CURRENT STATE OF WEB-BASED SURVEY METHODS

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Transportation Tomorrow Survey 2.0

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1 INTRODUCTION

The Transportation Tomorrow Survey (TTS) is a travel survey that is administered once every five years on behalf of "local, regional, provincial, and transit operating agencies in the Greater Toronto and Hamilton Area (GTHA)". The most recent TTS, conducted in 2011, surveyed a random sample comprised of 5% of households in the GTHA. The TTS traditionally collects data through a telephone interview. The 2011 TTS also gave participants the option to complete the survey online in lieu of an interview. The TTS continues to utilize a list of residential landline numbers as its sampling frame for the recruitment of households. (U of T Data Management Group, 2014)

One of the main issues with the TTS is the sampling frame from which participants are recruited. As landlines become less common, the utilization of a landline directory becomes less and less representative of the population and results in the underrepresentation of younger members of the population, students, and seniors (Miller & Habib, 2014). Traditionally, web surveys have suffered from low response rates and have been unable to obtain a representative sample of their target population. Developments in the technology behind web surveys, as well as an increase in the percentage of the population that has internet access has made web surveys a viable tool to be used by the TTS. While web surveys now have the potential to collect travel over a multi-day period and can be used to collect individual or household-based travel data, key differences still exist in the manner in which people respond to web surveys vs. more traditional survey modes. Care must be taken when designing a web survey, as the design of a survey can affect the representativeness of the survey data.

The purpose of this report is to explore and discuss the potential uses of web surveys in a new design of the TTS. *Section 2* discusses issues faced by web surveys pertaining to the sampling frame and response rates, methods that have been used to create sampling frames, and methods for improving response rates. *Section 3* discusses the current state of web surveys, including the differences between web and traditional survey modes, the aspects of survey design that must be given consideration, and the current state-of-the-art of web surveys. *Section 4* discusses the ability of web surveys to collect individual- and household-based travel data. *Section 5* discusses the potential to collect data over a multi-day (2-7 days) period using web surveys. *Section 6* presents an analysis of data collected in the 2011 TTS that examines the differences in responses provided by web and telephone survey respondents. *Section 7* identifies sub groups that may be missed or underrepresented by a web survey, and *Section 8* presents recommendations for pilot testing that will begin in 2016.

2 SAMPLING FRAME AND RESPONSE RATES

Two key factors that determine the representativeness of survey data are the sampling frame and the response rate of the survey. Ensuring that the sampling frame gives each member of the population a known, non-zero probability of being selected reduces the sampling bias in survey data, and helps to reduce the effects of errors due to sampling (Habib, 2014). Common sampling techniques include address-based sampling, random digit dialing, and stratified random sampling. Non-response among members of the sample can also reduce the representativeness of survey data, as data expansion techniques become less effective as the number of respondents decreases. This section describes the representativeness of data that has been collected through web surveys in past studies and describes strategies that have attempted to create a representative sampling frame of the target population. Also discussed are factors that influence response and drop-out rates, methods for improving response rates, and strategies that have been implemented by survey administrators to address concerns over the privacy and confidentiality of responses.

2.1 Statistically Representative Sampling Frames

2.1.1 Representativeness of the Sample

One of the key issues associated with the collection of data through web-based surveys is the inability of web surveys to recruit a sample that is representative of the population. Web surveys are particularly susceptible to sample bias (Alsnih, 2006), because they tend to capture a slightly different subsection of the population than traditional survey methods (Pan, 2010). Web surveys tend to over-represent younger, wealthier males who possess higher levels of education (Sills & Song, 2002), which historically was the result of the tendency of people with internet access to be younger, more educated, and have higher incomes than their counterparts (Messer B.L., 2011). In the past, survey researchers and practitioners have argued that an exclusively web-based survey should not be used to survey an entire population with the goal of collecting representative data, because internet access is not ubiquitous among members of most populations (Parsons, 2007). This is less of an issue nowadays, as the percentage of internet users in Canada has increased from 73.2% in 2007 to 85.8% in 2013 (The World Bank, 2015). In addition to the issues of sample representativeness and internet access, another major issue is the creation of a representative sample frame from which potential respondents can be selected.

2.1.2 Creating a Representative Sampling Frame

The issue of creating a sampling frame that is representative of the target population is neither unique to web-based surveys, nor is it a new issue. The TTS is currently faced with the issue of its sampling frame (a landline directory) under-sampling households without landlines, younger people, students, and seniors (Miller & Habib, 2014). Strategies that were used to create sampling frames, as well as databases that were adopted as sampling frames, have been documented and described in the literature, including: the formation of an "internet panel" from which survey data are collected (Stern, et al., 2014), and the Expanded Programme of Immunization that is used by the World Health Organization (Bostoen & Chalabi, 2006).

The formation and surveying of a representative "internet panel" is one method of ensuring that the survey data are representative of the population, however the survey administrators must ensure that particular demographics are not over- or under-represented, and that respondents are not answering questions haphazardly in order to quickly complete the survey (Stern, et al., 2014). The surveying of an "internet panel" has the potential to significantly simplify the collection of data from respondents, however the process of recruiting panel members may prove to be challenging. One such method for creating an "internet panel" is the probabilistic panel approach, wherein the panel is formed through a combination of traditional probability sampling and stratified "refreshment" samples in order to ensure that the sample is representative

of the population (Stern, et al., 2014). An example of an "internet panel" is the CentERpanel in the Netherlands, which consists of over 2,000 Dutch households that complete online surveys on a weekly basis (de Bruijne & Wijnant, 2013). The CentERpanel is meant to be a representative sample of the population of the Netherlands, and its membership is annually supplemented through the use of stratified sampling (de Bruijne & Wijnant, 2013). Although efforts are made to ensure that the panel adequately represents the population, the panel may include an inherent bias that stems from the type of people that choose to be part of such a panel.

One method for creating a sample without the presence of a sampling frame is the Expanded Programme on Immunization (EPI) that is implemented by the World Health Organization (WHO), in an attempt to provide universal access to relevant vaccines to all those at risk (World Health Organization, 2013). The WHO's method involves choosing and surveying an equal number of households from a particular set of clusters (e.g. neighbourhoods, villages) (World Health Organization, 2013). Within each cluster, a location close to its centre is chosen and a random household in a randomly-chosen direction is selected to participate in the survey (World Health Organization, 2013). The household closest to the previous household is then selected and surveyed if its members comply with the selection criteria; this process is repeated until the required number of households is surveyed (World Health Organization, 2013). This is a relatively simple method to survey a population without the presence of a formal sampling frame, however the EPI's ability to obtain a representative sample of the population is questionable.

Survey administrators have also adopted databases as the sampling frame of their surveys, particularly when address-based sampling (ABS) is employed, or when comprehensive records of the members of a survey's target population exists, such as a survey of the students of a particular university. In Canada, Canada Post makes its "Canada Complete mailing lists" available for rental to business owners for the purpose of targeted marketing (Canada Post, 2015). Canada Post boasts that their mailing list contains over 13 million Canadian residential addresses, over five million of which are in Ontario, and allows users to obtain complete and up-to-date addresses (Canada Post, 2015). The Canada Complete mailing lists also allow customers to target both households on the basis of household attributes, such as geography and residence type, and individuals on the basis of demographics and interests (such as travel frequency and reading interests). The Canada Complete ™ Consumer Masterfile, a detailed summary of the details that can be included in a Canada Complete mailing list, as well as the associated costs, can be found in Appendix D.

Past studies have used a database similar to the Canada Complete mailing list, namely the US Postal Service Delivery Sequence File, as a sampling frame to select and recruit participants for an online survey (Messer B.L., 2011). Regional travel surveys that have been conducted in the U.S. have also utilized the Computerized Delivery Sequence (CDS) file as a sampling frame, such as the Utah Travel Study (Research Systems Group, Inc., 2013) and the South Jersey Household Travel Survey (Westat, 2014 Household Travel Survey). In both cases the CDS file was used to create a sample of households in the survey area. Attempts were made to match telephone numbers to the sampled addresses, and said households were sent recruitment packages by mail. Sampled households that had an associated phone number also received phone calls during the recruitment process. In both cases, respondents were given the option to participate in the survey either over the phone or through a web interface. Other surveys have used the CDS file as part of a dual sampling frame, such as the Atlanta Regional Travel Survey, which utilized both an address-based frame and a Listed Residential frame, which included "listed telephone numbers … for which the name and address associated with the telephone number were known" (PTV NuStats, 2011). The address-based frame was used due to its ability to reach households that traditionally participate at below-average levels, such as households that do not have a landline, and the Listed Residential frame was used in order to "strengthen the coverage of households with listed landlines" (PTV NuStats, 2011). Similar to the Utah Travel Study and the South Jersey

Household Travel Survey, the Atlanta Regional Travel Study also gave respondents the option to participate in the survey by providing responses either over the phone or through a web interface.

2.2 Improving Response Rates

2.2.1 Influences on Response Rates

The factors that influence the response rate of a survey include: the nature of the study, the nature of the interaction between the surveyor and the participants, the characteristics of the respondents and of the sample, and the mode of survey response. When it comes to the decision to participate in a survey, Alsnih (2006) argued that topic salience and the topic of the survey have a major impact on response rates. This sentiment was shared by Sills and Song (2002) who state that the subject of a study has a significant impact on response rates. It is reasonable to believe that the subject of a study is an important factor in determining whether or not a survey participant will take the time to complete the survey. Individuals are more likely to bear the cost of responding to the survey, in terms of both time and response burden, if they have an interest in the process or the results of said study.

Another factor that has been shown to impact the response rate of a survey is the nature of the interaction between the surveyor and the participants, such as the manner in which participants are contacted, and the frequency with which reminders are distributed (Sills & Song, 2002). Alsnih (2006) states that prior studies have shown that increasing the number of contacts with participants increases response rates, regardless of mode, which is backed up by Parsons (2007) who states that the number of contacts, personalized contacts, and pre-survey contacts all impact response rates. These observations seem sensible, as increasing the number of contacts with participants serves to provide additional reminders to complete the survey, and the personalization of contacts has the potential to legitimize the survey in the minds of participants, as well as influence respondents to believe that completing the survey is worth their time.

The characteristics of the participants, and the sample frame as a whole, also influence the response rate of a survey. For example, web surveys may be a more appealing option for people who are busy, because they can complete it at their leisure, and because it allows them to save their progress and resume completing the survey at a later date. Another respondent characteristic that affects response rates are the characteristics of the household. Households that are larger than average and households that travel more than average tend to be non-respondents of travel surveys, partially due to the additional burden associated with recalling and reporting trips that were made by each member of the household (Stopher & Greaves, 2007).

Some surveyors have attempted to offset the costs incurred by participants to complete the survey by offering various incentives, however they have experienced varying degrees of success (Millar & Dillman, 2011). For example, Millar and Dillman (2011) found that offering a token cash incentive of $5 cash improved the response rates of web respondents and respondents who had to choice of response by web or mail by 17.9% and 20.6%, respectively. Conversely when the Utah Travel Study offered an additional $10 amazon.com gift card to respondents who had only partially completed the survey, response rates only improved by 1% (84 such households completed the survey; 9,155 household in total completed the survey) (Research Systems Group, Inc., 2013).

The choice of survey mode may be the design decision with the greatest impact on response rates. For example, the method in which surveyors contact participants can result in an additional response burden being incurred if the survey is to be completed through a different mode, such as a web survey that requires participants to manually enter the survey URL. In the case of web surveys, an additional response burden may be incurred by participants who are not web-literate (Alsnih, 2006), which in turn has the potential to increase

frustration on the part of participants, and ultimately lead to cases of survey non-response. This issue may stem from the fact that some people tend to be distrustful of the internet because they have little control over what takes place on their computer, are weary of phishing and spyware, or are worried about viruses (Dillman & Smyth, 2007). Another potential cause of these issues is the frustration experienced on the part of the respondents when completing the survey, particularly when a respondent is uncomfortable using a computer or when variations in browser settings, user preferences, and hardware result in a survey being presented in a manner that differs from its intended design (Andrews, et al., 2003).

With respect to mobile web surveys, de Bruijne and Wijnant (2013) argued that maximum user-friendliness is essential for mobile surveys (web surveys completed on mobile devices such as tablets), as it plays a key role in stimulating a willingness to participate and motivating respondents to provide valid data throughout the questionnaire. They also found that mobile surveys were likely to have lower response rates that traditional web surveys, possibly because the respondents of mobile web surveys will incur an additional response burden if they are required to switch devices in order to participate. Interestingly, providing participants with the option to choose their mode of response simultaneously did not guarantee higher response rates, because the inherent consideration of trade-offs and opportunity costs could result in each option looking worse than it would on its own; however, sequentially offering the choice of response mode had the potential to increase response rates in some cases (Millar & Dillman, 2011).

The two most common causes of survey participants dropping out prior to the completion of the survey are participant frustration and usability issues. Technical issues such as long transmission times and server timeouts tend to increase participant frustration, as does the need to scroll to see the entirety of a question (especially horizontal scrolling) (Schleyer & Forrest, 2000). Surveys that incorporate multiple or graphic designs and instructions that make the user's task ambiguous (Andrews, et al., 2003), as well as surveys with a relatively large number of data-entry boxes (Alsnih, 2006) tend to result in higher drop-out rates, mainly due to an increase in response burden. Features such as instructions that clearly instruct users on how to proceed, assurances regarding the ease of response, an indication the estimated time to complete the survey, and an indicator of one's current progress through the survey can help to reduce respondent frustration, and thus reduce drop-out rates (Alsnih, 2006).

2.2.2 Improving Response Rates

A variety of strategies for improving survey response rates have been implemented at various stages of the survey process, with varying degrees of success. The basic methods for improving response rates are based on reducing participant frustration and/ or the burden of responding to the survey. During the pre-survey contact stage, assurances that the survey would take less time (Andrews, et al., 2003), offering a paid-in-advance cash incentive (Millar & Dillman, 2011), the use of pre-survey contact and solicitation emails that are distinct from spam emails (Pan, 2010) have all been shown to increase response rates. Regarding the design of the survey, the sequential offering of response modes (Millar & Dillman, 2011), the provision of a personalized link to the survey via email (Messer B.L., 2011), and providing clear instructions (Parsons, 2007) have all had a positive influence on the response rate of a survey. Some studies have also found that sending email reminders to participants has the tendency to result in a spike in the number of responses (Pan, 2010). The table below summarizes strategies for improving response rates that have been implemented in studies and/ or surveys, and presents their effectiveness.

TABLE 1: A SUMMARY OF STRATEGIES FOR IMPROVING RESPONSE RATES

Study/ Survey	Method	Impact
Improving Response Rates to Web and Mixed Mode Surveys (Millar & Dillman, 2011)	Offering respondents the chance to answer through a different mode	1. Increase of 1.9 – 7.8% in response rates 2. Greatest increase occurred when web respondents were offered the chance to respond via postal mail
	Using email to maintain contact with respondents after the recruitment phase	1. Highest response rates among the four response types (web-only, mail-only, web or mail, and web + email)
	Offering a token cash incentive	2. Increased web response rate by 17%
Surveying the General Public Over the Internet Using Address-Based Sampling and Mail Contact Procedures (Messer B.L., 2011)	Allowing respondents of a web survey to respond by mail	3. Increased response rates by 12 – 19%
	Allowing respondents of a mail survey to respond by web	4. Increased response rates by 0.9 – 3.1%
	Offering an incentive for completion	5. Increases the odds that someone who possesses a lower level of education by 61%
Utah Travel Study	Offering twice the incentive (a $20 Amazon.com gift card) to finish a partially completed survey	6. 84 of the 889 (9.45%) partially completed surveys were finished

2.2.3 Addressing Privacy Concerns

One of the issues that can arise when people are invited to participate in surveys is the concern that the information that they disclose will not remain private. This may deter respondents from providing truthful answers to survey questions or deter them from participating all together. Specifically regarding web surveys, this issue has traditionally stemmed from the fact that the questionnaire is somewhat of a "black box" from the perspective of the participants, in that they have little-to-no control over where their responses are being sent. However, the near universality of internet access has mitigated some of these concerns, and other strategies for mitigating privacy issues that revolve around establishing the credibility of the survey in the minds of participants and making details regarding the survey available to the public have also been implemented. Strategies that have been implemented to mitigate privacy concerns include the separation of the invitation from the survey itself, the collection of data through web pages, the use of a credible domain, the disclosure of sampling procedures, and the posting of survey results (Andrews, et al., 2003).

The use of web surveys as a means of collecting data can also help mitigate this issue, as the inherent anonymity of web surveys tend to result in more honest responses from participants and elicit better data when sensitive data are asked to be reported (Parsons, 2007). This assertion was supported by Pan (2010), who stated that online survey respondents are more likely to respond to sensitive and private questions, as

well as provide more text when posed with opened-ended questions. This tendency was observed by Woo, Kim, and Couper (2014), when they analyzed the differences in the results of the web and cellphone administration of the 2010 Dongguk University Time Use Survey (DUTUS); web respondents' responses displayed significantly higher rates of agreement with university records at all levels of precision. The ability of a respondent to complete a web survey at their own leisure, as well as the knowledge that they need not worry about being judged on the basis of their responses, may contribute to the tendency of web respondents to provide greater amounts of text when presented with open-ended questions.

A number of travel surveys, such as the Utah Travel Study, the Atlanta Regional Travel Survey, and the Calgary and Region: Travel and Activity Survey all include assurances that the privacy of respondents will be respected and protected, with respondents being provided a link to the privacy policy of the respective survey administrator. In particular, NuStats instructs interviewers to address privacy concerns raised by respondents by responding: "We respect your privacy and promise to protect it. The information your household provides will be kept strictly confidential. Your name and personal information will be separated from your responses for analysis." (NuStats Research Solutions, 2012). Research Systems Group (RSG) and NuStats both reiterate that the privacy of respondents will be respected and protected in their Frequently Asked Questions (FAQ) materials.

3 THE CURRENT STATE OF WEB SURVEYS

In recent years, web surveys have become a tool that is commonly used by survey administrators to collect data from relatively large populations. Survey research consultation firms such as PTV NuStats and Research Systems Group (RSG) have utilized web surveys as their primary mode of data collection during the administration of regional travel surveys, such as the Utah Travel Study, the Atlanta Regional Travel Survey, and the Calgary and Region: Travel and Activity Survey. Although web surveys can be similar in both appearance and nature to traditional telephone and mail surveys, the design of a web survey, from recruitment to the appearance of the questionnaire, influences a participant's decision to complete the survey, as well as the manner in which participants respond to questions. This presents a series of design challenges, such as ensuring that the design of the survey does not influence responses, and ensuring that self-reported data are complete and accurate. The usability of the survey is also an important consideration, as respondents tend to drop out when they reach an unacceptable level of frustration. This section discusses the differences between web and traditional surveys, the considerations that must be made during the design of a web survey, and the current state-of-the-art in the field of web surveys.

3.1 Web vs. Traditional Surveys

3.1.1 Differences in Responses

Although web questionnaires can be made to look like paper questionnaires, and interviewers can ask participants all of the questions that would be asked on a web survey, there are still observable differences in the manner in which participants respond to web surveys versus more traditional survey modes. The presence of an interviewer can have a significant impact on the nature of the responses provided by respondents, as the presence of an interviewer tends to cause respondents to be more agreeable. The collection of survey data through an interview also increases the likelihood that respondents will provide socially desirable answers and decreases the likelihood that they will provide socially undesirable answers (Stern, et al., 2014).

This difference was observed by Woo, Kim, and Couper (2014) in their use of the Dongguk University Time Use Survey (DUTUS) to determine the differences in data collected via web and cellphone surveys. This survey utilized stratified random sampling to select a sample of 1000 students, of which 500 were to respond to the survey by using their cellphone to speak with an interviewer, while the other 500 were to respond via web. The survey contained 36 questions, with topics including the student's satisfaction with the school, the number of hours spent studying, and whether or not the student was a smoker. The questionnaire also included three questions that were used to estimate measurement error: whether the student is doing a double major or minor, their GPA, and whether the student is taking a teacher certification program. The responses that were provided to said questions were compared to the information available through school records, and this comparison was used to determine if a social desirability bias was present in data collected through cellphone interview. The investigators noted that higher social desirability bias was observed in the data collected via cellphone, although this could be the result of web respondents being able to look up their GPA rather than having to provide an estimate.

Another difference in survey responses via web versus other types of surveys is the reporting of the number of trips made by the members of a household. Households that report over the Internet tend to record higher trip rates than households that respond via traditional paper surveys (Alsnih, 2006); however, this may not be an issue with telephone surveys, due to the ability of an interviewer to encourage respondents to make a greater effort to recall all of their trips. This issue is not specific to web surveys, as traditional self-reported travel surveys have had the tendency to suffer from underreporting of the total number of trips made by a

household, and the rounding of start, finish, and travel times (Zhao, et al., 2015). Both web and traditional surveys have had to deal with several issues:

- tendency of participants to report a typical day of travel (instead of the trips that were made on that day)
- underreporting of short activities
- rounding of travel times to the nearest 5 or 10 minutes
- the existence of fairly significant intra-user day-to-day variability in travel and activity patterns

All of these may make the collection of a one-day snapshot of travel behaviour an inadequate method of collecting data for the purpose of understanding travel patterns and behaviour (Zhao, et al., 2015).

Although there have been instances where differences in the manner in which participants respond to web survey versus other surveys have been observed, there is no guarantee that these differences will be present in a given survey. In an attempt to determine possible mode effects on response behaviour, Marika de Bruijne and Arnaud Wijnant conducted a study in 2013, using the CentERpanel in the Netherlands as their sample (de Bruijne & Wijnant, 2013). The CentERpanel is composed of over 2,000 Dutch households that complete online questionnaires on a weekly basis, and whose members are meant to be a representative sample of the population. In their study, de Bruijne and Wijnant assigned each of the 661 participants to complete one of three versions of the same survey: a computer-assisted survey, a mobile device-assisted survey, and a hybrid computer-assisted survey whose layout emulated that of the mobile device-assisted survey. Upon analysis, there were no statistically significant differences in any of the mean values of the three survey formats on a 99% confidence level; on a 95% level, only four of the 26 questions displayed a statistically significant difference in mean values. This result may have been due to the fact that the three versions of the survey utilized a similar mode of response (typing answers and/or clicking on radio buttons as questions appear on a screen), or because the instructions were clear enough that the participants did not need to make use of visual cues to interpret what was expected of them.

3.1.2 Differences in Respondents

As mentioned in section 2.1.1, web surveys tend to capture a different subsection of the population than more traditional survey methods. This may be due to the relative convenience of web surveys compared to telephone and mail surveys, in that a web survey can be completed at one's leisure and need not be mailed back, which would introduce an additional burden on the part of the respondent. These features may make web surveys more appealing to busier members of the population (Alsnih, 2006) who may not be home or may not be available for interview during the moment that they are called by an interviewer. The difference in the types of respondents surveyed by web surveys versus other types of surveys may also be the result of internet accessibility on the part of respondents. Web survey respondents tend to possess higher levels of education and income than face-to-face respondents (Bayart & Bonnel, 2012), which may mean a greater number of computers and other devices with access to the web in the household, and more bandwidth available on a monthly basis. This difference in the income and education between web and landline respondents is not present in the data collected through the 2011 TTS, which allowed participants to respond through the phone or online, as the demographics of the two sets of respondents are fairly similar (see section 6 for a more detailed analysis of data from the 2011 TTS).

The relative convenience of a web survey may be offset by the response burden incurred by participants who are either not web-literate, or who may choose to respond to a survey through a mode with which they are more familiar and/ or comfortable, such as the telephone, although others may ask a friend or relative to complete the web survey for them. Participants who are not confident in their ability to use a computer to

respond to a survey may also incur an additional response burden, particularly if they experience difficulties when first attempting to complete the survey. Members of the population that fall into this category may drop out due to frustration, decide to complete the rest of the survey using a method with which they are more familiar (such as the telephone), or ask someone to complete the survey on their behalf. Taking this into consideration, it is sensible that the respondents of web surveys tend to be younger, as younger members of the population tend to possess a greater level of comfort and aptitude when it comes to using technology.

3.2 Design Considerations

3.2.1 Design Standards and Reference Designs

The design and presentation of the questionnaire is an important step in the survey design process. The layout of a survey influences the manner in which participants interpret the questions and response options of a questionnaire, particularly when the instructions or questions are worded in an ambiguous manner, or when users are unsure about the task at hand. In particular, users will seek out and utilize visual cues and/ or numerical labels in an attempt to infer what is expected of them (de Bruijne & Wijnant, 2013).

Below is a summary of various decisions that can be made with respect to the design of a survey, and the potential impacts that they can have on how respondents answer questions.

TABLE 2: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO SURVEY RECRUITMENT

Design Aspect	Description		Source
Use of Email Invitations	1.	Respondents are more likely to respond to an email invitation when they were told that the survey would take a short amount of time, when they received an embedded password, when the subject line referred to a survey or pleaded for help, when the invitation was personalized, and when they received frequent reminders	(Parsons, 2007)
Cover Letters as a Means of Survey Recruitment	2.	Cover letters that are sent out prior to the beginning of a survey should include assurances of confidentiality, which would serve to legitimize the study in the eyes of respondents	(Alsnih, 2006)
Offering Multiple Modes of Response	3.	Sequentially offering different modes of response has been shown to improve response rates [Millar and Dillman (2011) found that allowing the participants of a web survey to submit their responses through the mail increased the response rate of said survey by 17%]	(Bayart & Bonnel, 2012)

TABLE 3: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO SURVEY NAVIGATION

Design Aspect		Description	Source
Survey Introduction	1.	The introduction to the survey should be welcoming, motivational, convey the ease of responding, and instruct respondents on how to proceed	(Alsnih, 2006)
	2.	The welcome screen should be motivational, emphasize the ease of responding, and instruct respondents on how to proceed to the next page	(Parsons, 2007)
	3.	The introduction page of a survey should contain text that establishes the authority and credibility of the researchers, explains the purpose of the survey, establishes respondent confidentiality and privacy, and provides a third-party guarantee of the survey's authenticity and credibility	(Andrews, et al., 2003)
Placement of Instructions	4.	Instructions should be placed below question text and above the response options	(Crawford, et al., 2005)
	5.	Instructions on how to navigate through the survey should be clear and appear throughout the survey	(Alsnih, 2006)
	6.	Explicit instructions should only be provided where needed, and the ability of respondents to remember instructions, and their aptitude with computers and software should be taken into account	(Parsons, 2007)
Italicizing Instructions	7.	The italicization of instructions prevents them from drawing attention away from the questions, while still providing the necessary information	(Crawford, et al., 2005)
Survey Navigation	8.	The navigation of a survey should be facilitated by action buttons that are distinct from any response element	(Crawford, et al., 2005)

TABLE 4: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO VISUAL FEATURES

Design Aspect	Description		Source
Background Colours and Images	1.	May create contrast issues, making test difficult to read	(Crawford, et al., 2005)
	2.	The presence of background images may increase download time	
Graphics	3.	Must be carefully considered, as they may influence how respondents answer questions	(Crawford, et al., 2005)
Multimedia	4.	Should be avoided, as it will increase the time needed to download the survey	(Crawford, et al., 2005)
Estimated Time to Complete Survey	5.	Providing respondents with an estimated of how long the survey will take can help reduce respondent frustration and avoidable terminations	(Alsnih, 2006) (Parsons, 2007)
Use of Visual Elements	6.	Visual elements should help respondents answer questions correctly the first time, as error messages tend to increase respondent frustration	(Dillman & Smyth, 2007)

TABLE 5: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO THE PRESENTATION OF QUESTIONS

Design Aspect	Description		Source
Bolding Question Text	7.	Allows users to quickly determine where a question ends and the response options begins	(Crawford, et al., 2005)
Layout of Questions	8.	Organizing questions in a manner that requires respondents to scroll horizontally on their screens should be avoided	(Crawford, et al., 2005)
Use of Skip Logic	9.	In questionnaires that utilize skip logic, numbered labels should be excluded from questions as they may cause confusion	(Crawford, et al., 2005)
	10.	Incorporate a skip pattern to shorten surveys	(Parsons, 2007)
Presentation of All Survey Questions	11.	Allowing respondents to view all of a survey's questions may imply to them that each question must be answered	(Alsnih, 2006)

TABLE 6: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO SCREEN DESIGN

Design Aspect	Description		Source
Contact and Supplemental Information	12.	The inclusion of contact and other supplemental information should be included, to allow respondents to contact the survey administrators if need be	(Crawford, et al., 2005)
Maintaining a Consistent Screen Design	13.	If the top of every screen looks the same, respondents will tend to ignore the area after their first review	(Crawford, et al., 2005)
Survey Presentation	14.	The segmentation of a survey into several sequential screens keeps transmission times to a minimum, helps avoid server timeouts, and reduces and/or eliminates the need for users to scroll while completing the survey	(Alsnih, 2006)
	15.	Reduce instances in which scrolling is required	(Parsons, 2007)
	16.	Web surveys should be designed to support multiple web browsers, prevent multiple submissions, have the ability to present questions in a logical or adaptive manner if needed, provide multiple opportunities to stop and resume at a later time, collect both qualitative and quantitative data, and provide a "thank you" upon completion of the survey	(Andrews, et al., 2003)
Format of Text	17.	Dark text on light backgrounds maintains readability and reduces measurement error	(Parsons, 2007)

TABLE 7: A SUMMARY OF THE IMPACTS OF DESIGN DECISIONS PERTAINING TO THE PRESENTATION OF RESPONSE OPTIONS

Design Aspect		Description	Source
Presentation of a Full-labelled Scale	18.	Fully-labelled scale response options should be arranged vertically, especially if a horizontal arrangement cannot accommodate all response options in one row, without requiring respondents to scroll horizontally	(Crawford, et al., 2005)
	19.	All response options should be visible, not requiring users to scroll down the page	(Parsons, 2007)
Soliciting a Single Response to a Question	20.	When there are more than eight response options, drop-down boxes should be used to present response options to respondents, however they should not be pre-loaded with a response	(Crawford, et al., 2005)
	21.	When there are fewer than eight response option, radio buttons should be used for input	
	22.	Using radio buttons prevents users from submitting multiple responses to questions when only one is desired	(Andrews, et al., 2003)
Use of Check Boxes	23.	Check boxes should be used when categorical multiple response options are provided to respondents	(Crawford, et al., 2005)
	24.	Avoid check-all-that-apply response options	(Parsons, 2007)
Use of Data Entry Boxes	25.	Response burden tends to increase as the number of data entry boxes increases	(Alsnih, 2006)
	26.	Limit the number of open-ended questions	(Parsons, 2007)

3.2.2 Design Challenges

When attempting to survey the members of a population over the internet, a number of design challenges – both those unique to web-based travel surveys and those that are common to every type of travel survey – arise. One of the issues that plague diary-based household travel surveys is the ability of respondents to provide accurate and complete information. Respondents tend to be able to accurately describe the distances that they have travelled, however they have the tendency to round their arrival and departure times (Bayart & Bonnel, 2012). Respondents also have difficulties providing detailed and accurate reports of their trips over a relatively long period of time (generally one day), although this can be mitigated by the presence of an interviewer, who can encourage respondents to make more of a "memory effort" (Bayart & Bonnel, 2012). Travel surveys that are administered through the internet must also deal with the issue of variations in the appearance of the survey across different web browsers. The variable presentation of an online survey can impact a respondent's ability to complete the survey, as well as their responses to said survey. This impact is

exacerbated when the survey is interactive, or makes use of internet browser features such as JavaScript (Pan, 2010). Apart from the issues of sample representativeness and non-response, a key design challenge that must be dealt with is reducing the measurement error associated with collecting households travel data through web-based surveys.

3.2.3 Ensuring the Accuracy and Completeness of Self-Reported Data

A benefit of utilizing web surveys as a means of collecting self-reported data are the ability to automatically code said data, as well as the ability to validate data through the administration of logic checks. Some travel surveys have incorporated logic checks into their data coding process, such as the 2011 TTS, which built logic checks into both the interview and the data coding software in order to reduce the potential of the inclusion of error in the survey data (U of T Data Management Group, 2013). These kinds of processes and algorithms allow the quality of survey data to be checked; however, it is difficult to ensure that self-reported data are adequate both in terms of accuracy and completion. While logic checks can be applied after data has been collected, the data collection process would be more efficient if respondents are not required to add information to their initial responses after the fact. In addition, a larger sample size has the potential to provide a more representative reflection of the behaviour of interest.

One method of ensuring that self-reported data are both accurate and complete is to provide respondents with sample answers that reflect both the degree of accuracy and completeness that is expected by the survey's administrators. This, however, has the potential to influence the nature of the submitted responses. Another potential solution is to discretize the individual components of a response, particularly when soliciting the address of a trip origin or destination. This would ensure that each and every address that is provided by a respondent is detailed enough to be automatically geocoded. Some surveys have attempted to ensure that survey data are complete by requiring that a particular subset of questions include responses in order to progress through the survey. While this has the potential to be successful, the questions for which responses are required must be carefully chosen, as requiring responses to questions regarding sensitive information (such as income) has the potential to deter respondents from completing the survey. The Calgary and Region: Travel and Activity Survey attempted to mitigate this issue by assigning each variable to one of six "tiers", with tier 0 being the most important tier 5 being the least important (NuStats Research Solutions, 2012). Variables that were assigned to tiers 0 and 1 required response from all respondents, and included variables such as household size and the number of employed persons in the household (NuStats Research Solutions, 2012).

3.2.4 Influence of Survey Design on Survey Responses

One of the issues that arise when designing a survey is the mitigation of influence of measurement errors on survey data. The manner in which a questionnaire is designed and presented has been shown to influence the manner in which some respondents respond to questions. One example of this influence was observed by Woo, Kim, and Couper (2014) when they analyzed the differences in the results of the web and cellphone administration of the 2010 Dongguk University Time Use Survey (DUTUS). They found that 15 of the 36 survey items displayed a statistically significant difference in the responses obtained via web versus through cellphone interview, with a 95% level of confidence. These discrepancies are partly due to the manner in which respondents experience surveys, and their expectations when participating in a survey. Survey respondents tend to behave as if they are engaged in a conversation, and as such adhere to the so-called universally observed laws of communication. This included that "one should be understandable, clear, concise, honest, and not repetitive," and, so they expected the administrators to do the same (Dillman & Smyth, 2007). Part of why web surveys are inherently different from conventional methods is the lack of non-verbal communication elements that are a key component of analyzing and understanding focus groups (Parsons, 2007). Also a factor is the absence of an interviewer to encourage and prompt respondents to provide

answers to questions. If a web questionnaire is designed in a manner that is contradictory to said laws, such as the ambiguous wording of questions or asking of repetitive questions, users may interpret questions in a manner that differs from the intentions of the administrators. This may result in data that does not accurately represent the desired behaviour of interest.

Differences in the nature of responses among response modes, particularly when compared to web surveys, can be due to the tendency of respondents to seek visual and/or numerical cues when they are unsure about the task at hand. Respondents attempt to determine what is expected of them by interpreting such cues, which may lead to respondents misunderstanding questions. This misunderstanding may lead to respondents providing inaccurate or irrelevant information; however, this can be mitigated by the clear wording of cues and the limitation of visual cues (de Bruijne & Wijnant, 2013). The difference in the nature of responses could also be due to the fact that web and traditional surveys tend to capture different subgroups of the population. Depending on the characteristics in question, this difference in subgroups may lead to an inherent difference in said characteristics (such as age, income, gender, etc.), which would manifest itself in differences in responses among different response modes.

Studies have also shown that travel diaries completed over the telephone result in the omission of a significant number of trips (Stopher & Greaves, 2007). Telephone respondents tend to omit roughly 20-30% of their trips (the omission of up to 60% of a respondent's trips have been observed), with short trips commonly being omitted (Stopher & Greaves, 2007). Respondents have also displayed a tendency to round travel times to the nearest 5-10 minutes, an inability to provide precise location details, and a failure to provide basic route information. The issues that respondents have providing accurate and complete trip information may form an argument in favour of activity-based reporting, rather than trip-based reporting (Bayart & Bonnel, 2012). In activity-based reporting, respondents would report their activities first, then work backwards to recall the trips.

Apart from the mode through which the survey is administered, the manner in which survey response options are presented can also have a significant impact on the manner in which respondents answer questions. The use of a respondent-friendly design, such as a survey that is designed to accommodate the abilities of web respondents of all skill levels, helps to reduce measurement error. This is accomplished by reducing distractions that may prevent responses from accurately reflecting the true nature of the behaviour of interest (Parsons, 2007). One example of how the presentation of a response option can influence the nature of responses is observed when respondents are asked open-ended questions. Questionnaires that provide an answer box whose size reflects the size of the expected answer have the tendency to elicit responses that were of the desired length (Dillman & Smyth, 2007). One of the issues that arises when administering a web survey is the potential for item non-response; however, this did not appear to be an issue among web respondents of the 2010 DUTUS, where the survey administrators observed fewer instances of item non-response to the three open-ended questions that were presented to respondents (Woo, et al., 2014). This issue can be mitigated by designing a questionnaire that requires each question to have a response before allowing respondents to proceed to the next screen, or the presence of an interviewer to both prompt respondents to provide an answer to each question and to ensure the completeness of survey submissions.

One of the possible reasons that the design of a questionnaire has an influence on the nature of responses is the existence of so-called visual heuristics. Studies such as Toepoel and Dillman (2011) and Tourangeau et al. (2004) have investigated the nature and influence that visual heuristics have on the manner in which respondents respond to questions. Tourangeau et al. argued that there may be a hierarchy of features to which a respondent reacts. This was proven to be correct, as the results of their study revealed that verbal labels tend to have the greatest impact on responses, followed by numerical labels, and finally visual cues

(Toepoel & Dillman, 2011). Tourangeau et al. also argued that survey respondents follow simple heuristics when interpreting the visual features of a question:

1. The middle option is seen as the most typical.
2. The leftmost or topmost response option will be seen as the "first".
3. Nearness implies relatedness.
4. The higher the option, the "more good" it is, meaning that the top option will be seen as more desirable.
5. Response options that are visually similar will be regarded as conceptually closer (Toepoel & Dillman, 2011).

The study also revealed that when a scaled response (such as good, very good, poor) is desired, the uneven spacing of scale points resulted in the response option closest to the visual midpoint being selected more often, rather than the option closest to the conceptual midpoint (Toepoel & Dillman, 2011). The unequal spacing between categories can also lead to an increase in the visual prominence of an isolated category (Toepoel & Dillman, 2011). In the case of response options, it may lead to both an increase in the number of options chosen by respondents, and an increase in the likelihood that respondents would choose one option from each category or subgroup. This would be regardless of the method through which said subgroups were created (Dillman & Smyth, 2007).

When soliciting scaled responses from respondents, the presentation of the response options must be carefully considered, as the layout of and values associated with said options has been shown to have an influence on responses. For example, if response options are presented in multiple rows along multiple columns, respondents tend only to read the top row of response options. On the other hand, the arrangement of all response options into a single column results in respondents reading the list from top to bottom (Dillman & Smyth, 2007). Thus, when respondents are asked to provide a scaled response to a question, the response options should be presented in a Likert-style arrangement (an example is shown in Figure 1). Another decision that can influence responses is the choice of the value associated with each response option. Respondents tend to consider the extremes of a scale to be conceptually further apart when they differed in both value and sign, than when they only differ in value (Toepoel & Dillman, 2011). The inclusion of negative values is significant because people tend to be hesitant to assign negative scores to themselves, which was observed by Toepoel and Dillman (2011). They found that the use of shading and values that ranged from -2 to 2 resulted in a greater number of respondents choosing options that were positive. As a result, positive values should be associated with response options, where possible, to reduce their influence on responses. The need to scroll horizontally should also be prevented, as it is a burden on the respondent and may result in some response options being neglected.

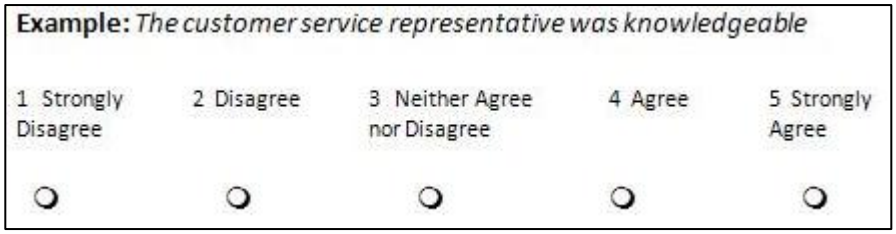


FIGURE 1: AN EXAMPLE OF RESPONSE OPTIONS THAT HAVE BEEN PRESENTED IN A LIKERT-STYLE ARRANGEMENT (VOICECLOUD, 2015)

3.2.5 Potential Satellite Surveys

At times it is necessary to conduct satellite surveys in order to gain a better understanding of the behaviour or characteristics of a sub-group of a survey sample or a sub-population that was overlooked by the core survey. Satellite surveys are small-sample surveys that are more focused and detailed than core surveys, and are meant to enrich and/ or augment the data collected from the core survey (Transportation Association of Canada, 2014). The use of the core-satellite survey design paradigm allows the survey designer to take a very flexible approach to data collection, as satellite surveys can be used to respond to new needs and issues (with respect to data) as they arise (Transportation Association of Canada, 2014). A satellite survey need not be conducted through the same methods that were utilized by the core survey. This allows the designers of the survey to choose the mode of response based on the characteristics of the sub-group, or in order to compensate for a deficiency in the core survey. One example is the use of a GPS-based survey in cases where accuracy and precision of the reported trip information is inadequate.

One example of a satellite survey that was designed to reach a particular subgroup was a survey of users of Public Transport Victoria's online journey planner tool (Schmitt, et al., 2014). This survey presented a poll to every fourth user of the tool, as well as a follow up survey regarding the trip planned through the journey planner. The poll asked whether the journey was being made by transit for the first time, and about their experience with Melbourne Public Transit, with respondents being invited to leave their email address to complete a follow-up questionnaire. The questionnaire included an explanatory statement, included questions regarding demographics and whether the respondent would use public transit to make the trip again. Respondents who completed the follow-up questionnaire were entered for a chance to win $A200 and $A50 vouchers, which could be used at local businesses. The manner in which the survey was administered ensured that members of the targeted sub-population, in this case transit users, were reached. This satellite survey allowed the administrators to develop a greater understanding about the criteria upon which transit riders evaluate the quality of transit service, and gain a general idea of the demographics of transit users. (Schmitt, et al., 2014)

One regional travel survey that has utilized satellite surveys to supplement data collected via the core survey was the 2012 Utah Travel Study. The core of the Utah Travel Study was the Household Travel Diary, which consisted of the Household Information Survey, the Travel Diary, and the Debrief. Respondents were asked to log their trips using a web tool provided by the survey administrators; however, Westat made telephone operators available to those who preferred this mode of response. The Utah Travel Study had seven satellite surveys, three of which were administered solely through web surveys: the College Diary, the Bike/ Pedestrian Barriers Survey, and the Residential Choice Stated Preference Survey. (Research Systems Group, Inc., 2013)

The College Travel Diary was a one-day travel diary that focused on trips with at least one end off-campus that were made on the most recent weekday. It was administered to students at eight colleges in Utah, in an attempt to correct for the underrepresentation of younger members of the population. The College Travel Diary asked participants to report individual-based travel information, and allowed all students to participate. The Bike/Pedestrian Barriers Survey was administered to respondents who had completed the Household Travel Diary and had expressed an interest in participating in future surveys, and to members of bike clubs and neighbourhood groups. The survey focused on identifying the physical barriers to cycling and walking, and asked respondents to identify "problem areas". The Residential Choice Stated Preference Survey was also administered to respondents who indicated an interest in participating in future surveys, and asked one adult to describe the aspects of their current housing and neighbourhood characteristics. The survey also asked respondents to answer a series of trade-off questions. The College Travel Diary allowed the survey administrators to ensure that younger members of the population receive adequate representation, which is an issue with the TTS. The Bike/ Pedestrian Debrief provided insight regarding the choice to utilize

active modes of transportation; it also had the potential to provide data pertaining to short trips, which tend to be omitted from travel diaries. The Attitude Debrief and the Residential Choice Stated Preference Surveys allowed the survey administrators to develop an understanding of the decision making processes of the members of the population, as well as learn about the hierarchy of the criteria upon which alternatives are evaluated. (Research Systems Group, Inc., 2013)

3.2.6 Usability Considerations

One of the main causes of respondents dropping out before they have completed a survey is the sense of frustration that stems from usability issues. Ensuring that a web survey is designed in a respondent-friendly manner should be key, as respondents already incur an additional response burden associated with responding via web. As previously discussed, the design of a questionnaire has the potential to influence the nature of the responses submitted by respondents, which means that it has the potential to introduce response bias into survey data. Ensuring that web surveys are respondent friendly is particularly important when respondents can access the survey through their mobile phone or tablet, as the use of a relatively smaller screen increases the difficulty of completing a survey (de Bruijne & Wijnant, 2013). User-friendliness is of particular importance when it comes to web surveys completed through mobile devices, as mobile surveys tend to have lower response rates than computer-assisted web surveys, and are likely to be more demanding (de Bruijne & Wijnant, 2013). de Bruijne and Wijnant (2013) discussed this tendency, stating that survey participants who completed the survey by using a mobile device (cellphone or tablet) reported a significantly longer survey that those who responded to the computer-assisted web survey, regardless of the layout. This effect was documented in Pierre-Leo Bourbonnais and Catherine Morency (2014). As confirmed by their household-and person-based interview duration models, the use of small screen devices to respond to a relatively complex survey has a "significant and positive impact on duration" (Bourbonnais & Morency, 2014).

Steve Krug (2013) provided an excellent guide on how to design web pages with usability in mind. One of the key points brought up by Krug was the importance of designing a web page to be "self-evident", or at least self-explanatory, in order to ensure that respondents can understand the information presented to them in a near-effortless manner. Ambiguity tends to detract from the cognitive ability of respondents, increasing the likelihood that measurement errors will be included within the survey data. Krug also pointed out that people have the tendency to skim and/or scan web pages, often employing the process of "satisficing" (choosing the first reasonable option). This is because there is no penalty for choosing an "incorrect" response, and weighing different options may not yield an optimal outcome. This tendency means that response options should be presented such that all options are visible upon first glance. Another usability consideration is the presence of a visual hierarchy, such as: importance being proportional to prominence, the visual relation of things that are logically related, and the use of nesting to signify belonging (Krug, 2013). The presence of a visual hierarchy is an important feature of web pages, as a lack of a hierarchy requires more thinking on the part of the users (Krug, 2013). If respondents are expected to require guidance at a particular point in the web questionnaire, it should be brief, timely, and formatted such that it is unavoidable (Krug, 2013).

3.3 The Current State-of-the-Art of Web Surveys

3.3.1 Potential Uses of Web Applications

When web surveys first began to be used by survey practitioners, they were predominantly used to take the place of paper questionnaires. As time has gone on, however, the use of web surveys has diversified. One of the attractive features of web surveys is that data can be coded and verified automatically (Andrews, et al., 2003), and tend to have lower variable cost less than traditional survey modes, albeit with the potential for greater fixed costs (Bayart & Bonnel, 2012). One of the newer applications of web surveys is the validation

of data collected through smartphones or GPS devices, such as the Future Mobility Survey in Singapore. This survey utilized a smartphone app to collect activity and travel data and presented this information to participants in the form of a timeline, through a web interface (Kim, et al., 2014). Participants used the interactive web interface to validate trip data and to provide supplemental trip data, such as the number of occupants in the car, and whether or not parking was free (Zhao, et al., 2015).

Web surveys are also being used as stand-alone methods of collecting data. Survey administrators have taken advantage of the ability to integrate visual features, such as maps and videos, into the survey itself in order to ease the response burden on respondents. Travel surveys have also begun to incorporate tables and maps into web surveys in order to make the data entry process more understandable. The Utah Travel Study, which primarily used web surveys to collect data, allowed respondents to identify the locations of the origin and destination of each of their trips by entering an address, entering a business name, or by placing a marker on the interactive Google map that was provided (see Figure 2). Other travel surveys have also utilized web surveys as a means of data collection, such as the Atlanta Regional Travel Survey, the South Jersey Household Travel Survey, and the Calgary and Region: Travel and Activity Survey. In terms of mode of data collection, the aforementioned surveys are fairly similar to the Utah Travel Study; however, they also gave respondents the option of responding via mail (PTV NuStats, 2011), (Westat, 2014 Household Travel Survey), (NuStats Research Solutions, 2012).

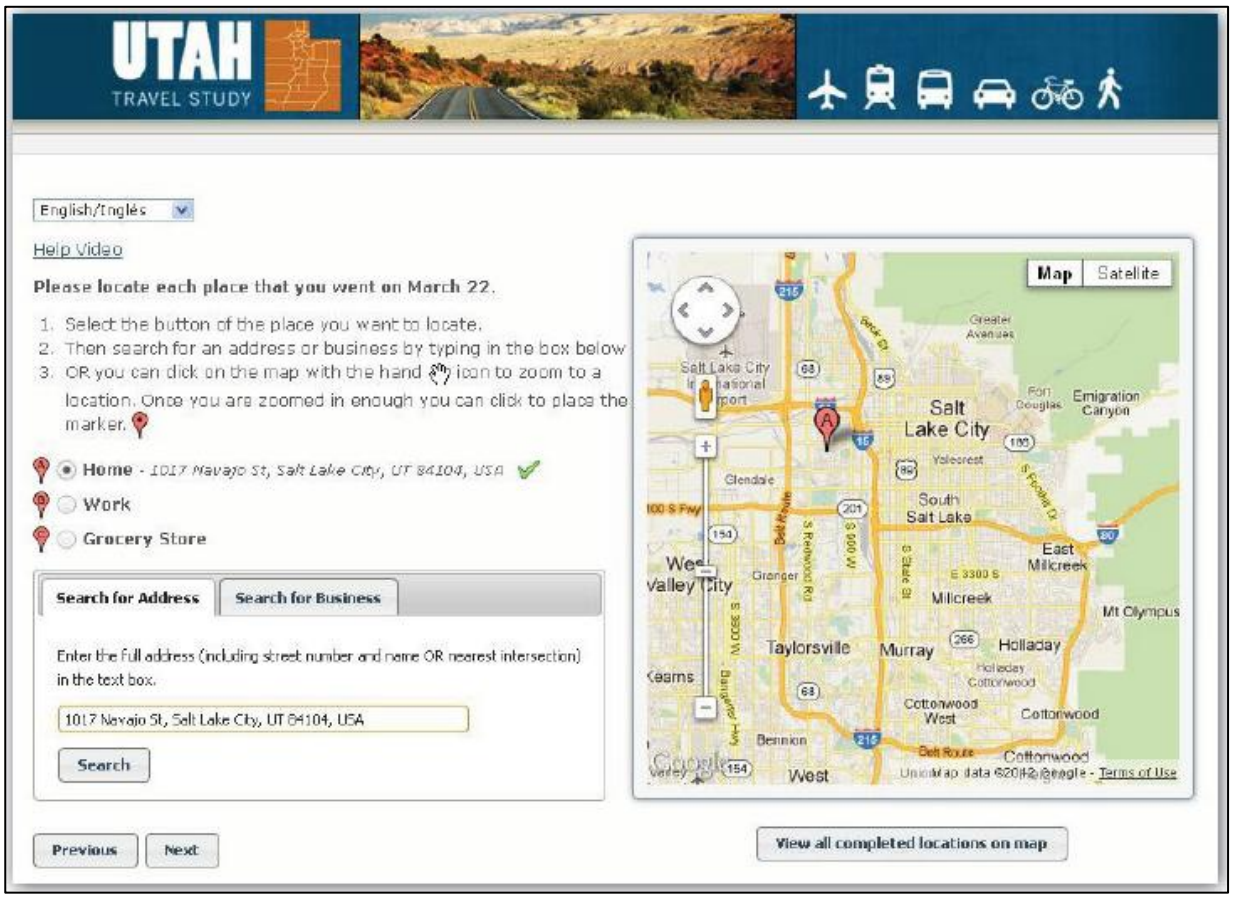


FIGURE 2: A SCREENSHOT OF THE INTERFACE USED BY RESPONDENTS TO COMPLETE THE UTAH TRAVEL STUDY (RESEARCH SYSTEMS GROUP, INC., 2013)

3.3.2 Potential Future Data Requirements

Advances in technology have resulted in an increase in the precision and accuracy of the travel data that can be collected from respondents, and the field of modelling is beginning to take advantage of this improvement. Presently, the field of modelling is trending towards reducing the size of traffic analysis zones (Stopher & Greaves, 2007), which would increase the demand for geographic precision in location data. Newer models are placing greater demands on the nature of data collected through travel surveys, such as the desire for point-geocoded data, and an interest in observing multiple activities that take place at the same time (in order to accommodate the sensitivity of tour-based and activity models to missing trip and activity location information) (Stopher & Greaves, 2007). Web-based surveys can assist with the collection of point-geocoded data, as web surveys allow respondents to enter the location or their trip origins and destinations via address, business name, or map marker. Entering data in this manner allows locations to be geocoded with a desired level of precision, with minimal effort on the part of the respondent. Web surveys can also be used to collect activity information from respondents, and may be a more efficient manner of collecting such information. They allow for all the trip information to be laid out in front of respondents, reducing the need to remember several facts at once.

Other models, such as behavioural process models, require travels surveys to elicit behavioural processes (Stopher & Greaves, 2007), which some surveys (such as the Utah Travel Study) attempt to collect through satellite surveys (Research Systems Group, Inc., 2013). Web surveys lend themselves well to stated preference (SP) surveys, particularly when said survey is primarily composed of a series of trade-off questions, as respondents need only click on their preference and move on to the next question. This would be a faster, and possibly more efficient, method of collecting information on respondents' behavioural processes than a landline survey. The latter requires an interviewer to read each of the questions and response options to each respondent. Advances have also occurred in the field of data fusion, where simulation techniques have been used to generate travel data for households based on the demographic and locational characteristics of each household, and the distribution of pertinent travel characteristics derived from national and regional surveys (Stopher & Greaves, 2007). The issue with this type of data fusion method is the requirement that national and regional surveys are conducted, and are able to collect data that is representative of the population in order for such a data fusion method to work.

3.3.3 The Present State of Web Survey Practice

As web surveys have become a more widely used method of surveying a population, private companies have developed tools and services to assist the administrators of such surveys. For example PTV NuStats, who were involved with Atlanta's Regional Travel Survey, provide services to assist in the administration and analysis of web surveys, usually in conjunction with a mail or phone survey (PTV NuStats, 2015b). NuStats has developed a tool designed to collect data through web surveys that are optimized for completion via Android tablet. The tablet offers features such as the ability to collect data while offline, the automated geocoding of location data while the tablet possesses internet access, and the relatively large screen size and longer battery life of tablets compared to smartphones (PTV NuStats, 2015a). NuStats also developed NuTripX™, which is a web-based mapping tool designed to collect data, and offers features such as "Real-geocoding, mapping features, a routing function, data verification and validation" (PTV NuStats, 2012). This tool can be integrated with other mapping tools, can be delivered through web surveys, and smartphone or tablet apps, and utilizes Google maps to geocode data, as well as calculate speeds, distances, and travel times (PTV NuStats, 2012).

Another firm that provides services to survey administrators is Marketing Systems Group, whose ARCS ® software is designed to assist administrators in the delivery and management of panel surveys (Marketing

Systems Group, 2015a). The ARCS® data collection software is capable of recruiting panelists, collecting data over the web, includes a questionnaire builder, and is designed to be adaptable for viewing on smartphones and tablets (Marketing Systems Group, 2015b). M.S.G. also boasts that "Questionnaires created using ARCS® will render properly on smartphones, tablets, and traditional web browsers," and that once programmed, a survey can be launched through both Interactive Voice Recording, where responses are provided through the keypad of a touch-tone phone, and a web survey (Marketing Systems Group, 2015c). Research Systems Group Inc., who conducted the Utah Travel Study, also offer a cloud-based survey platform that allows for the creation of a fully customizable web or mobile surveys, the synthesis of "big data," and the establishment and management of longitudinal panel surveys (Research Systems Group, Inc., n.d.). Westat offers survey design services, such as the development and implementation of a survey design, the identification and sampling of the population of interest, and the analysis of survey data (Westat, 2015a). Westat also offers survey evaluation services, namely the pretest of survey instruments, which includes an "Expert review, cognitive testing, and a variety of techniques to assess usability" (Westat, 2015b).

In terms of software that could be readily adapted to the TTS, the NuTripX™ and TripBuilder™ software packages developed by PTV NuStats, as well as the ARCS® software package developed by Marketing Systems Group appear to be the most applicable. The NuTripX™ tool could be utilized to develop a standalone web survey, or to create a web survey that complements and/or supplements the current landline survey, or a potential smartphone survey. The utilization of NuTripX™ can be part of the design of a web survey that is optimized for web response, rather than the web survey used by the 2011 TTS whose focus was on ensuring that data collected via web and landline survey were compatible. Incorporating NuTripX™ into a web-version of the TTS would allow respondents to access the survey through the web, or through smartphones and tablets, allow mapping tools to be integrated into the survey, and include built-in data verification and validation features (PTV NuStats, 2012). TripBuilder™, another software package that was created by NuStats, is a web-based tool used map and geocode each location visited by a given respondent, and collect information pertaining to each location (PTV NuStats, 2011). The TripBuilder™ Tool was utilized by NuStats during their management and administration of both the Atlanta Regional Travel Survey and the Calgary and Region: Travel and Activity Survey (NuStats Research Solutions, 2012). The incorporation of mapping tools, particularly GIS, into a web survey also allows trip purposes to be predicted.

Another software package that can be adapted for use by the TTS is the ARCS® software package that was developed by Marketing Systems Group. This software package can be used to design and create a web survey that would maintain its appearance across different browsers, and could be adapted for viewing through a smartphone or tablet (Marketing Systems Group, 2015c). The utilization of this software package would allow the TTS to be administered online through smartphones and tablets, as well as through traditional web browsers.

The pilot testing of web surveys generally involves inviting a small percentage of the target population to complete the current iteration of the survey and provide feedback. For example, the administrators of the Utah Travel Study invited 4,230 households to complete the UTS as part of their survey pre-test and asked all adult participants to respond to two open-ended questions regarding how the survey could be improved. The responses provided during the pre-test were used to evaluate the overall survey process, identify areas of improvement, evaluate the effectiveness of survey tools, and estimate response rates (Research Systems Group, Inc., 2013). The Atlanta Regional Travel Survey followed a similar methodology when conducting their pilot study, wherein it "consisted of all necessary data collection activities required to produce a data set" (PTV NuStats, 2011). The pilot study was conducted as if it were the actual survey, and allowed the administrators to become aware that the wording of a particular question caused confusion, and that the pre-test data was skewed to older respondents (PTV NuStats, 2011). Through the completion of a pilot study, the

administrators of the Calgary and Region: Travel and Activity Survey found that many variables displayed higher-than-expected levels of non-response. This led to each variable being assigned to a particular level of importance, which determined whether or not particular questions required responses (NuStats Research Solutions, 2012).

4 HOUSEHOLD VS. INDIVIDUAL WEB SURVEYS

Web surveys have the ability to be included as part of both household-and individual-based surveys. GPS and smartphone surveys have begun to incorporate web surveys in their data collection process, particularly as a means to validate trip data. The Future Mobility Survey is a prominent example of such a survey (Zhao, et al., 2015), and studies such as (Greaves, et al., 2010) and (Bohte & Maat, 2009) have implemented similar methods of data collection in their investigations of GPS-based data collection methods. Recent regional travel studies have utilized web surveys as part of a dual-core approach to collecting information, both pertaining to the members of the household and the household itself. One example was the Utah Travel Study, which asked one member of each participating household to provide demographic information pertaining to the household and its members, either over the phone or through a web survey (Research Systems Group, Inc., 2013). A second example was the Calgary and Region: Travel and Activity Survey, which collected demographic information during the recruitment stage of the survey through both web and telephone survey (NuStats Research Solutions, 2012).

Due to the manner in which web surveys collect data, web surveys have the potential to collect household data that is of higher quality than that collected over the phone. Because a web survey can be completed at the leisure of the respondent, it is possible for said respondent to ask each and every member of the household to report their own characteristics (such as trips, age, employment status, etc.), instead of having one member of the household respond on behalf of all of its members. This characteristic of web surveys has the potential to eliminate proxy bias from survey data, however this benefit may be offset by the absence of an interviewer, who would encourage respondents to provide as detailed answers as possible and would provide clarifications when necessary. This issue can be mitigated by providing clear and concise instruction on how to complete the survey, potentially through an introductory video, or by providing a sample response that reflects the levels of accuracy and precision that are expected by the administrators.

As previously discussed, web surveys tend to have lower variable costs that traditional phone and mail surveys, albeit with higher fixed costs. When a web survey is administered as part of a travel survey, it is a more effective method of collecting household-based travel than individual-based data, unless travel data are being collected via GPS devices or smartphones. When travel data are entirely self-reported, the difference in the cost of developing a household-based survey and an individual-based web survey is likely to be negligible, meaning that a household-based travel survey would be a more cost-effective means of collecting travel data. Furthermore, the collection of household-based data allows intra-household interactions to be examined, such as car sharing and chore allocation, which is lost when collecting individual-based data. A respondent-friendly design and the presence of at least one web-literate member of each participating household will make web surveys an efficient and effective tool for collecting household-based travel data.

5 POTENTIAL FOR MULTI-DAY DATA COLLECTION

The main benefit of collecting travel data over a multi-day period is the ability to capture variations in the number and type of trips made from day to day. There tend to be significant intra-user day-to-day variability in the travel and activity patterns of respondents, which has the potential to be captured by a multi-day survey. Another benefit of the collection of travel data over a multi-day period is the ability to gain insight regarding the potentially immobile members of the population. For example, 20,159 of the 159,157 households that were surveyed as part of the 2011 TTS reported making zero trips on their respective trip days. A multi-day travel survey, rather than a one-day snapshot would help to reveal which members of the households who reported making zero trips are immobile, and potentially socially excluded, and which members of said households simply chose not to make a trip on their assigned travel day.

Web surveys have the potential to serve as either a standalone method of collecting trip data over multiple days, or as a complement to data collected through smartphones or GPS devices. One example of a standalone multi-day web survey was the Computerized Household Activity Schedule Elicitor (CHASE) that was developed and utilized by Doherty and Miller (2000). It was one of the first studies to conduct empirical research into the process by which individuals schedule their activities. The survey employed by Doherty and Miller (2000) was based on the idea that each member of a household assigns activities derived from the needs of said household, and that until and even during the execution of said activities, schedules are continuously being modified. As part of this survey, participants were asked to make use of the CHASE program to add activities to their schedules for the following week, as well as adding, modifying, and deleting activities where necessary (Doherty & Miller, 2000). The program prompted users for additional information, particularly when an activity was modified or deleted. It also included functions and prompts that were "designed to check for logical consistencies and missing data" (Doherty & Miller, 2000).

The CHASE program was utilized by Roorda and Miller (2004), wherein respondents were asked to log in at least once per day over the course of a week, report all of the activities that they had planned or carried out, and document any changes to planned activities (Roorda & Miller, 2004). A multi-day web survey derived from the design of CHASE could be an online travel diary that utilizes a pre-survey mail contact and an online interface. Due to the near universality of internet access, laptops would not need to be loaned out, as occurred with that study (Roorda & Miller, 2004). The survey would require respondents to log in at least once per day, to report the trips that they made during said day. Such a survey would need to be carefully designed, as Roorda and Miller (2004) reported that some respondents spent anywhere from 139 to as many as 380 minutes per week logged into the CHASE interface (Roorda & Miller, 2004). The design of a web survey in a user-friendly manner can result in the adoption of survey participation into one's normal web browsing routine. This was observed by Greaves et al. (2010) when discussing the usability of their online GPS data validation interface.

GPS devices and/or smartphones are perhaps the most suitable tools for collecting travel data over a multi-day period, particularly if such tools collect data in a passive manner. The use of GPS devices and/or smartphones in conjunction with web surveys allows more precise location and time data to be collected, processed, and validated by users. This has the potential to produce survey data that is more accurate and complete than what would be collected from self-reported surveys. The automated collection of trip data reduces the response burden associated with the self-reporting of trips, which in turn may have a positive impact on the response rates of the survey. Several studies have utilized web surveys as a means of supplementing and validating data collected by GPS devices and smartphone apps (Kim, et al., 2014) (Bohte & Maat, 2009) (Greaves, et al., 2010).

One survey that utilized an online interface to validate data, as briefly discussed in section 3.3.1, was the Future Mobility Survey (FMS). Over 1,000 participants took part in the FMS, for an average of 15 days each, with a total of 793 participants collecting data for a minimum of 14 days and validating data for a minimum of five (Kim, et al., 2014). Another example is described by Bohte and Maat (2009). Their study consisted of 1,104 individuals in the Netherlands who participated in a week-long survey. Handheld GPS loggers were distributed to participants for the purpose of data collection, with a web interface used to validate said information (Bohte & Maat, 2009). Bohte and Maat found that the travel mode and trip purpose shares were almost identical to the data from the 2006 Dutch Travel Study, leading them to conclude that web-assisted, GPS-based methods can be used to provide reliable multi-day data.

While it is certainly possible to utilize web-based surveys to collect data over a multi-day period of 2 to 7 days, there are difficulties that must be overcome to ensure that the data that has been provided is complete, detailed, and accurate. One of these issues is the tendency of respondents to struggle to provide detailed and accurate reports of their trips over the course of a relatively long period of time, generally the length of a day (Bayart & Bonnel, 2012). Also of concern is the tendency of respondents to report trips after-the-fact, reducing the accuracy of the time and location data (Bohte & Maat, 2009). This issue could be mitigated by providing worksheets on which respondents can document their trips on a set of given days, as RSG did wen administering the Utah Travel Study (Research Systems Group, Inc., 2013). Another method is through the use of phone calls and emails to remind respondents to log into a web interface in order to report the trips that they made, as was done by Greaves et al. (2010).

Although the potential to collect travel data over a multi-day period exists, there are few instances in which travel diaries that pertained to trips made over the course of more than two day have been utilized in practice, partly due to a significant decrease in reporting on the second day (Stopher & Greaves, 2007). The use of a GPS device or smartphone, and an associated web-based validation tool, to collected trip data has the potential to yield accurate, complete, and precise travel data collected over a multi-day period; however, this method of data collection has its own set of issues. One of the key disadvantages is the existence of a minimum level of aptitude that is required to complete the process of validating travel data (Bohte & Maat, 2009). This issue was experienced by Bohte and Maat (2009), where 70% of study participants reported some degree of difficultly using the validation tool, and roughly 30 minutes being needed to validate a week's worth of trips.

6 EMPIRICAL ANALYSIS OF 2011 TTS DATA

6.1 Comparison of the Demographics of Web and Landline Respondents

TABLE 8: A BREAKDOWN OF RESPONSE MODES OF HOUSEHOLDS THAT PARTICIPATED IN THE 2011 TTS

Mode	Trip-Making Households	Non-Trip-Making Households	Total	Percentage
Web	24,338	2,525	26,863	16.88%
Landline	114,660	17,634	132,294	83.12%
Total	138,998	201,59	159,157	100.00%

For the purpose of comparing the demographics of members of the survey sample who responded by web and by landline, TTS micro data was aggregated in Microsoft Excel and a series of plots were created to determine the distribution of a number of household, respondent, and trip variables. This was done for data collected through both web and landline survey, and the respective distributions of the two sets of data are evaluated in order to compare the demographics of the two groups. It should be noted that some households began their participation in the TTS using the web survey, but ultimately completed the survey through the phone; unfortunately, the micro-data provides no indication of the households that completed the survey in this manner. Appendix B contains aggregated TTS data, as well as figures plotting the frequency with which a particular value was reported for a given variable. The percentage of responses is used, rather than a count of responses, in order to account for the fact that roughly five times as many households responded to the TTS through the phone survey than by using the web survey.

6.1.1 Household Characteristics

The number of vehicles and the number of employed persons in the household displayed a similar distribution among web and landline respondents, which may imply that the incomes of the members of the two groups were similar. The number of students in the household also displayed similar distributions among the web and landline respondents. Figure 3 and Figure 4 below show the distribution of the number of employed members in a household among web respondents and the distribution of the number of household trips by response mode, respectively.

As seen in the figures, the distribution of the number of trips made by a household is similar for both response modes; however, a greater portion of households that did not make any trips completed the TTS over the phone. These similarities may imply that households that completed the TTS through the web survey are demographically similar to households that completed the landline survey. This somewhat contradicts the traditional tendency of web surveys to over-represent wealthier member of the population, which may be due to the fact that the TTS' sampling frame was a directory of landline telephone numbers.

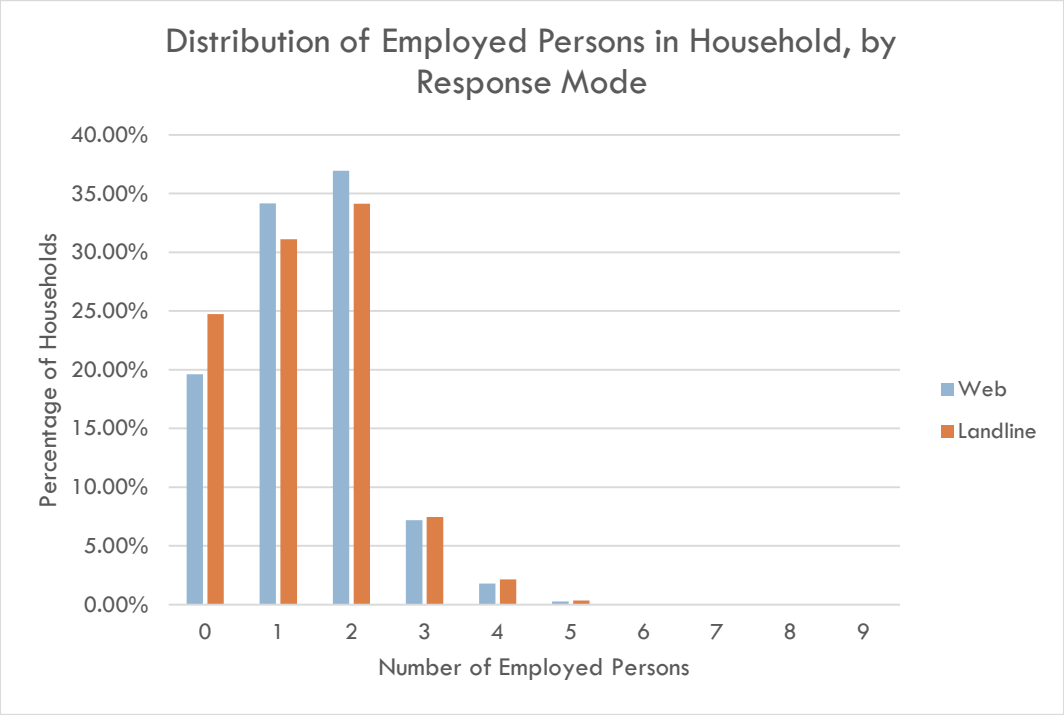


FIGURE 3: THE DISTRIBUTION OF THE NUMBER OF STUDENTS IN THE HOUSEHOLD

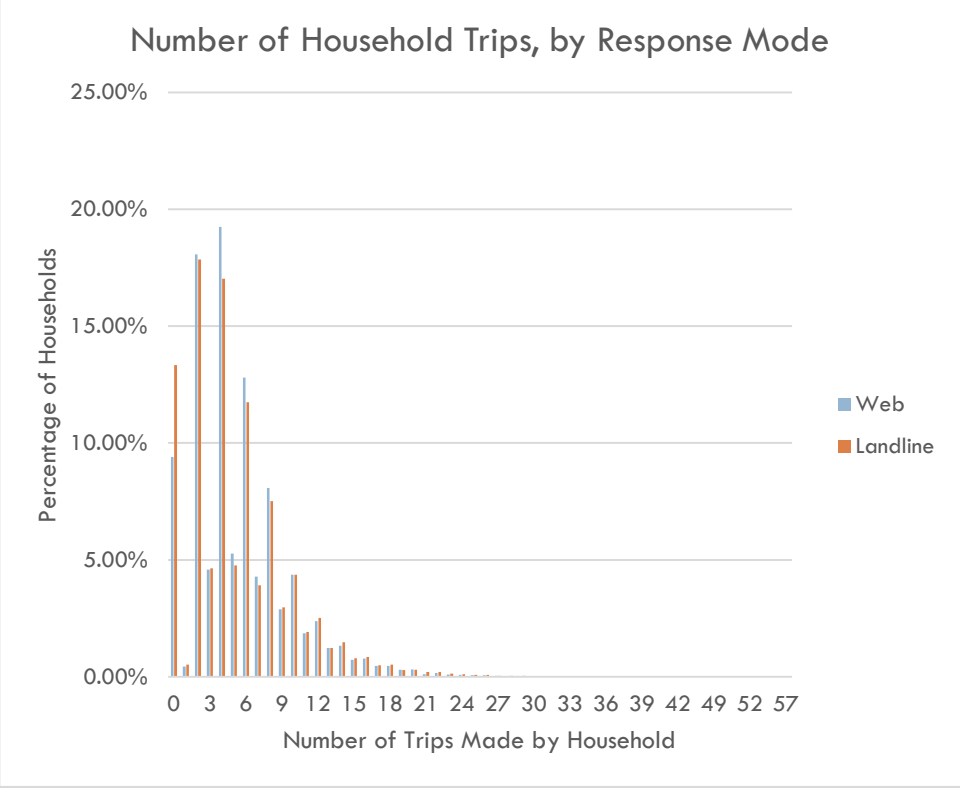


FIGURE 4: THE DISTRIBUTION OF THE NUMBER OF HOUSEHOLD TRIPS, BY RESPONSE MODE

6.1.2 Respondent Characteristics

When comparing the employment status of web and landline respondents, the distribution of employment types (full time, work at home part time, etc.) was found to be similar, regardless of whether the respondents recorded a trip or not. When considering trip makers, roughly half of respondents were employed full time (approximately 49% of web respondents and 46% of landline respondents). The second most frequent response to this question was that the respondent was unemployed (approx. 37% of web and 40% of landline respondents). This was a stark contrast to the employment status of non-trip makers, where over 80% of both web and landline respondents reported being unemployed. This is somewhat misleading, as children between the ages of 0 – 10 would be designated as "unemployed," with children aged 6 – 10 assumed to be full-time students (U of T Data Management Group, 2013). Figure 5 below shows the distribution of the employment status of non-trip makers and trip makers, by response mode.

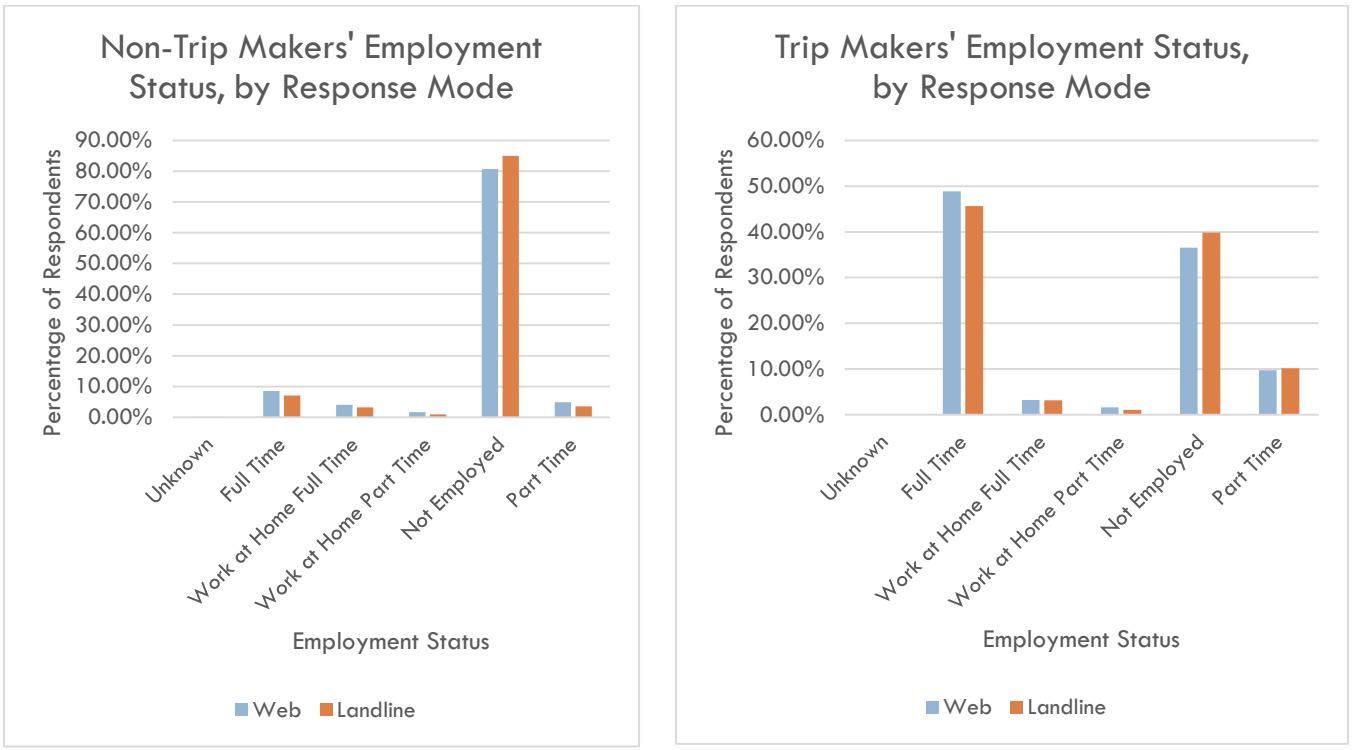


FIGURE 5: A COMPARISON OF THE EMPLOYMENT STATUS OF NON-TRIP MAKERS (LEFT) AND TRIP MAKERS (RIGHT)

With respect to the ages of respondents, households who responded via landline were more likely to contain children younger than 10 years old. Regardless of the consideration of whether a respondent reported making a trip on their assigned trip day, the distribution of the age of web and landline respondents are still fairly similar. Figure 6 below shows the distribution of the ages of trip makers and non-trip makers, by response mode compared to data collected in the 2011 Census pertaining to the agencies that participated in the 2011 TTS (Statistics Canada, 2012). Figure 7 below shows the distribution of 2011 TTS respondents, by response mode, compared to the respondents of the 2011 Census. Household members who are younger of 11 years of age did not have their trip information recorded (U of T Data Management Group, 2013).

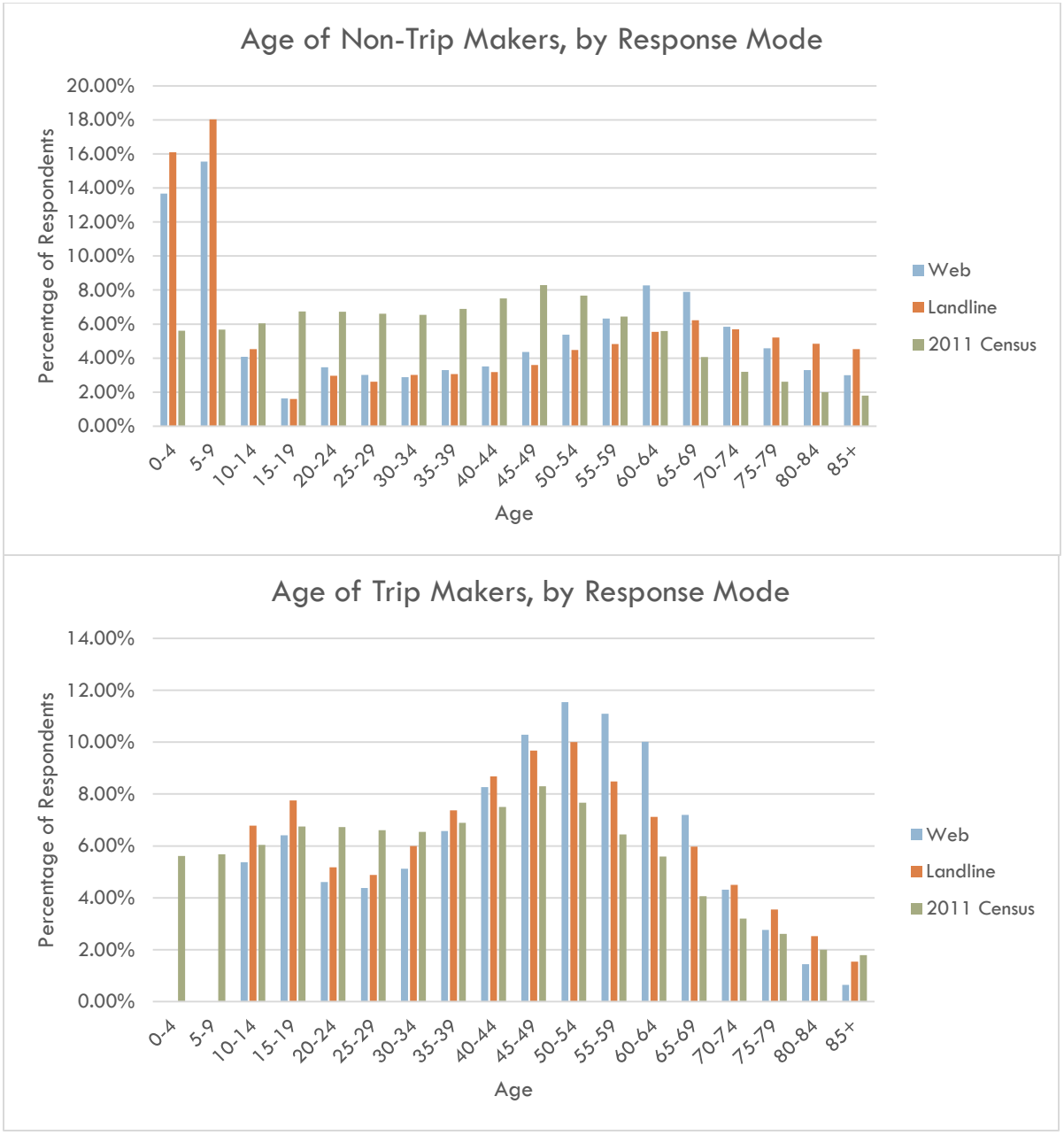


FIGURE 6: A COMPARISON OF THE DISTRIBUTION OF THE AGE OF TRIP MAKERS (TOP) AND NON-TRIP MAKERS (BOTTOM)

As Figure 6 and Figure 7 show, the current survey administration methods employed by the TTS resulted in the overrepresentation of older members of the population, and the underrepresentation of members of the population under the age of 30. The distribution of sex among web and landline respondents was also fairly even (Figure 8).

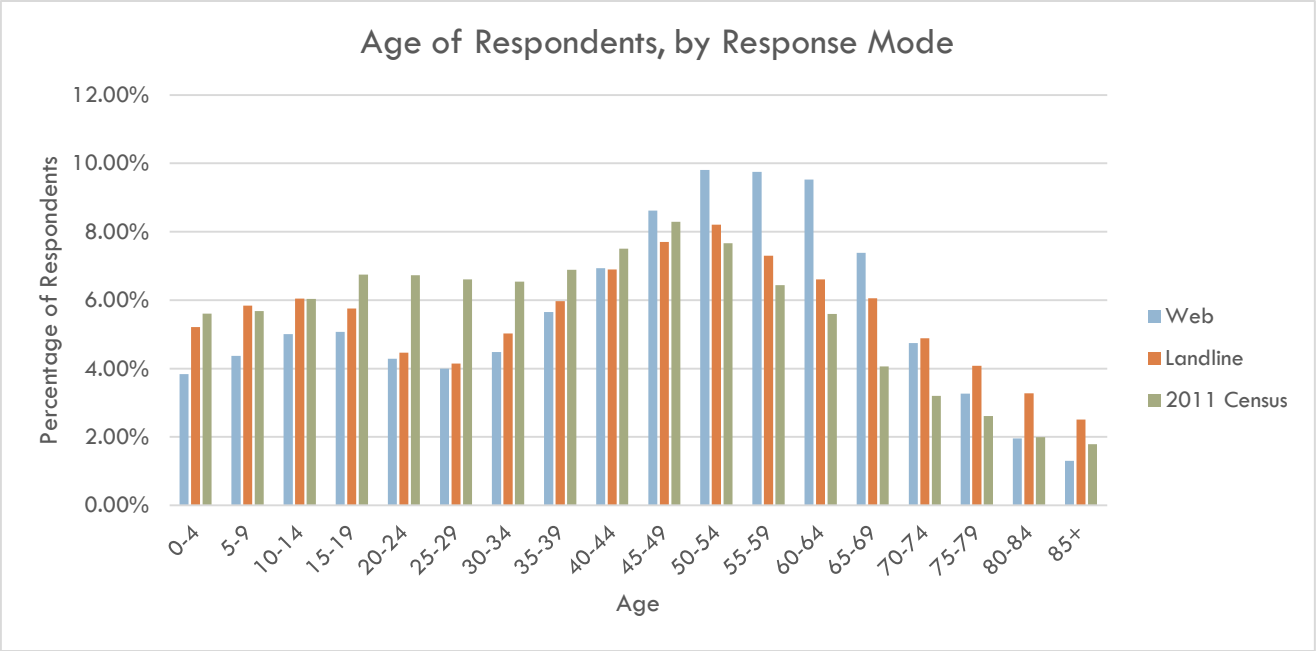


FIGURE 7: THE DISTRIBUTION OF RESPONDENTS, BY RESPONSE MODES

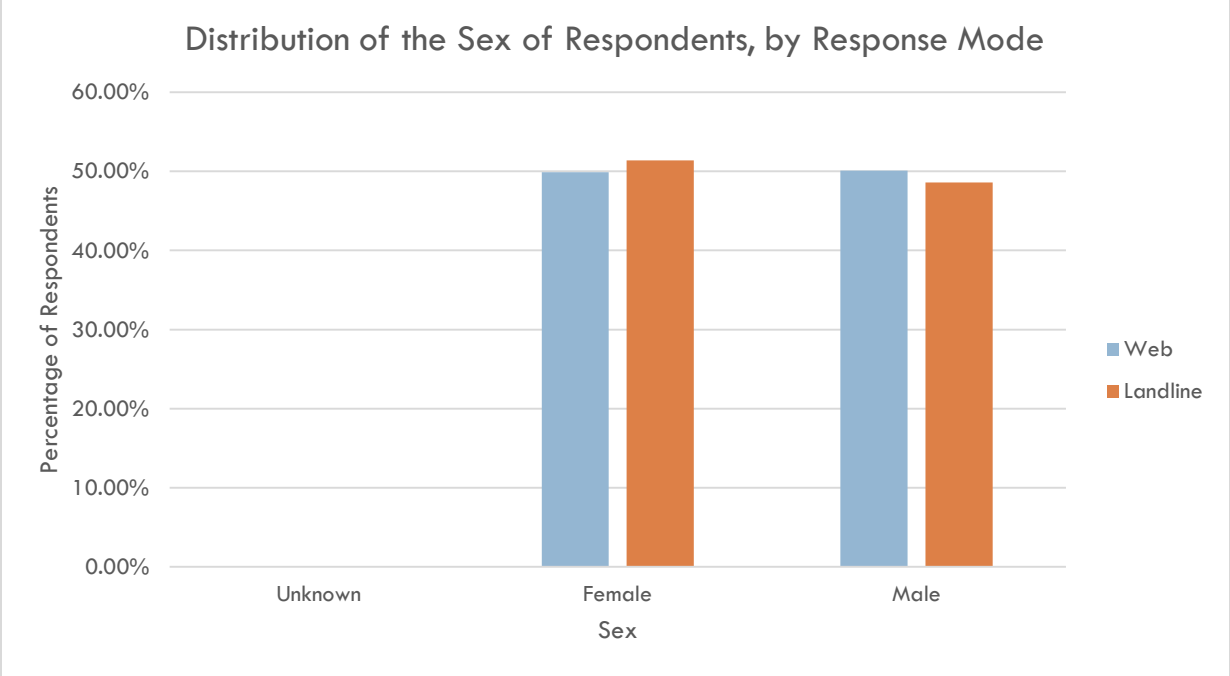
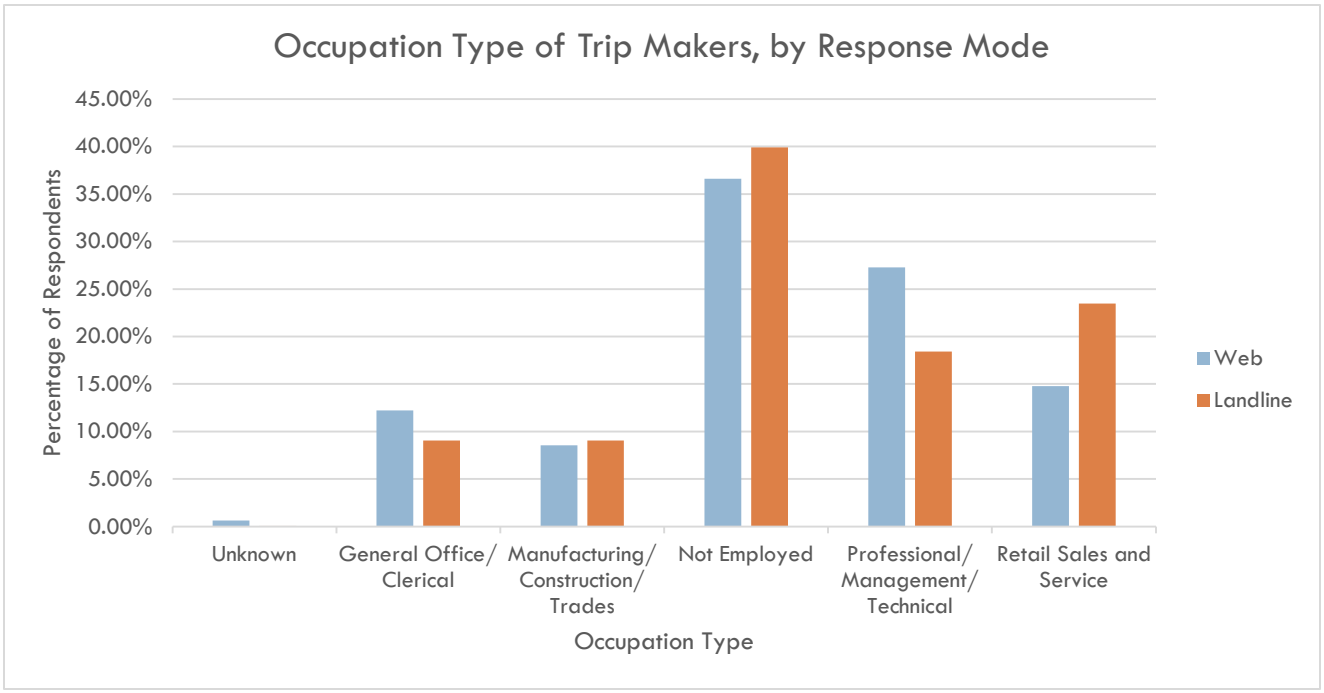


FIGURE 8: THE DISTRIBUTION OF SEX AMONG RESPONDENTS

This similarity in the distribution of responses was also observed in the occupation type of both trip and non-trip makers, where "not employed" was the response that was most frequently provided by respondents. Although the percentages of respondents are not exactly the same, the relative ranks of the response options are similar, as shown in Figure 9.



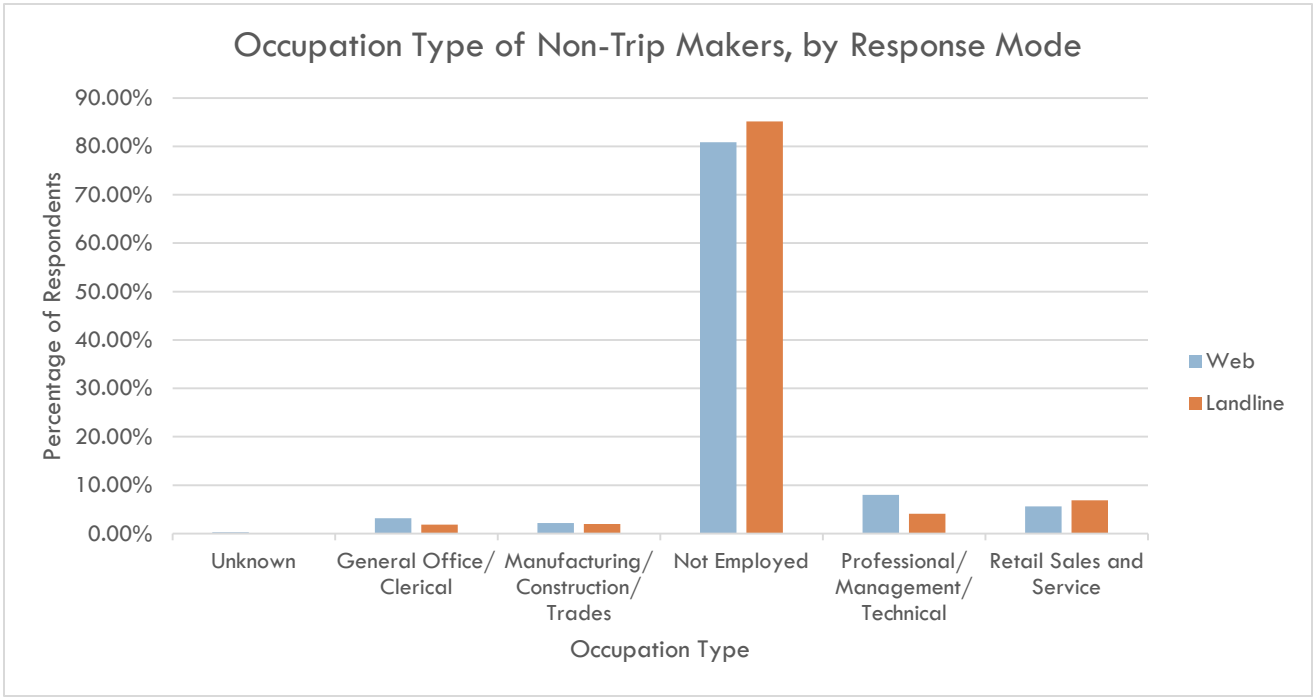


FIGURE 9: A COMPARISON OF THE OCCUPATION TYPES OF TRIP MAKERS (ABOVE) AND NON-TRIP MAKERS (BELOW)

The existence of the aforementioned similarities implies that the demographics of the web and landline respondents of the TTS were similar. This would mean that the web survey that was offered as a mode of response to the 2011 TTS was unable to exceed the landline survey's ability to collect data from younger members of the population; however, it is not clear if this was the result of the design of the web survey or the result of systematic non-response on the part of said members.

6.2 Comparison of Sample Means

Using the Central Limit Theorem, it was assumed that each of the aggregate statistics at the household, person, and trip-level were normally distributed, as the sample size greatly exceeded 30. Hypothesis testing was carried out on household, respondent, and trip variables, and generally tested the difference in sample means of a given variable between web and landline respondents. In the case of the age of a respondent, hypothesis testing was also carried out to compare the sample mean of trip makers versus that of non-trip makers. Each hypothesis test considered confidence levels of 95% and 99%, and the results of each test were consistent for both levels of confidence. See Appendix C for a detailed presentation of each hypothesis test. The Two-sample Kolmogorov-Smirnov test was applied with a 99% confidence level to each variable to determine whether the two datasets were sampled from populations with different distributions.

6.2.1 Household Variables:

Number of Vehicles:
On average, households that responded to the 2011 TTS through the web survey owned statistically significantly more vehicles than households that completed the survey over the phone. This may be a reflection of the historical trend of web respondents to possess higher incomes than their counterparts, or may be an indication that larger households prefer to complete to web surveys.

Number of Persons:
Households that completed the 2011 TTS over the phone appeared to contain more members than households that responded through the web survey, however this was not statistically significant. This may be the result of older members of the population being more likely to possess a landline, and somewhat more likely to have a family, whereas younger members of the population may be somewhat more likely to respond via web survey and live on their own.

Number of Students:
Households that participated in the 2011 TTS through the web survey did not have a statistically significant difference in the number of students compared to households in the phone survey. This may be the result of the information of students being captured through a parent's participation in the TTS, coupled with the tendency of non-response on the part of students themselves.

Number of Households Trips:
Households that completed the 2011 TTS through the web survey did not have a statistically significant difference in the number of trips as households that completed the 2011 TTS over the phone. This somewhat contradicts the tendency of web respondents to report more daily trips than respondents to more traditional survey modes.

TABLE 9: A SUMMARY OF THE COMPARISON OF THE SAMPLE MEANS OF HOUSEHOLD VARIABLES

Variable	Population 1	Trend	Population 2	Significant (p=0.01)
Avg. Number Vehicles	Web respondents	>	Landline respondents	Yes
Avg. Number of Persons	Web respondents	>	Landline respondents	No
Avg. Number of Students	Web respondents	<	Landline respondents	No
Avg. Number of Household Trips	Web respondents	=	Landline respondents	No

6.2.2 Respondent Variables:

Age: - Web vs. Landline Respondents:
Respondents whose information was collected through web survey were statistically significantly older than those whose information was collected through the phone. This may indicate a greater number of younger people in households that respond by phone, such as the children in a family.

Age - Web vs. Landline Trip Makers:
The average age of a web respondent who made at least one trip on their assigned trip day was greater than that of a trip-making landline respondent. This may stem from the tendency of web respondents to be older than landline respondents.

Age - Web vs. Landline Non-Trip Makers:
Web respondents who did not report making any trips on their assigned trip day were older than their counterparts whose information was collected via landline survey.

Age - Trip Makers vs. Non-Trip Makers:
TTS respondents who reported making at least one trip on their assigned trip day were statistically significantly older than respondents who did not report making a trip. This may be due to the fact that trip data are only collected for member of a households who are 11 years of age or older (U of T Data Management Group, 2013), meaning that children aged 0 – 10 were considered to be non-trip makers in the data set. When children aged 0 – 10 were removed from the data set, non-trip makers were older than trip makers. Before the data for children under 10 was removed, on average, non-trip makers were younger than trip makers (37.7 vs. 45.4 years old), however once said data was removed, non-trip makers were significantly older than trip makers (57.1 vs. 45.4).

Number of Trips Made by an Individual:
Web respondents made a statistically significant greater number of trips on their assigned trip day than landline respondents, which is consistent with the tendency of web respondents to report more trips than people who respond using more traditional survey modes. This may also be the result of web respondents having more time than landline respondents to recall their trips.

Number of Transit Trips:
The number of transit trips made by web and landline respondents to the 2011 TTS were not statistically different. This may be the result of the random selection of households capturing a wide range of respondents from varying tax brackets and professions.

TABLE 10: A SUMMARY OF THE COMPARISON OF THE SAMPLE MEANS OF RESPONDENT VARIABLES

Variable	Population 1	Trend	Population 2	Significant (p=0.01)
Age	Web respondents	>	Landline respondents	Yes
Age	Web trip makers	>	Landline trip makers	Yes
Age	Web non-trip makers	<	Landline non-trip makers	Yes
Age	Trip Makers	>	Non-trip makers	Yes
Age	Trip Makers (11+ y.o.)	<	Non-trip makers (11+	Yes
# of Trips by Individuals	Web respondents	>	Landline respondents	Yes
# of Transit Trips by an Individual	Web respondents	=	Landline respondents	Yes

7 UNDER-REPRESENTATION OF SUBGROUPS BY WEB SURVEYS

One subgroup that will be under-represented, and potentially missed entirely, is households that do not have internet access. As of 2013, an estimated 85.8% of Canadians were Internet users (The World Bank, 2015); however, this does not guarantee that each Canadian household has access to the internet. Prior studies, such as Roorda and Miller (2004) and de Bruijne and Wijnant (2013), have attempted to include such households by providing computers on which the survey can be completed. In the case of Roorda and Miller (2004), members of the Toronto Area Panel Survey were provided with a laptop containing a customized scheduling software called CHASE, in order to complete a week-long survey meant to observe the scheduling process. In the case of de Bruijne and Wijnant (2013), members of the CentERpanel in the Netherlands who did not have internet access or a computer were provided with a computer for the purpose of completing online surveys; this would not be feasible for a large-scale survey. Other methods of including households without internet access are the recruitment of such households through the mail and over the phone, and the use of lists containing residential addresses or phone numbers as a sampling frame.

Another subgroup that would be underrepresented by web surveys are so-called "difficult-to-reach" members of the population. Delbosc and Currie (2010) identified five attributes that contribute to making a population difficult to reach: people are missing from official records; people are away from home during data collection; people who refuse contact; people who refuse to answer the questionnaire; and people who cannot answer the interviewer. Groups such as the elderly, youth, the homeless, those on low income, the unemployed, single parents, disabled persons, and people from racial minorities have been identified by prior research (Social Exclusion Unit 2003, Currie et al. 2007) to be of concern with respect to travel surveys. Living conditions are also likely to exclude groups from travel surveys, such as the homeless, transient workers, illegal immigrants, residents of group quarters, sub-letters of dwellings, and people who frequently change addresses (Delbosc & Currie, 2010). Methods for recruiting members of such populations include snowballing, where the members of the target group recruit other members of the same group, and location sampling, which is used when members of a target population are known to gather in specific locations, at specific times (Delbosc & Currie, 2010).

8 RECOMMENDATIONS FOR PILOT TESTING

1. Determination of the suitability of the Canada Complete mailing list offered by Canada Post as a sampling frame for the TTS

Presently, the TTS utilizes "listed residential phone numbers within the boundaries of the survey area defined as accurately as possible by postal codes" (U of T Data Management Group, 2014). As the number of households that own a landline decreases, so too does the representativeness of the sampling frame. This issue has already arisen, and is likely to become worse as cellphones and call screening services become more ubiquitous. Other regional travel surveys have already shown that address-based sampling procedures are capable of providing an adequate sample of the population, such as the Utah Travel Study and the South Jersey Household Travel Survey, and the Canada Complete mailing list is capable of offering household information, such phone numbers (Canada Post, 2015). As the TTS already uses an advance letter to recruit participants, the adoption of the Canada Complete mailing list has the potential to provide a sampling frame that is more representative of the population that the current sampling frame, while still providing the means to implement the present design of the survey. Households whose addresses have an associated telephone number can be called for the purposes of follow-up contact, whereas an incentive to respond could be offered to households without an associated number.

2. Comparison of the demographics of the respondents of an online survey that is optimized for web response vs. the demographics of the respondents to the web survey in the 2011 TTS

Although the web survey offered during the 2011 TTS was not able to collect data from a sub-population that was demographically different from the sub-population that was surveyed by the landline survey, it is not clear if this was the result of the design of the web survey, or if it is an issue of systematic non-response by younger members of the population. The purpose of this pilot study would be to determine the effect that the design of a web survey has on the demographics of respondents. A redesign of the web survey used in 2011 with a focus on improving the usability of the survey, such as integrating an interactive table-and-map interface into the survey, has the potential to provide a statistically valid basis for the comparison of the demographics of the members of the two samples.

3. A study of the impact that explicitly offers respondents the opportunity to provide responses over the phone, after being given the chance to respond online, has on response rates

As Messer and Dillman (2011) noted, offering the respondents of a web survey the opportunity to complete the survey through the mail can improve response rates by an additional 19%. As response rates decrease, data expansion techniques become less able to provide a dataset that that is truly representative of the behaviour of interest. During the administration of the 2011 TTS, there were instances in which respondents who initially used the web survey to participate decided to complete the rest of the survey over the phone. Other respondents may have also wanted to do this but instead still completed the survey online, which may have impacted both the quality of the responses provided and on the response rates themselves. Explicitly offering respondents the opportunity to complete a survey using the mode with which they are most familiar, has the potential to eliminate these sorts of errors.

4. Comparison of the quality of responses provided through a web survey optimized for completion via tablet vs. a survey that is designed to be completed using a traditional web browser

As the use and ownership of tablets becomes more common, it is possible that a greater percentage of web survey participants will attempt to access and complete a web survey on a tablet. Designing a tablet-intercept survey presents its own set of unique challenges, particularly when it comes to dealing with the smaller screen. While traditional web surveys provide the user with the ability to view a screen of a constant size throughout the completion process, a tablet must impede a user's ability to view a web page in order to present a virtual keyboard. This may reduce a respondent's willingness to provide written answers, or at least motivate them to provide shorter responses, and may influence designers to utilize radio buttons and drop-down menus wherever possible. The purpose of this pilot study would be to determine whether the optimization of a survey for viewing on a tablet is worth an additional expenditure of resources.

5. A study of the impact that providing a map that is integrated with a web survey has on the quality of survey responses (comparison with 2011 TTS data)

Both web-only and web-assisted travel surveys, such as the Utah Travel Study and the Future Mobility Survey respectively, have begun to integrate mapping tools into their web interfaces in order to present trips in a more intuitive manner. The purpose of this pilot study is to determine whether the inclusion of a mapping tool into the web interface would result in more precise and accurate data being collected.

6. A survey that targets members of difficult-to-reach populations

One of the issues with trying to collect data from members of difficult-to-reach populations, such as the homeless, the elderly, the unemployed, and those on low income, is that they are often underrepresented in travel surveys. As a result, the expansion of the data that is collected may include an inherent proxy bias, as the data collected that is collected may not adequately represent the true nature of the behaviour of interest. A satellite survey that makes use of location sampling and snowballing has the potential to improve the robustness of the survey data. The purpose of this pilot study would be to determine whether satellite surveys administered at various service agencies (e.g. support groups, homeless shelters, etc.) using a web survey could improve the quality of the survey data as a whole.

7. Determination of whether a satellite that targets post-secondary and/or high school students supplements TTS data to the degree that people aged 18-30 are adequately represented

One of the issues with how the TTS is currently conducted is the underrepresentation of members of the population aged 18-30. The purpose of this pilot study would be to determine whether a web-based satellite survey, administered to college and/or high school students in areas in which younger people are underrepresented, can improve the representativeness of the TTS data as a whole.

8. The impact that the distribution of a travel log or app has on the quality of responses

Regional travel surveys, such as the Utah Travel Survey (Research Systems Group, Inc., 2013), have begun to include travel logs as part of the survey recruitment packages in the hope that giving respondents the ability to document trip characteristics, e.g. start times, trip purposes, etc., as they happen will result in the recording of more precise trip data. Presently the TTS requires respondents to remember the details of each and every trip that they make on their assigned trip day which may result in respondents rounding their departure and/or arrival times, or neglecting to report short trips. Providing respondents with the means to document their trips, whether it be on paper or digitally, would be particularly beneficial to a multi-day survey, as

respondents generally have issues recalling the detailed information pertaining trips that were made more than one day ago.

8.1 Final Comments

Web surveys have the potential to be used as part of the core of the new design of the TTS, or as a satellite. The new design of the TTS could utilize web surveys as part of its core, in conjunction with another survey mode in order to ensure that respondents have the opportunity to utilize the mode with which they are most familiar. This may mean that future iterations of the TTS could be administered in a manner similar to the 2011 TTS, however the web survey must be designed in a manner that utilizes the full potential of web surveys. A web survey that incorporates an interactive map interface may help to improve the accuracy of data reported through said web survey. Satellite surveys that utilize web surveys also have the potential to be very effective, particularly when targeting younger members of the population or students. A satellite survey that utilizes a web survey would also be effective in situations where respondents are asked a series of multiple choice questions, such as a stated preference survey, or when the questions being asked are relatively long. The choice to administer a satellite survey through a web survey should take the overall web-literacy of the targeted sub-population into consideration.

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