Title: Experiences with GPS travel diaries in rural older driver research

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ABSTRACT

This paper describes using passive Global Positioning Systems (GPS) data collection and Geographic Information System (GIS) with participant prompted recall to study the travel habits of rural older drivers. It is based upon the research of a convenience sample of 60 rural drivers (29 men, 31 women, average age 69.6 years) in New Brunswick, Canada. The transportation needs of a growing population of older rural residents, many who face the risk of not being able to meet their needs if they can no longer drive, are not well understood and represent an immediate and future policy need. GPS-based travel diaries are a useful method to obtain origin/destination and other contextual information in support of rural transportation planning.

A total of 1649 “stops” (periods of non-movement lasting 1 minute or more) by participant vehicles were recorded with the GPS units. Approximately 8% of all “stops” were due to stoplights or traffic delay. The remaining “stops” were organized into 1494 trips (one origin with one destination), with participants supplying purposes, who was driving, and passenger details for 99.1% of recorded trips. Travel data were collected on average for 5.3 days per participant. An external battery for the GPS unit minimized the typical satellite acquisition but was exhausted in 10% of cases. Only 2.2% of recorded trip ends were due to lost reception or acquisition delay and in each case the missing distance data were interpolated. Service clubs and snowball sampling were the most effective means of recruiting rural participants.

INTRODUCTION

The collection of revealed travel behaviour data while minimizing respondent burden has made Global Positioning System (GPS)-based travel diaries an important tool for urban transportation planning and policy analysis. Rural transportation planning, however, relies almost exclusively on vehicle counts for infrastructure planning (*1*) (*2*) and national datasets that underrepresent rural areas for policy analysis (*3*). GPS travel diaries have the potential to provide a wealth of useful information in support of rural transportation planning, but have typically only been employed in urban areas. The transportation needs of a growing population of older rural residents, many who face the risk of not being able to meet their needs if they can no longer drive, are not well understood and represent an immediate and future policy need.

This paper describes a methodology for conducting a detailed prompted recall-based Global Positioning Systems (GPS)-based travel diary study of the travel habits of rural older drivers to maximize their participation and data collection. It also presents findings regarding the methodology, and suggestions for inclusion of the method in rural transportation policy development. It is based upon the research of a convenience sample of 60 rural drivers (average age 69.6 years) in New Brunswick, Canada. The goal was to demonstrate the usefulness and practicality of the method and to discuss potential opportunities and challenges if adopted into rural transportation planning.

Background

The growth in the Canadian population 65 years and older is expected to double to 9 million and represent 23% of the total population by 2031 (*4*). Many in this population will be automobile drivers and will depend on their vehicle to help them meet their needs, however, the aging process can make driving difficult or impossible over time meaning alternatives will be necessary. This has particular implications for jurisdictions encompassing a large rural population, like New Brunswick, where over 40% of older people live in rural areas (*5*). Many rural areas do not have alternatives available and alternatives that do exist tend to be underutilized or unmatched to the community's needs (*6*, *7*). This may lead some rural drivers to hold on to their drivers license longer than they should, and may explain why collision rates for rural seniors aged 81 years and older have been found to be higher than their urban counterparts (*8*).

Considerable research supports the need to address this growing demographic in transportation planning; however, it is unclear how jurisdictions will address this issue in their rural transportation planning since the data are not collected. The unavailability of detailed travel data on seniors in rural areas can mean governments infer policy directions from readily available urban-based studies or outdated data sources. The results can be mass-transit solutions for a low-density rural problem and perpetuation of incongruent policy directions. Since most rural older people choose to use the private automobile (*9*, *10*, *11*) (out of necessity or convenience), it seems logical that for any alternative to be successful, it needs to approximate the conditions that make the automobile attractive (*12*). It is the measurement of these conditions which is typically lacking in rural jurisdictions.

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Literature Review

Travel diary surveys have been around for decades but collecting travel information by electronic travel diaries and GPS is a relatively new method. The TRB Committee to Review the Bureau of Transportation Statistics' (BTS) Survey Programs recommended that the BTS "take advantage of a range of design concepts and new technologies in its continuing efforts to improve the response rate and data quality for the NHTS." The ITE Planning Handbook does not specify the duration of a travel survey (*13*), though historically they have been one day in length, with the occasional two day survey (*14*). Some have suggested only multiday surveys are appropriate for understanding travel behaviour and its variability (*15*), but increases respondent burden. Concerns with the accuracy of pen and paper diaries, including omitted trips and increased respondent burden, combined with improved spatial data collection with GPS have prompted the development and use of electronic travel diaries (*16*, *17*, *18*, *19*, *20*).

The main difference among electronic travel diary surveys is that some require participant interaction with a Personal Digital Assistant (PDA) to enter trip purpose, passenger numbers, etc. (*16*) while others derive trip purpose solely from the GPS data (*19*) and others have employed prompted recall to fill in the data gaps (*20*). The use of electronic travel diaries can address many issues with underreporting in traditional travel diary surveys. Individuals between 50-69 years of age, men, people who are unemployed, those who travel long distances (> 32 km) on an average trip, and those who trip chain all tend to underreport trips (*21*). These attributes suggest that conventional travel diaries for rural older drivers would result in considerable underreporting. The limiting factors in GPS travel diary surveys of rural older people have been the trackpoint memory of the equipment and the recall ability of participants (***Error! Bookmark not defined.***).

A 2004 proof-of-concept study by Hildebrand, et al. demonstrated that GPS and GIS could be used to collect detailed information on the travel habits of rural older drivers resulting in a comprehensive database permitting detailed analysis (*22*). The study followed 21 rural older people for an average of 2 days per person and explored issues with equipment set up, data recovery and analysis, participant interaction (including prompted recall interviews). The main challenges experienced related to ensuring continuous power to the GPS units (the units were not powered by the vehicle battery) and the extensive time requirements to sort the GPS data into trips to present to participants for the prompted recall survey.

Currently, Candrive (Canadian Driving Research Initiative for Vehicular Safety in the Elderly) (*23*) is exploring ways to improve safety for older drivers and is recruiting 1000 drivers aged 70 years and older to be involved with seven projects in seven of Canada's largest urban centres. One project in particular will study the travel patterns of older Canadians using GPS tracking, and is expected to be underway by summer 2010 (*24*). This research effort will produce a rich dataset, especially with the prevalence of revealed travel choices through the collection of GPS travel data; however, it will be comprised primarily (if not exclusively) of urban data.

METHODOLOGY

This research builds upon the 2004 proof-of-concept study by older drivers by Hildebrand, et al. and sought a more representative driver sample, an increased survey period length, automated data processing and presentation, and expanded contextual data collection to support analysis. It also sought to reduce respondent burden associated with traditional travel diary surveys by limiting the effort required for participation, such as eliminating the need for participant note taking, and meeting participants at their homes where practicable.

A multiday travel diary survey of rural older drivers was desired. The goal of reducing respondent burden meant employing all possible means (technological and methodological) to make participation convenient. GPS equipment was sought that was commercial-off-the-shelf, easily and discreetly installed in a vehicle, had sufficient trackpoint memory to permit multiday study, permitted easy and quick data download into a Geographic Information System (GIS) so participants could be prompted to recall their trip purposes (instead of note-taking).

Equipment selection and travel data collection methodology

The Shadow Tracker ® commercial fleet vehicle tracking system from Advanced Tracking Technology Inc. (ATTI) was identified and procured for pilot tests. It employs a passive GPS unit (approximately the size of a standard deck of playing cards) which can be easily connected to the vehicle battery by means of a 12V adapter. Reception is from a power antenna connected to the unit and mounted in the vehicle. A back up battery pack was also procured (battery is housed in the same type of plastic shell that houses the GPS unit), which allowed it to be connected back to back with the GPS unit using a special plastic mounting frame. The GPS unit was connected to the battery pack with wires and the battery pack was connected by means of a 12 V adapter to the vehicle battery. This ensured the GPS unit would remain constantly powered, while the battery would be charged by the vehicle battery when the vehicle operated (it should be noted that the 12 V outlets in most late model vehicles are only powered upon vehicle ignition). This method minimized the number of missed trips associated with the 1 – 2 minute satellite acquisition lag with initial power up of the GPS unit.

A proprietary GIS was also acquired, Shadow Tracker Professional, which contained algorithms to automatically calculate trip ends based on user-defined stop times and could display travel instantly. Following successful pilot tests, 10 Shadow Tracker J2 units were acquired. The Shadow Tracker Professional software permits the user to specify a time threshold of non-movement recorded by the GPS units to correspond with the ends of “trips”. Wolf (*19*) had employed a 2 minute threshold of non-movement to identify a trip-end, but Hildebrand et al. found that 22% of rural trips would have been missed with that threshold, therefore recommended a 1 minute threshold. “Trips” were defined as travel activities having a single origin and a single destination. “Trip chains” were defined as the total number of “trips” completed between leaving and returning “home”.

A prompted recall interview with participants was used to differentiate between the end of a trip and a period of non-movement. A time threshold of 1 minute or greater of non-movement was employed to signify the end of a trip. This required compiling all the recorded travel for each participant into a single file and filtering the data to remove periods of non-movement not associated with the end of a trip (such as a stop light). Participants supplied “trip purposes” such as “shopping” for each trip by reviewing their travel and their destinations (by time of day) on the GIS in Figure 1.

The sampling intervals for GPS points can be adjusted to as little as 3 seconds, though pilot studies were undertaken using a 10 second sampling interval to maximize trackpoint memory. The 3 second interval provided better resolution in viewing travel behaviour; therefore, was the threshold employed in the active surveys.

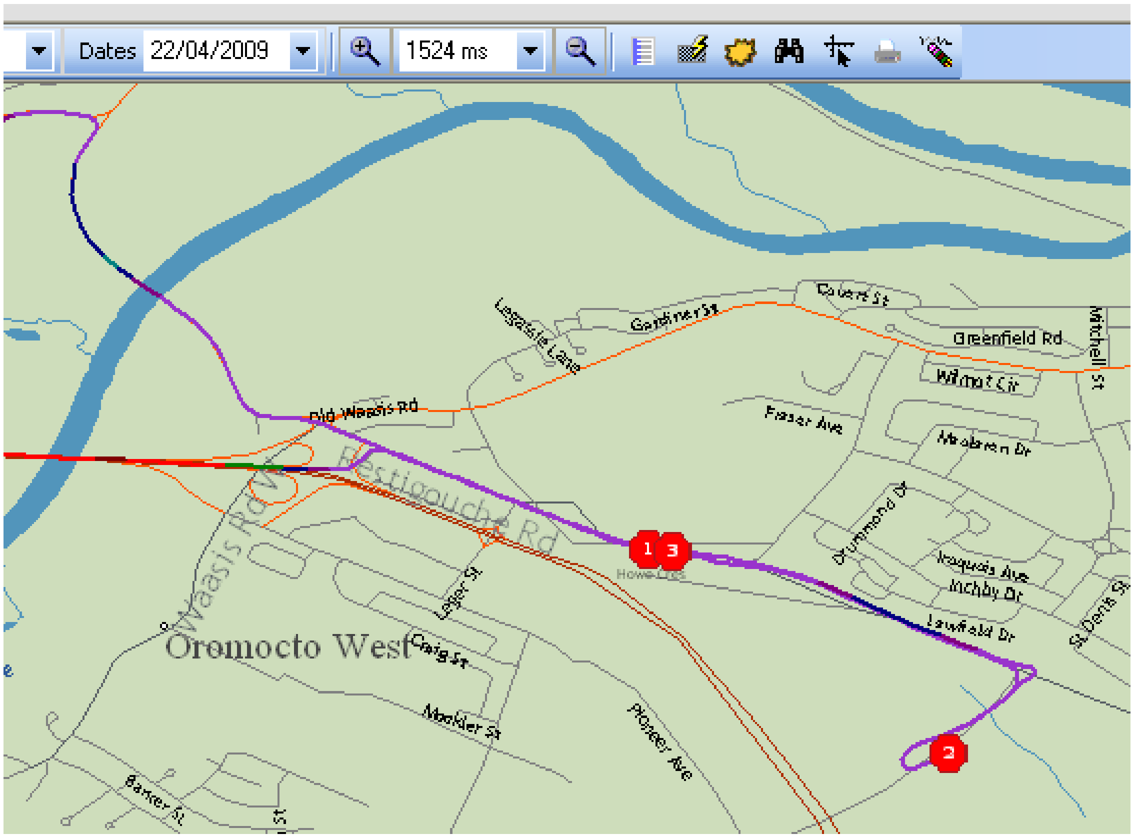

FIGURE 1 Example of screenshot of the Shadow Tracker GIS for prompted recall

Participant eligibility

Eligible participants were aged 60 years of age and older, who lived in a rural area, and maintained a drivers licenses. Rural areas were considered anywhere outside of urban areas, with urban areas defined in Canada as an *"area with a population of at least 1000 and no fewer than 400 persons per square kilometre" (25).* Transportation studies have used the age of 65 as a threshold to be considered a "senior"; however, there are studies that include participants as young as 50 and 55 years old (*26*, *27*). Statistics Canada (*5*) reports the average retirement age to be 61.5 years, down from 65 in 1977.

The guide for sample size was the minimum number within a class (age, gender) that would permit statistical comparison while also complying with an expected distribution of those variables when compared to larger census data. The Chi-squared test is a useful test to determine whether there is a significant difference between an observed and expected distribution (*28*). This study aimed for a minimum of 30 male and 30 female participants to make use of the normal distribution test, while seeking a minimum of 5 male and 5 female participants in each age class (60-64 years, 65-74 years, 75-84 years, 85 years >) to be eligible for the Chi-squared test.

Individuals from the same household were eligible for participation, but their travel habits (travel as a driver and as a passenger in their own vehicle) were reported separately. The prompted recall interviews were used to differentiate between drivers and passengers.

Participants were recruited through convenience sampling methods. This method is appropriate when dealing with sensitive issues (*29*), policy specific questions (*30*) and "can in some circumstances yield samples that faithfully portray the important features of a population" (*31*).

Equipment installation

The GPS unit was installed in an inconspicuous location within the vehicle, such as a centre console (Figure 2), under the front seat, or in a pouch behind the front seats. The GPS unit was connected to the equivalently-sized battery pack and the battery pack was connected to the vehicle battery by the 12V connector. The external antenna was run from the inconspicuous location to a place allowing a clear view of the sky (such as attached to the metal rods connecting the head restraint to the seat), where it was secured with a wire twist tie.

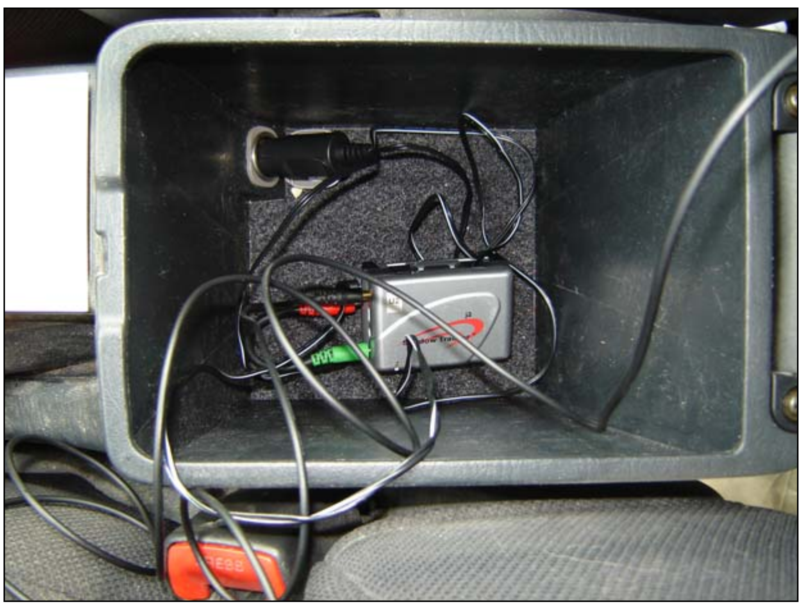

FIGURE 2 Shadow Tracker passive GPS unit with battery and connecting wires

Process to conduct travel survey

The information in Table 1 depicts the process employed to undertake the survey and the general timelines and estimated duration of each task.

TABLE 1: Travel diary survey methodology

Step	Task	General timelines	Estimated duration
1	Recruit participant and arrange for convenient meeting time and place	1-2 weeks before survey	
2	Meet with participant and collect demographic and other data	Day before survey	15 minutes
3	Instrument participant vehicle(s) with GPS unit(s)	Day before survey	5 minutes
4	Arrange for convenient meeting time and place to retrieve GPS unit(s) following survey	Day before survey	
5	Retrieve GPS unit(s) and download data into laptop	1 week after first meeting	5 minutes
6	Present travel data to participant and conduct prompted recall survey	1 week after first meeting	15 - 45 minutes
7	Conduct stated adaptation survey based on busiest day of participant travel	1 week after first meeting	10 minutes
8	Collect participant views on driver's licensing issues and driving alternatives	1 week after first meeting	10 minutes

Generally, participants were met the day before the survey was to begin (ensuring a complete day of travel beginning the next day), though in some cases, participants were met in the early morning (8 am) if they indicated they were not planning to travel until later in the day. Approximately 20 minutes were allotted to Steps 2 and 3, and up to an hour for Steps 5 -8.

Participant-supplied data were transcribed by hand onto a survey sheet, then later entered into a computer spreadsheet creating a “Participant Database”. Revealed travel behaviour from the GPS units were sorted into a computer spreadsheet and combined with the stated trip purposes and stated adaptation responses into a “Trip Database”. Each GPS data point were exported into MS Access where qualifying attribute information were assigned (age, gender), then exported for use in ArcView 3.3 where each data point were assigned to a particular road class on the New Brunswick road network.

RESULTS

The results are presented in terms of the number of participants surveyed, successful methods of recruitment, length of survey, number of trips recorded, recording of miscellaneous trips and equipment performance.

Participant summary

A total of 29 men and 31 women (average age: 69.6 years) were recruited for the research (Table 2) from 43 households. A total of 50 vehicles were instrumented. Two exceptions were made for participants under 60 years of age: one person aged 54 years (who was retired) and one person aged 56 years (working from home) where it was not expected that their attributes and travel would be markedly different from those aged 60-64 years, therefore were included in that division.

TABLE 2: Participants by age group

	Age			Grand Total
	54-64	65-74	>75	
Male	9	13	7	29
Female	11	14	6	31
Grand Total	20	27	13	60

While several participants over the age of 85 years were recruited, the goal of five men and women in this category was not achieved; therefore, they were combined with the age group 75 – 84 years of age. Chi-squared tests were undertaken to compare the observed distribution of participant attributes (age, gender, employment status) to the expected distribution from Canadian census data. In each case, the difference between the observed and expected distributions was not significant at the 5% level, suggesting the sample can be useful for policy discussions and alternative development. The sample was also compared to the observed and expected distribution of reported kilometres travelled per year (n=53), drawing from the 2009 National Household Transportation Survey for rural drivers aged 60 years and older, where no significant difference was found.

The most effective methods for recruiting participants included: an appeal for volunteers in a local newspaper; presentations to service clubs, seniors social clubs, or groups with predominately senior members; snowball sampling (Table 3). Unsuccessful methods included: appeals through seniors' advocacy groups, both local and national (primarily because their membership were urban based).

TABLE 3: Participant recruitment and interview location

Method of participant recruitment	**No.**	**Percentage**
Responded to newspaper ad in one rural community	5	8.3%
Responded to call for volunteers at presentation to service or social clubs	12	20.0%
Direct solicitation	18	30.0%
Referred by other participants (snowball sampling)	25	41.7%
Non-participants who travelled in participant vehicles		
Ineligible household members where travel data were collected by virtue of being a driver or passenger in participant vehicle	8	42.1%
Eligible household members who did not participate	11	57.9%
Location of participant interviews and equipment installation	**No.**	**Percentage**
Met at participant's home	46	76.6%
Met at a central location (community centre, seniors club)	9	15.0%
Met at home of another participant	5	8.3%

Most participants were met at their homes where the interviews were conducted and the equipment installed (Table 3). Several participants were met at a central location within the rural community, such as a service club, legion or seniors club. The remainder were met at the home of another participant, which served as a central location if the participants own home was too remote. The interviews for each household were conducted in private, even when met at a central location or another participant's home.

Survey duration

GPS units were generally distributed and collected on a weekly cycle and the maximum number of useable travel days for the survey was six (if units installed in the evening) or seven (if units installed in morning prior to trip making). A useable travel day was one where a complete record of the trip making that day. Partial days were not included. The goal was to achieve at least three useable travel days per participant, with any additional useable travel days considered a bonus. The data in Table 4 show that only one of 60 surveys had fewer than three useable travel days, and this was due to the participant's vehicle experiencing mechanical issues and being sent to a service bay for the remainder of the survey. The exhaustion of the trackpoint memory was the primary reason why some participants only had three or four useable travel days.

TABLE 4: Frequency of useable travel days in survey

Total useable travel days in GPS survey	Number of participants
2	1
3	2
4	13
5	9
6	30
7	5
Grand Total	60

Summary of study attributes

A total of 285,895 data points were collected with the Shadow Tracker GPS units, which following processing, represented 217 hours, 320 days, and 12449 km of individual participant travel in their household vehicle(s). The total number of "stops" recorded by the Shadow Tracker GIS software at a 1 minute non-movement threshold was 1649 (Table 5). The prompted recall survey was able to identify 132 of those stops as a traffic light or traffic delay, accounting for 8% of all stops. Occasionally, the GPS units would record an erroneous point, which accounted for 23 recorded stops. Stops due to traffic lights and erroneous points were removed from the travel database, leaving a total of 1494 vehicle trips in the database. Participants successfully recalled the trip purposes of 1481 of the 1494 recorded trips, which is a recall rate of 99.1%.

TABLE 5 Summary of study attributes

Summary characteristic	**Survey totals**
A -Total number of stops recorded in useable travel days (1 min stop threshold)	1649
B - Total number of stops removed due to stoplight or traffic delay	132
C - Total number of stops removed due to erroneous recording	23
Total number of trips recorded (A-B-C)	1494
Number of miscellaneous stops included in total number of trips	102
Total recorded kilometres of participant travel	12449 km

Miscellaneous trips

There were 102 stops recorded by the Shadow Tracker which were found not to correspond with a trip end, where the 1 minute threshold was too coarse, or the stop did not correspond with a specific trip purpose. In that case, stops were assigned a code for "Miscellaneous" and a qualifier used to define the trip/stop purpose (Table 6).

TABLE 6: Recorded stops not associated with a trip end

Event recorded as "Misc."	Total stops	Action
Lost reception	33	Interpolated to beginning of next trip
Stopped to look at something	23	
Missed short trip	16	Trip created in database, interpolated distance
Unknown	13	
Forgot something round trip	7	
Carpool with others	3	
Pleasure drive	3	
Asking directions/cellphone	3	
Repositioning vehicle	1	

The 33 recorded stops identified as lost acquisition were spread over 10 surveys where there were truncated or missed trips. In six surveys, this was attributed to the exhaustion of the external battery. The exhaustion of the battery lead to acquisition delays generally in the range of 1 – 2 minutes. This contributed to the missed recording of short local trips, which were subsequently identified in the prompted recall interview. Trip distances were interpolated and applied to the trip database. In one survey, the participant rearranged the antenna, which may have contributed to equipment error. In the remaining three cases, the lack of data collection could not be discovered. In each case it occurred a few days following the start of the survey and the trackpoint memory was not exhausted. One explanation is that the participants may have disconnected and then reconnected the unit.

"Stopped to look at something" was the most frequent non-equipment related trip type. Given the rural context of the travel, the most common "something" was an animal adjacent to the roadway. The "forgot something round trip" presented a challenge to interpret because the beginning and end of the trip were in the same location and often not too far apart in time. Typically, participants who reported this trip type left their home and forgot something, so returned back to retrieve it. The Shadow Tracker software permitted viewing of travel point-by-point in chronological order; only then was the travel pattern evident.

In 16 instances, short passenger pick up and drop off trips were missed, a function of the 1 minute non-movement threshold. Participants identified instances where these trips were missed (and confirmed on the GIS when the non-movement threshold was lowered).

Equipment performance

The trackpoint memory was exhausted prior to equipment retrieval in five of the 50 vehicle installations. In those cases, participants completed more than 10 hours of driving during the first few days of the study. The external battery was exhausted in only six of the 50 surveys. An increased battery life and trackpoint memory would have permitted a longer study.

DISCUSSION

There were a few caveats to this research. First, this research was not a survey of the rural older person population rather a focus on a sample of the rural older driver population and, by extent, a sample of their travel. The former would include all older people, including non-drivers (institutionalized older people were sent the 2006 Census). The sampled population reflects the attributes of its volunteers, including any bias that resulted in their participation rather than choosing not to participate. While the number of travel days sampled was not uniform for all participants due to equipment limitations, this was not considered an issue since data analysis was conducted in terms of participant averages per day. Any additional travel data would serve to refine those averages. Sampling active rural older drivers also meant that the small (but undefined) population of licensed non-drivers risked exclusion (though one participant was a licensed driver but did no driving). The travel behaviour of non-licensed older people was excluded.

Second, this research focused on individual driver behaviour associated with a specific vehicle. The vehicle that the participant normally drove was instrumented. There were 13 participants who were part of a two vehicle, two person household (minimum) where the other household member and their vehicle were not instrumented (at their request). There were six participants that were part of a two vehicle, two person household where one vehicle was considered the couples primary vehicle, with the second vehicle a seasonal vehicle. The participants indicated they did not believe it worthwhile to instrument the second vehicle given its low usage.

Third, it is possible that the knowledge of being observed may have affected travel behaviour. Anecdotally, while several participants reported that they "forgot the unit was even there", the knowledge that speed and position data were being recorded likely had some small impact on behaviour. Perhaps someone who typically exceeds the speed limit displays compliant behaviour under observation. It is impossible to know the exact impact or degree of behaviour modification. Nevertheless, when compared to existing methods for travel data collection (primarily self-reported pen and paper survey), the use of the GPS travel diary returns actual travel distances, routes, speeds and locations. It is a far more accurate means of collecting travel information and provides information on secondary and tertiary trips that take place enroute to a final destination, which are often overlooked in pen and paper surveys.

Lessons learned

There are several lessons learned from employing the described research method to better understand rural older drivers. The Shadow Tracker system (GPS units and GIS) were appeared to be well-suited as a commercial-off-the-shelf solution to support the research method, but with some modifications, the system would be better aligned with conducting travel surveys instead of its fleet management function. A larger track point memory would be valuable (currently only about 10 hours of driving at a 3 second sampling rate) as would a longer battery life. Relying exclusively on the vehicle battery to power GPS units is not recommended given the potential for missed short trips. The inability to remove erroneous points from the Shadow Tracker GIS necessitated exporting the data to another platform and in those cases made the Shadow Tracker analysis tools useless.

Employing a pen and paper method of recording participant recall and stated adaptation survey information ensured a "hard" copy of information, but introduced possibilities of transcription errors. There would still have been potential for these errors had an electronic entry method been used, however, these errors would be minimized by eliminating a transcription step. Employing this traditional method was more a function of the lack of readily available way to tie participant-supplied data with data collected through Shadow Tracker.

The type and frequency of miscellaneous trips presents a challenge from a coding perspective since they do not fit into typical categories such as "home" or "work", but do represent an important outcome of the method and a better understanding of what rural people use their vehicles to do. An automated method to assign trip purposes by address or land use would misinterpret those stops, or in some cases (depending on the non-movement time threshold) would miss the stops completely. While "stopping to look at something" may not be a critical transportation need, it highlights the uniqueness (and wide spectrum) of transportation experiences in rural areas.

The methods described by this paper are replicable; however, the degree of success is highly dependent on the ability of the researcher to understand the communities of interest and to work with local groups and individuals. Advances in satellite-based online mapping programs that permit one to view communities at a street level could be a valuable means to garner a better understanding of a study area.

The duel issues of personal privacy and fitness to drive converge in studies such as this, meaning that not every organization that has the interest to collect the data *should* collect the data. Transportation agencies are in the best position to identify a need and use for travel data, but the optics of being a regulator and planner could limit participation in a GPS travel-diary survey, especially if the participant believes the data will be available to enforcement agencies or insurance companies. In that case, services should be procured from an independent source such as a university which can offer an arms-length solution to collecting highly personal information, is subject to an ethics review board, and can ensure participant data remains confidential.

CONCLUSIONS

The use of GPS travel diaries was an effective means to collect travel data on rural older drivers. The Shadow Tracker J2 unit and associated Shadow Tracker Professional software were highly effective in their roles of collecting data and presenting them to participants in a meaningful and timely way. Participants successfully recalled the trip purposes of 1481 of the 1494 recorded trips, which is a recall rate of 99.1%. The use of a passive GPS and no participant interaction with the units minimized the potential for tampering and reduced participant burden. Participants generally appreciated not having to interact with the equipment. Travel data were collected on 60 participants representing 320 days of travel, which was approximately 5.3 days per person. This was a marked improvement on previous 1 and 2 day studies.

Service clubs and snowball sampling were the most effective means of recruiting participants and resulted in a sample with attributes (age, gender, employment status, driving kilometres per year) not statistically different from the larger population from which it was drawn. It was important, however, to communicate with seniors' advocacy groups to inform them of the project and invite their participation. One challenge with recruiting rural participants was that the larger advocacy organizations were often headquartered in urban areas which reduced their ability to supply volunteers.

The use of a battery pack to compliment a vehicle's power supply to the GPS unit was highly effective. The external battery was exhausted in only six of the 60 surveys which minimized the typical acquisition delay of 1 – 2 minutes and potential missed trips that could have occurred had the GPS unit power been tied to the vehicle ignition exclusively. Only 33 of 1494 recorded trip ends (stops) were due to lost reception or acquisition delay and in each case the missing distance data were interpolated. Future GPS travel diary surveys should ensure a continuous power supply for the duration of the survey, though this is complicated by the need for a small and portable survey method.

Jurisdictions with substantive rural populations should consider this method to complement their rural transportation planning efforts, but should involve a third party for the data collection and analysis to avoid perceptions of it being a government driving assessment tool.

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