistical challenges (i.e., the need for centralized management and real-time data feedback); and economic downturn (21).

The Resurgence/Evolving Role of EVs in Shared-Use Systems
Shared-mobility systems have experienced a recent EV resurgence. Being almost completely phased out by the mid-2000s in favor of hybrid vehicles, there are new driving forces and interests behind EVs (4). Due to technological advancements, automakers have launched next generation EVs at lower costs than before with longer-range batteries (e.g., lithium-ion). In addition, the California Zero Emission Vehicle (ZEV) Mandate requires automakers to sell more zero-emission vehicles, and as an incentive they receive ZEV sales credit by placing them in transportation systems that demonstrate technology-enabled vehicle sharing, such as carsharing and station car programs. Monetary rebates are now available to encourage carsharing operators to purchase ZEVs and other low-emission vehicles (24).

Worldwide carsharing experts believe a key trend over the next five years will be the re-emergence of EVs in shared-use fleets. Hertz on Demand began integrating EVs into its carsharing fleet in New York City in December 2010; they expanded to locations in North America, the United Kingdom, and China. In 2011 Paris began an all-electric program called Autolib', and Nissan launched a pilot test in Yokohama, Japan incorporating Nissan Leaf EVs into its existing fleet with the option of a chauffeur driver.

Additionally, five global automakers (BMW, Ford, General Motors, Mitsubishi, and Toyota) are either providing carsharing services or integrating their EVs into new and existing carsharing operations or both. BMW's DriveNow carsharing program was recently initiated in San Francisco with a fleet of 70 BMW ActiveE electric vehicles (25). Similarly, car2go's carsharing program has all electric fleets in San Diego and Amsterdam and has implemented EVs into its existing fleet in Portland, Oregon (26) (27) (28). Like car2go, other carsharing programs have added EVs to their fleets. City CarShare deployed EVs in the Bay Area, iGo in the Midwest, and Zipcar throughout North America (29) (30) (31).

Transportation Options for Older Adults
The Baby Boomer population is anticipated to "change the profile and expectations of old age in the U.S." (32). This age group is expected to maintain their independence, prolong their physical and mental health, have a longer life expectancy, and stay active longer (32). The economic recession of 2008 and existing residential land use patterns in the U.S. underscore the need for more accessible and affordable transportation options for older adults. More than three-quarters of older adults are aging in suburban or rural areas "where daily activities require frequent car trips" (2). Other than a personal automobile, viable options to connect senior adults to their destinations are limited, do not exist, and/or lack needed funding (2). While many senior adult communities offer transportation services to their residents, many do not meet all their mobility needs, including making multi-destination trips, transporting packages and groceries, and traveling to rural or suburban areas (33). Thus, there is a need to further explore alternative options. Carsharing, one such alternative, has yet to be studied in senior adult communities.

METHODOLOGY
From December 2009 through May 2011, researchers conducted a study at the Rossmoor Senior Adult Community in Walnut Creek, California. In this study, the authors applied qualitative and quantitative methods to evaluate the feasibility of an EV carsharing program within the community. Additionally, the study focused on understanding resident travel behavior and preferences for a shared-use system.

Researchers collected data in three separate phases. The first phase was conducted in December 2009 and involved seven in-depth interviews with Rossmoor residents. To recruit participants for the interviews, an announcement was posted in *The Rossmoor News*, a weekly newspaper delivered to each Rossmoor residence. Respondents were screened based on housing type, vehicle ownership, and possession of a valid driver's license. Three of the seven in-depth interviews were conducted with condominium residents and four with cooperatives. Despite placing notices in *The Rossmoor News*, which specifically requested participation from single-family homes, this data collection phase failed to include subjects from this housing type.

During the first phase, researchers gained preliminary information on resident travel behavior and preferences, as well as their response to an EV carsharing program at Rossmoor. Prior to the interview, participants kept a seven-day travel diary of all trips taken. This diary included the travel time, mode, purpose, destination, and number of passengers for each trip. Based on the travel diary, researchers conducted an in-depth, two-hour interview with each participant to clarify points in their travel diary and to probe each on their travel patterns. Reflexive questions were asked to gather information on trips that could have been made by alternative modes, timing flexibility, trip chaining, their use of or interest in EVs, and opinions about an EV carsharing program at Rossmoor. Each respondent received a US$100 gift certificate to Amazon.com for his or her participation.

The second phase of data collection was conducted in September 2010 and provided researchers with qualitative data on the viability of implementing an EV carsharing program at Rossmoor. This phase consisted of four focus groups with a total of 31 participants, which provided insight into respondent preferences by housing type. Participants included 17 Rossmoor residents who reside in cooperative units and 14 who live in condominiums. No single-family home residents participated. Prior to the start of each focus group, an intake survey was administered to establish key socio-demographic and attitudinal variables. The survey also captured participant travel patterns, which were expanded upon in the group discussions. Researchers developed a detailed protocol as a guide including: general travel behavior questions; vehicle ownership costs; an introduction to the carsharing concept (i.e., existing programs and how they operate); ridesharing elements; vehicle technology; level of comfort with charging stations; and willingness-to-pay. At the end of each focus group, participants received a US$50 Amazon.com gift card as compensation.

The third study phase consisted of survey data collection. Researchers employed insights gathered during the in-depth interviews and focus groups to develop the community-wide survey. Several methods of administration were employed to increase response rates. In February 2011, 7,000 copies of the questionnaire were inserted into *The Rossmoor News* and sent to all Rossmoor households. One month later, a link to an online version of the survey was posted in *The Rossmoor News*. Finally, in May 2011, researchers distributed the survey outside the Gateway Clubhouse. All Rossmoor residents were eligible to participate in the survey, and there were no screening criteria.

The questionnaire was pretested with four members of the Rossmoor administrative staff, including two members of the transportation department. The pretest provided feedback on question wording and length, font size, and overall design. A total of 357 residents completed the community-wide survey—342 from the newspaper insert, eight via the online survey, and seven from the table outside the Gateway Clubhouse. This questionnaire consisted of 71 questions and required approximately 30 minutes to complete. The survey obtained data regarding resident travel behavior, public transit use, vehicle ownership, interest in an EV carsharing program, anticipated use, and willingness-to-pay for the program. In addition, age, gender, household annual income, and education level were collected. The survey also asked stated-preference questions about how respondents might use carsharing for shopping trips, medical appointments, daytime, nighttime, and weekend travel.

In May 2011, a six-question newspaper and clipboard survey (i.e., the same instrument) was administered outside of the Gateway Clubhouse to obtain additional feedback from residents. The survey asked five questions from the community-wide survey, plus a screening question to determine if the subject had already completed the longer survey. Questions included interest in an EV carsharing program, willingness-to-pay for such a service, and preferred carsharing vehicle locations. This effort yielded 65 completed clipboard surveys and 21 completed short newspaper surveys (a total of 86 short questionnaires were collected). Snacks and beverages were available to those who completed surveys at the Gateway Clubhouse. Incentives were not offered for completion of the surveys administered through newspaper inserts or online.

Study Limitations
As with any social science research, there are limitations to this study. First, the survey reflects a non-respondent bias, as limited incentives were employed. Second, the length of the community-wide survey (30 minutes) played a role in lowering overall response. While an effort was made to include residents from all three housing types within Rossmoor, no residents from single-family units responded to recruitment efforts for either the in-depth interviews or focus groups. Furthermore, less than 2% of respondents to the community-wide survey and 2% to the clipboard/short survey represented this demographic. Additionally, while carsharing was defined in the in-depth interviews, focus groups, and community-wide survey, the definition was omitted in the clipboard/short survey to reduce its length. Thus, the 86 clipboard/short survey respondents may not have clearly understood the carsharing concept. Furthermore, the in-depth interviews, focus groups, and community-wide survey informed participants that the Nissan Leaf had a recharging time of four to eight hours. This information may have introduced a response bias, as participants might have assumed they could not reserve a vehicle until it had charged that amount of time. As mentioned earlier, researchers did not collect socio-demographic, trip, or attitudinal data in the clipboard/short survey to reduce the number of questions asked, which limits understanding. Finally, since this study was administered in only one retirement community with a limited sample size, it is difficult to generalize the findings to other locations, which could be more or less responsive to the service.

RESULTS
The data collected from the in-depth household interviews, focus groups, and surveys provide key information on items such as potential vehicle demand and usage, the best locations for charging stations, and initial reaction to system pricing. This section includes the following analyses: demographics, travel interest in an EV carsharing program at Rossmoor, and willingness-to-pay.

Demographics
Table 1 illustrates the distribution of respondents by each of the study instruments. It is important to note that the interview and clipboard/short survey did not address each of the categories and are marked "NA" (not applicable) in Table 1. Forty-seven percent or greater of all participants lived in cooperatives, and the majority (86% of in-depth interview, 65% of focus groups, and 72% of community-wide survey) had one vehicle in their household. Thirty-five percent of focus group participants and 25% of community-wide survey respondents had two cars.

TABLE 1 Respondent Demographics by Instrument

	Interview (n=7)	Focus group (n=31)	Community-wide survey (n=357)	Clipboard/short survey (n=86)
% Co-op residents	57%	55%	52%	47%
% Condo residents	43%	45%	46%	51%
% Single-family home residents	0	0	2%[1]	2%
% Single-car households	86%	65%	72%	NA
% Two-car households	NA	35%	25%	NA
% No-car households	NA	0%	3%	NA

[1] 1.49%
NOTE: NA = not applicable

Table 2 presents key demographics of the study participants from the focus groups and community-wide survey. This table does not include data from in-depth interviews or the clipboard/short survey because these instruments did not ask questions regarding demographics. Demographic data for the U.S.'s current population of older adults, specifically 55 years of age and older, is included in Table 2 for comparison to the study's sample. Some demographic variables are affected by non-response. The total responses for each question are indicated in Table 2. It is important to note that the U.S.'s racial breakdown represents the entire U.S. population, not just 55 years and older.

TABLE 2 Demographic Profile of the Focus Groups, Community-Wide Survey, and U.S. Population of 55 Years and Older

Demographic Attribute	Focus Groups	Community-Wide Survey	U.S. Population (55 Years and Older)
Age Category	n = 31	n = 330	n = 76,750,713
55-60	6.5%	5.5%	30%
61-65	16.1%	8.2%	21%
66-70	16.1%	13.3%	15%
71-75	19.4%	17.9%	12%
76 or over	41.9%	55.2%	22%
Total	100 %	100 %	100%
Education	n = 31	n = 338	n = 74,008,000
Grade School	0.0%	0.3%	8%
Some High School	3.2%	0.0%	8%
High School	6.5%	4.7%	33%
Some College	12.9%	19.5%	24%
Bachelor's Degree	35.5%	20.7%	16%
Graduate School, Master's, or Ph.D.	35.5%	52.4%	11%
Other	6.5%	2.4%	NA
Total	100 %	100 %	100%
Household Income	n = 31	n = 327	n = 47,190,000
Less than US$10,000	0.0%	1%	8%
US$10,000 to $20,000	3.2%	6%	17%
US$20,000 to $50,000	38.7%	31%	33%
US$50,000 to $75,000	9.7% [i]	23%	16%
US$75,000 to $100,000	29.0% [ii]	16%	9%
More than US$100,000	9.7% [iii]	10%	17%
Decline to Respond	9.7%	13%	NA
Total	100 %	100%	100%
Race	n = 31	n = 344	n = 308,745,538
White/Caucasian	94%	85.1%	63.7%
Black/African American	0%	1.2%	11.9%
Native American	0%	0.9%	0.9%
Asian	6%	6.7%	4.8%
Hispanic	0%	1.5%	16.3%
Pacific Islander	0%	0.3%	0.2%
Other	0%	1.2%	2.3%
Decline to Respond	0%	3.2%	NA
Total	100%	100%	100 %

[i]   US$50,000 to $79,900
[ii] US$80,000 to $109,900
[iii] More than US$110,000
NOTE: NA = not applicable

In comparison to the U.S.'s 55 and older population, focus group participants were older, more educated, higher income, and more were White/Caucasian. Similarly, the community-wide survey participants were older, more educated, had comparable incomes, and represented a higher percentage of the White/Caucasian race. Both the focus groups and community-wide survey over-represented Whites/Caucasians and under-represented other races. Thirty-three percent of the U.S. 55 and older population's income is between US$20,000 and $50,000, which is well represented by both the focus group and survey respondents. In contrast, the focus groups and survey mostly represented the age group of 76 years and older, which comprises only 22% of the U.S. 55 years and older population (34) (35) (36).

Travel Behavior
Participants from in-depth interviews, focus groups, and the community-wide survey answered questions related to their current travel behavior such as: How long is an average daily trip for you; what are the destinations you travel to inside and outside of Rossmoor and how frequently; and how often do you take public transit? The results in Table 3 provide a summary of travel patterns and response to a carsharing service at Rossmoor (clipboard and community-wide survey).

TABLE 3 Travel Patterns by Instrument Type

Possible responses	In-Depth Interviews (n = 7)		Focus Groups (n = 31)		Clipboard Survey (n=86)		Community-Wide Survey (n = 357)	
	Count	%	Count	%	Count	%	Count	%
Please indicate all trip distances that you drive five or more times a month								
8 km	NA		NA		NA		208	83%
16 km							126	60%
24 km							82	48%
32 km							57	36%
48 km							34	27%
64 km							25	24%
>80 km							27	16%
Indicate all destinations you travel to inside of Rossmoor by frequency of trips (more than once a week)								
Gateway Clubhouse	NA		NA		NA		199	67%
Library							56	28%
Gym							150	65%
Visit friends							144	59%
Theater							85	33%
Other							109	69%
Indicate all destinations you travel to outside of Rossmoor by frequency of trips (more than once a week)								
Downtown Walnut	NA		NA		NA		198	63%
Library							17	9%
Visit friends							87	37%
Theater							8	4%
Medical appointments							31	10%
Other							120	59%
How many hours would you use a carsharing vehicle for an average daily trip?								
< 1 hour	NA		NA		NA		10	4%
~ 1 hour							37	15%
2-4 hours							189	75%
> 4 hours							15	6%
How comfortable would you feel using an electric vehicle?								
Very comfortable	NA		NA		NA		171	57%
Somewhat							79	27%
Somewhat							26	9%
Very uncomfortable							22	7%
Please estimate how many kilometers you drive annually.								
0 - 8.045	NA		9	31%	NA		NA	
8.047 - 16.092			9	31%				
>16.093			11	38%				
If you take public transit, please select all modes of public transit you take.								
Rossmoor Bus	NA		5	16%	NA		60	41%
County Connection			3	10%			6	4%
BART			17	55%			71	48%
MUNI			3	10%			4	3%
Other			3	10%			6	4%
During a typical week, how many times do you take public transit?								
1	NA		NA		NA		49	18%
2							10	4%
>3							26	9%
None			11	35%			191	69%
Do you typically plan your driving trips in advance?								
Yes	7	100%	NA		NA		236	70%
No	0	0%					29	9%
Sometimes	0	0%					72	21%
If so, how far in advance do you typically plan your trips?								
< 1 day	1	25%	NA		NA		55	20%
> 1 day	3	75%					214	80%
Would you be interested in a carsharing system at Rossmoor?								
Yes	NA		NA		42	49%	88	25%
No					13	16%	133	38%
Maybe					30	35%	125	36%

NOTE: 1.61 kilometers = 1 mile, NA = not applicable

Rossmoor residents make shorter driving trips more frequently than longer ones. As shown in Table 3, 83% of community-wide survey respondents make five or more eight-km trips per month, while only 16% make five or more 80-km trips per month. Of participants who plan their driving trips in advance, 80% of community-wide survey respondents and 75% of interviewees plan ahead at least one day prior. The majority of participants in the focus groups and community-wide survey are influenced by fuel costs and thus combine trips, make fewer trips, travel to closer destinations, or carpool. At the time of the survey, gasoline prices were approximately US$3.55 per gallon on average in the Walnut Creek area, where Rossmoor is located.

Table 3 shows that study participants seldom use public transportation. While 55% of focus group and 48% of community-wide survey participants take BART to Walnut Creek's surrounding cities—such as San Francisco, Berkeley, and Oakland—35% and 69% of focus group and community-wide respondents, respectively, never take public transportation. The Rossmoor Bus and BART are the forms of public transit used most often among the Rossmoor residents.

Interest in an EV Carsharing Program at Rossmoor
The in-depth interviews, focus groups, and community-wide survey defined carsharing as short-term vehicle use (i.e., a few hours or less) and explained that every car is used by several drivers. Users have access to the vehicle during their reservation time. It was also stated that members pick-up and return vehicles at shared-use lots (e.g., public transit stations and neighborhood parking lots), and fees are based on travel distance/time and cover maintenance, insurance, registration, and fuel.

Each study instrument, except the clipboard/short survey, explained that the carsharing service envisioned for Rossmoor would employ a fleet of Nissan Leaf EVs with a driving range of 160 km and a recharging time of four to eight hours. Upon receiving this information, study participants were asked their opinions regarding carsharing in general as well as the proposed EV carsharing program at Rossmoor.

Table 3 shows that 25% of community-wide survey participants and 49% of clipboard/short survey respondents were interested in participating in a carsharing service at Rossmoor. This question did not specify whether the program was with EVs. Thirty-six percent and 35% of community-wide and clipboard/short survey participants, respectively, were maybe interested. The community-wide survey results were cross tabulated to determine if there was a correlation between program interest and the age, income level, education, or race of the participants. However, there was not any correlation of significance.

In the focus groups, residents of cooperative units were more receptive to carsharing than condominium residents. The majority of focus group participants and 84% of community-wide survey respondents felt comfortable (or somewhat comfortable) using an EV. Eighty-two percent of community-wide survey respondents were willing to try an EV carsharing program on a trial basis free of charge (i.e., for one or two trips), and 86% were either very or somewhat comfortable with plugging-in an EV.

Fifty-two percent of community-wide survey participants are willing to drive 80 km or more in an EV with a 160-km range, and 77% are willing to drive 48 km or more. Sixty-seven percent of community-wide survey respondents were comfortable operating shared EVs with a 120-km range remaining. Results show that 48 to 80 km is a long enough range to accommodate most of the residents' trips. If a roadside assistance service were available; however, 80 to 145 kilometers would provide a sufficient range. If a vehicle was less than 100 percent charged, 20% of the community-wide survey respondents would be most comfortable driving only 32 km, 14% 16 km, and 11% would only use the vehicle if it were fully charged. Many of the focus group participants expressed concerns about battery depletion and worried that there would not be an adequate amount of charge for their desired trip when they picked up the vehicle.

Due to the small preliminary fleet size envisioned (10 vehicles or less), participants were asked to choose one optimal location to place the carsharing vehicles. Forty-one percent of community-wide survey respondents, 57% of clipboard/short survey respondents, and all interviewees believe the parking lot at the community's Gateway Clubhouse to be the most convenient location to pick up and drop off a vehicle because it is centrally located, has ample parking, and is frequented on a regular basis by most residents.

In-depth interview participants reported typical travel outside Rossmoor during the off-peak hours of 10:00am and 3:00pm. Most community-wide survey participants predict they would use the carsharing service in the early afternoon and late morning, and 28% anticipate using a vehicle two to three times a week. Seventy-five percent of community-wide survey respondents would use a vehicle for two to four hours for an average daily trip. Potential users indicated that they would use a carsharing vehicle to go shopping, attend medical appointments, run errands, or go dining. Community-wide survey respondents would be willing to walk 400 to 800 meters to access a carsharing vehicle, and 37% would consider using the Rossmoor Bus to get to a carsharing station. The majority of focus group participants want to reduce the number of transportation modes they use per trip to reduce travel time, and most avoid taking the Rossmoor Bus when possible.

To gauge interest in a carsharing program, residents were asked the likelihood that they would participate if non-EVs were made available as part of the carsharing fleet. Seventy-one percent of community-wide survey respondents are likely or maybe likely to sign up under the circumstances that they could reserve a non-EV for longer trips.

Many survey questions were aimed at measuring behavioral changes and the modal shift that might result from the proposed carsharing service. Sixty-one percent of community-wide survey respondents do not believe they would sell their household vehicles if they were to join such a program, however, 38% would or might. Fifty-nine percent of community-wide survey respondents thought they would or might take public transit and carpool more if a carsharing service were available, while 41% thought they would not. Two of seven in-depth interview participants would consider replacing their personal vehicles with carsharing, while another respondent reported that he would consider eliminating his second vehicle. The remaining four participants were concerned about vehicle availability in an emergency and thus reluctant to sell/forego a personal vehicle.

Most community-wide survey participants (70%) are willing to use smart keys and personal identification number (PIN) codes to access vehicles, as well as an Internet-based system that provides information on vehicle availability, charging status, and vehicle reservations (62%). However, 46% of community-wide survey respondents prefer a phone reservation system to an Internet-based one. All of the focus group participants would prefer both online and phone reservations systems.

Willingness-to-Pay

Focus group and survey participants were asked about their willingness-to-pay for an EV carsharing service in their community. The focus groups presented various payment schedules derived from those used by carsharing programs at the time; participants discussed their opinions of memberships and usage fees. This discussion allowed researchers to design willingness-to-pay questions specific to a Rossmoor carsharing service.

Forty-four percent of clipboard/short survey respondents were willing-to-pay for a service, while 39% were maybe willing. The clipboard/short survey did not ask respondents how much they were willing-to-pay. Community-wide survey participants are likely or willing-to-pay up to US$4 per hour of carsharing vehicle use, and they are definitely or likely willing-to-pay up to US$15 a month as a membership fee. In comparison, City CarShare charges US$10 per month for their occasional driver plan, and San Francisco's Zipcar charges a US$60 annual fee; however, their hourly rates are higher than City CarShare's (US$8 in contrast to US$5) (37) (38).

CONCLUSION

This study explored the feasibility of an EV carsharing program in a senior adult community, as well as its potential to increase the mobility options in the community. Rossmoor was selected as the location for this study given its large population size, early adopter characteristics (e.g., higher incomes and education), and proximity to the research team.

The seven in-depth household interviews collected preliminary information about resident interest and response to an EV carsharing program, and all participants indicated that they were interested. Interview participants plan their trips at least one day in advance, and almost all of their trips are short distances (i.e., less than 16 km), which could be satisfied within EV range. Interview participants reported that they would like the shared-use vehicle locations to be easily accessible.

Focus group results complement the interview findings in that the majority of respondents are interested in an EV carsharing program at Rossmoor. Participants living in cooperatives, which typically house those of lesser income levels, were more receptive to the idea. Many of the focus group respondents expressed concern about battery depletion, and some noted that they would only use a vehicle if it were 100 percent charged.

The surveys found that more were interested in an EV carsharing program at Rossmoor than those that were not. Specifically, 25% and 36% of community-wide and clipboard/short survey respondents, respectively, were interested, while 49% and 35% were maybe interested. Only 36% of community-wide survey respondents and 35% of clipboard/short survey respondents had no interest. Eighty-nine percent of community-wide survey respondents were willing to drive a vehicle that was not fully charged, and many already drive shorter distances (8 km or less) and combine trips.

Overall, results showed support for an EV carsharing program at Rossmoor. Participants chose a central and convenient location for the shared-use vehicles (Gateway Clubhouse) and indicated that they would use the program frequently (two to three times a week). Most of the Rossmoor respondents do not use the community's transportation services often. This, as well as other logistical details such as a reservation system and specific pricing structure(s), should be further researched and addressed prior to a pilot program. If successful in the Rossmoor community, other senior adult communities throughout the nation might consider and improve the mobility of residents through carsharing.

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