Development of the online Travel and Activity Internet Survey Interface (TRAISI) platform

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TTS 2.0 Final Phase

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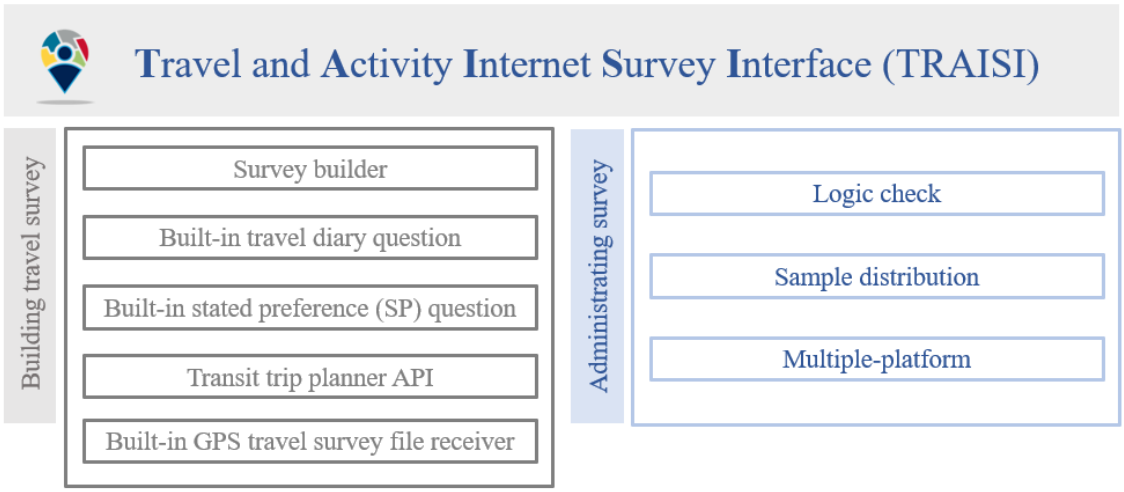


Figure 1. Description of functionalities of TRAISI

The University of Toronto Transportation Research Institute (UTTRI) research team developed the online Travel and Activity Internet Survey Interface (TRAISI). The survey instrument is designed to conduct various types of transport-related surveys, including large-scale household travel surveys. Key functionalities of TRAISI are presented in **Figure 1**. Like any commercial survey tool, TRAISI is equipped with a survey builder that contains various survey question types and allows users to build their questionnaires customarily. The built-in travel diary question enables TRAISI to serve as the survey instrument for household/personal travel surveys that collect the core dataset for urban passenger travel demand modelling. Details of the travel diary question will be described in **Section 2.0** of this report. Moreover, TRAISI has advanced transport-related question types, including stated preference question, transit routes question connecting to an external transit planner API, and the capability to receive output files from GPS-based travel tracking application.

	Driven by someone you know	Public Transit	Exclusive Autonomous Vehicle	Pooled Autonomous Vehicle
Interior Description	Conventional Car	-	Leisure	Office
In-Vehicle Travel time (time spent in vehicle in mins)	47.0	40.0	47.0	50.0
Walking Time (mins)	1.0	2.0	1.0	1.0
Waiting time (mins)	0.0	5.0	2.0	2.0
Total Travel Time (sum of above times)	48.0	47.0	50.0	53.0
Travel cost, excluding parking ($)	3.6	3.2	8.6	8.4
Parking Cost ($)	3.5	-	-	-
Number of Transfers	-	2	-	-
Presence of other riders (people you do not know)	-	Yes	No	Yes
	◉	○	○	○

Figure 2. Example stated preference choice matrix

The stated preference question type is a powerful tool that allows the survey administrator to collect data on the inclinations of the survey takers toward different combinations of options. The main mechanism of this question type involves a set of fully customizable alternatives that the survey creator may alter depending on the objective of the survey. The number of alternatives as well as the amount and type of characteristics of each may be tailored specifically for different targets. By showing a set of possible choices, information about preferences towards each option may be obtained. After asking a series of stated preference questions, an approximate utility value of each option may be estimated from the responses. An example of a stated preference question matrix may be found in **Figure 2**.

The TRAISI platform also has a question type that supports selecting transit routes from an external transit API. The Triplinx API is a service maintained by Metrolinx that allows developers to provide a wide variety of functionality relating to transit. This includes searching and obtaining the properties of transit lines, which allows users answering the question to precisely select any lines taken from a map interface. This graphical interface gives respondents a much easier option to mark out their transit route rather than describe it textually. Thus, this question type provides a streamlined and accurate way to collect information about transit data from commuters.

Lastly, the newest developed question type for the TRAISI platform is a geographical data file parsing tool. To preface, GPS-based travel guidance systems may record daily trips and locations visited for each consenting user. This data is stored in special geographical annotation files in a KML (Keyhole Markup Language) format. These files record each leg of a user's journey with valuable supporting information such as time and location, average speed, mode of transportation, etc. The function of this new question type is to allow the survey taker to upload these data files downloaded from their account, after which TRAISI will parse, analyze, and store the contained data. The survey platform will verify that the uploaded file is in a valid KML format and is from the specified date that the survey administrator chooses. Then, a summary of the trips described in the file will be restated to the survey taker, after which they may verify if the travel information is correct. Finally, TRAISI saves the uploaded information into its databases for convenient storage and recall.

TRAISI allows survey administrators to set logic checks between inputs in the questionnaire to reduce survey costs and improve data quality. This feature is designed to preemptively control the quality of the data during the collection stage. TRAISI will prompt survey takers if the pre-determined logic is violated during the survey. **Figure 3** provides an example of the logic check feature. The logic that household members who are younger than 12 years old should be full-time students is pre-determined. During the survey, TRAISI will prompt the respondents with a message if they reported person 1 (7 years old), not a student. Before proceeding to the rest of the survey, the respondents must either change their inputs or confirm that the violation

accurately reflects reality. TRAISI also supports personal computers and mobile devices for the convenience of survey takers. The functionality mentioned above would empower TRAISI as a prime instrument for computer-assisted web interviews (CAWI) surveys.

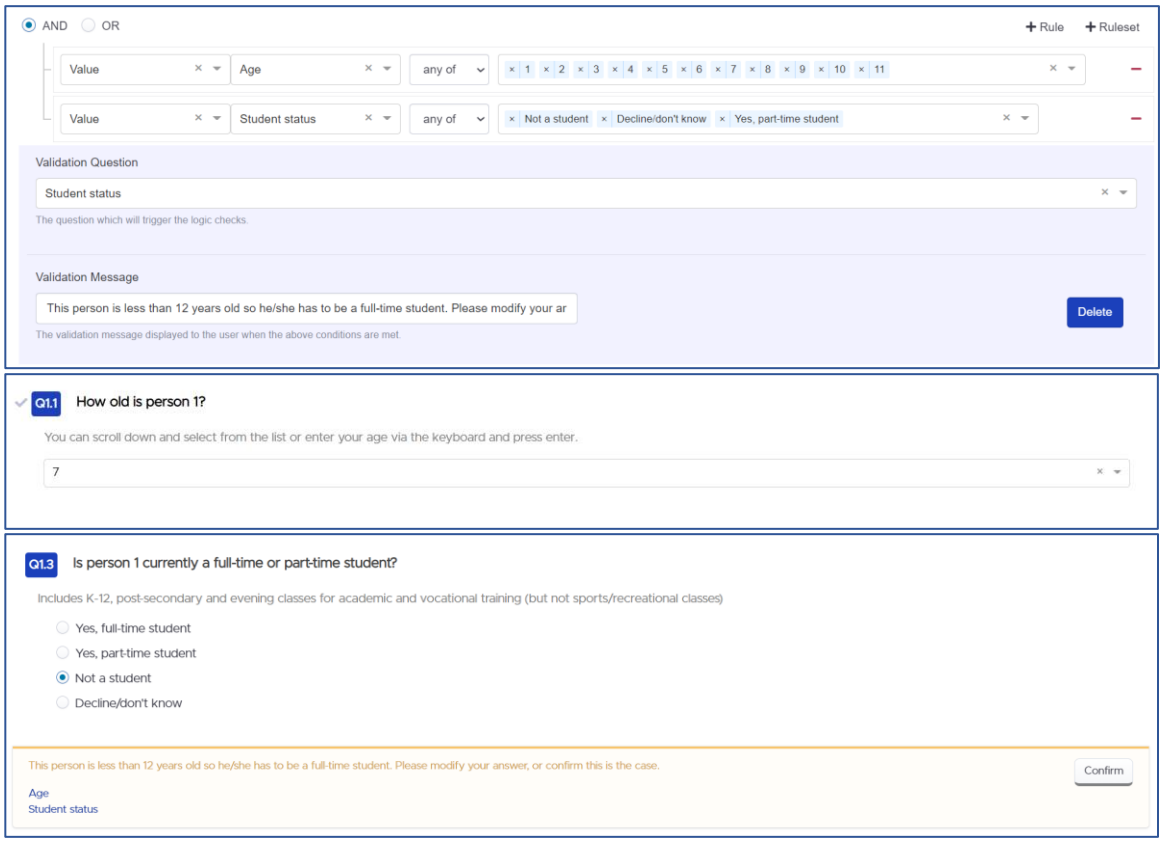


Figure 3. Example of logic check in TRAISI

2.0 Designing travel diary question in TRAISI

The travel diary collects core datasets for passenger travel demand models. There are two major challenges for successful travel diary designs. First, the design should smoothly convey the concept of travel dairy to survey takers. A travel diary is intricate as it accurately reports the purposes and locations of out-of-home activities, departure times, travel modes, etc. Moreover, it becomes more complicated in proxy-reported household travel surveys, where one household member will report the diaries for the entire household. Some concepts (e.g., trips conducted to facilitate another household member; in this case, respondents should report two different trip purposes) need a detailed explanation and a significant level of comprehension from respondents. Traditionally in CATI surveys, interviewers were responsible for explaining such concepts to respondents and ensuring adequate information was reported (Data Management Group, 2018a). In CAWI surveys, respondents must complete it independently without external help. This required the travel diary question to be intuitive and straightforward, allowing an average person to comprehend the concept and report their diaries directly. Although detailed

explanations and instructional texts can be provided during the CAWI survey, Chung et al. (2021) reported that survey-takers wanted a simple and short explanation. In the least ideal scenario, impatient respondents might skip instructional texts and drop the survey if they find the travel dairy question is not user-friendly. The second challenge is to improve data quality while reducing the response burden. Madre et al. (2007) found that respondents refused to participate in the travel survey softly by reporting immobility. Thus, it is crucial that the travel diary question accurately determines mobile and immobile respondents. Also, the design should avoid unnecessarily repetitive user inputs to reduce respondents' burden.

2.1 Calendar design

The first design allows respondents to log their travel diaries similarly to activity logs in digital calendars, which are heavily utilized by people nowadays. **Figure 4** presents an example of the calendar design, where both mobile and immobile people must fill their travel diaries. The activity log for immobile people is "stay at home all day." For mobile respondents they will add trips by clicking the "add trip" button and then report all relevant information on one pop-up page.

The calendar design will automatically generate skeleton activities for mobile respondents. This design takes inspiration from the skeleton schedule activity-based modelling approach (Dianat et al., 2020). Skeleton activities refer to out-of-home work and school activities that are mandatory for people based on their socioeconomic status (Dianat et al., 2020; NASEM, 2014). It is a common practice to generate a skeleton schedule and then insert discretionary activities to complete the schedule. This feature aims to improve data quality while reducing the response burden. Before entering the calendar interface, a set of trip confirmation questions will be asked for respondents (all household members in a household travel survey). (1) Was the respondent at home at 4 am on the survey day? (2) Did the respondent leave home for work/school at their usual work/school location on the survey day? (3) Did the respondent leave home for any other activities during the survey day. (4) Did the respondent return to the home location reported in the previous section by 4 am the next day? (5) If reported no to question 2 and 3, please indicate reasons for staying at home all day. It should be noted that question 2 will be asked based on respondents' socioeconomic status. Question 3 will be asked for respondents who answered no or ineligible for question 2. Subsequently, the trip confirmation question will classify respondents into immobile or mobile groups, and their partial travel diaries (skeletons) will be generated automatically.

The automatic generation of skeleton schedules brings at least two benefits. First, it raises the barrier of soft non-participation reported by Madre et al. (2007). Instead of directly asking respondents to report immobility, the design exhaustively asks about all possibilities of being mobile on the survey day, so immobility will be derived from responses instead of directly reported. Any immobile record will have to be confirmed multiple times during the trip confirmation stage, increasing the likelihood of collecting accurate information. Thus, this feature will guarantee the accuracy of the skeleton schedule collected at least, leaving potential

for any post-data-collection evaluations and corrections. Secondly, the design will significantly reduce the response burden as it takes advantage of work/school and home locations reported earlier in the survey. Also, in proxy household travel surveys, household heads (the self-respondents) can report if any other household members (the proxy-respondents) are attending the same activities. After being reported by self-respondents, the same activity will appear on proxy respondents' diaries. However, this feature should only be enabled to ensure data quality when self-respondents enter their own diaries. Self-respondents might lack the knowledge of activities participated only between proxy-respondents. Disabling this feature will deliberately require self-respondents to report the instance (two proxy-respondents attending the same activity) more than once. Such repetition will serve as double-checking and might reduce undesired measurement errors.

Figure 4 illustrates the calendar design. The example presents a diary with pre-generated skeleton activities highlighted by orange boxes indicating missing information (e.g., travel modes and departure time). With a partially pre-filled travel dairy, respondents are only tasked to report travel modes and departure times for pre-generated diaries and add missing out-of-home activities. By clicking the activities, respondents can add missing information or adjust any pre-generated information so the diary will reflect reality. Once all missing information is reported, the activity box will become blue, indicating the diary is completed. Certainly, respondents can add absent activities if necessary.

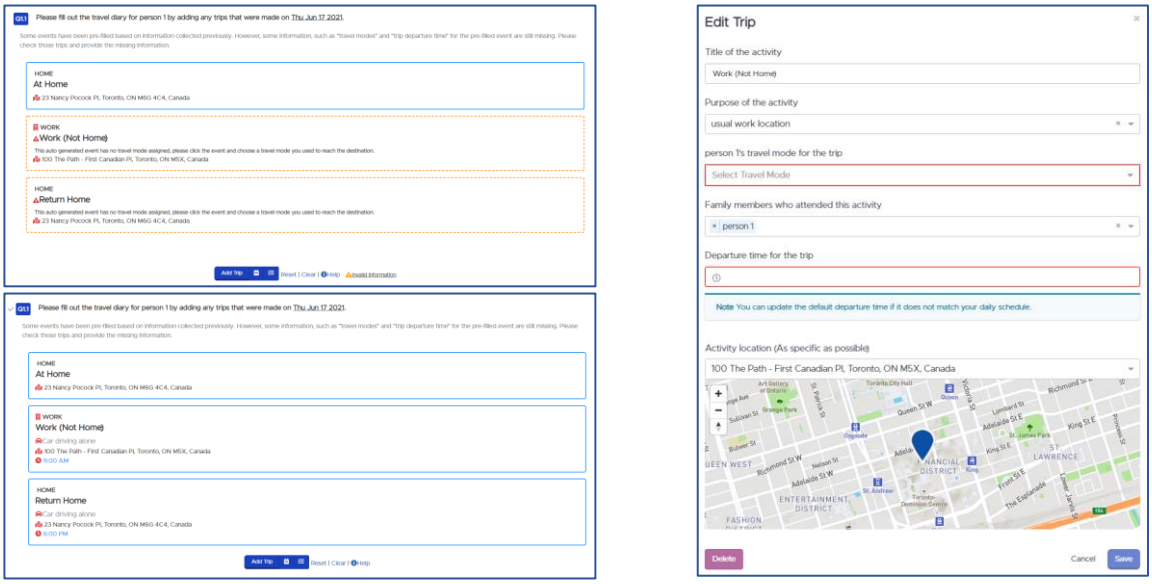
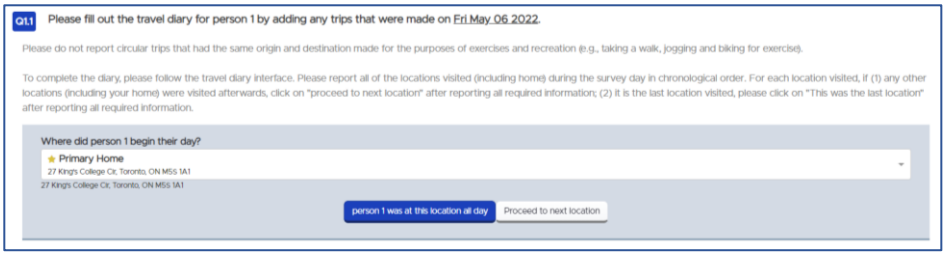


Figure 4. Example of pre-built & completed travel diary in calendar design

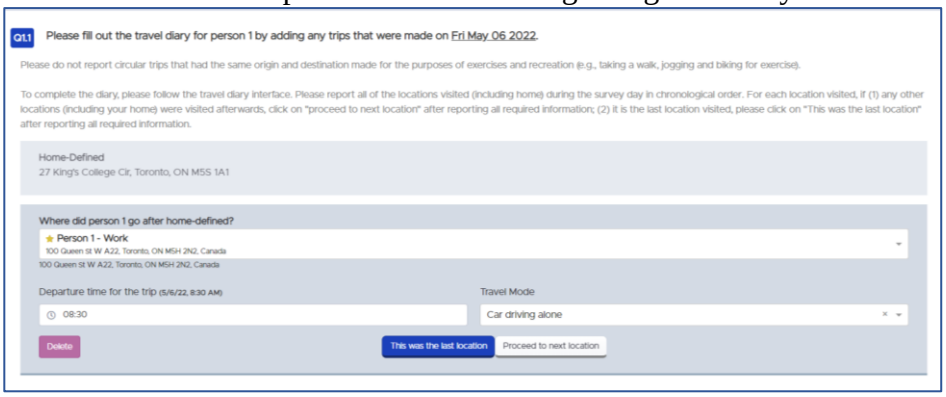
2.2 Sequential design

The second design follows the classic sequential approach (also called the cyclic approach in some literature). The approach allows respondents to report their travel diaries by walking through their travel day chronologically. **Figure 5** presents an example of the sequential design. The sequential diary first asks respondents to report their location at the beginning of the day.

Then, respondents report each out-of-home location they visited during the travel day. They have to provide detailed coordinates, travel modes, departure times, and activity purposes for each location. However, respondents are exempted from reporting location coordinates if the activity is work or study at a pre-reported location. Finally, respondents confirm that all out-of-home locations have been reported and complete the diary. Respondents are prompted for confirmation if the last location on their timeline is not home. If it is a proxy-based household survey, the self-respondents must repeat the above steps for all household members.



a. Report location at the beginning of the day



b. Report out-of-home activity

c. Completed travel diary

Figure 5. Example of travel diary in the sequential/cyclic design

3.0 Case study on travel diary dropout during household travel survey

Respondents' willingness to complete (survey completion rates) such surveys defines the cost of the survey and non-response biases. In recent years, survey completion rates of household travel surveys decreased dramatically. For instance, the overall completion rate was 16.2% in the 2016 Transportation Tomorrow Survey (TTS). The overall completion rate in 2016 was the lowest completion rate among all TTS cycles. The historical completion rates were 63.4%, 43.9%, and 46.1% in the 2001, 2006, and 2011 TTS cycles. The TTS is one of North America's oldest and largest samples of repeated cross-sectional household travel surveys, which covers 5% of the population in the Greater Toronto and Hamilton Area (GTHA), Canada (Data Management Group, 2018a).

One major cause for such a dramatic decrease is the replacement of computer-assisted telephone interviews (CATI) with computer-assisted web interviews (CAWI) surveys. Unlike CATI surveys, where respondents can receive guidance from interviewers, CAWI surveys place respondents in an uncontrolled environment where respondents must complete the surveys independently. In TTS, the CAWI mode was first introduced in 2011 and widely adapted in 2016. In 2016 TTS, address-only samples which could only be surveyed online had a 10.3% completion rate. At the same time, address-and-phone samples that were subjected to up to eight phone follow-ups had 36.9% completion rates (Data Management Group, 2018a). Resultantly, substantial resources must be spent to compensate for such a low completion rate in the CAWI travel surveys. For example, nearly one million invitation letters had to be mailed for the 2016 TTS could meet its survey coverage target (Data Management Group, 2018a).

Among all the components of a travel survey, a travel diary is the most challenging part, especially in CAWI modes. In CAWI surveys, respondents are expected to fully comprehend the concept of a travel diary and the operation of the question interface. Survey-takers might drop off the survey once they find the task exceeds their capability or is burdensome (Chung et al., 2021). This might also introduce measurement errors in the survey (Chung et al., 2021; Srikukenthiran et al., 2018). The non-response bias might arise when significant differences exist between respondents who complete and drop off the diaries. Therefore, the following section of this report compares the performance of different travel diary designs using household travel surveys completed by TRAISI. Using data from two proxy-based household travel surveys, the report will empirically investigate factors that correlated with respondents' decision to drop out of the travel diary sections and their implication on travel demand reflected in the dataset. Then, recommendations for future travel surveys will be discussed based on findings from the above empirical investigations.

3.1 The dataset: the COVHITS Survey

TRAISI was successfully deployed in two household travel surveys. In both surveys, many respondents dropped out at the travel diary question. The following sections describe the data used for the empirical investigations.

The **COV**id-19 influenced **H**ouseholds' **I**nterrupted **T**ravel **S**chedules (COVHITS) survey is a multi-cycle online household travel survey monitoring impacts of the COVID-19 pandemic on passenger travel demand in the Greater Toronto Area (GTA), Canada (Wang et al., 2021). The first cycle was conducted in the Fall 2020, and the second cycle was conducted in the Fall 2021. Both cycles randomly drew samples from commercial survey panels. The commercial market research company compensated participants after completing the survey. The COVHITS survey was proxy-based, as the heads of households (self-respondents) were required to report information on behalf of all household members (proxy-respondents). The surveys collected socioeconomic attributes at the household and personal levels, travel diaries, and additional revealed preference information. Travel diaries for the previous weekday were collected for all household members at least 6 years old. The data models for both cycles are presented in **Figure 6**.

The 2020 survey adopted the calendar design, whereas the 2021 survey used the sequential design. In the 2020 survey, 7,797 survey-takers reached the travel diary question. The final dataset contained around 3,721 households after data cleaning. In the 2021 survey, 8,870 survey-takers reached the travel diary question. After cleaning, the final dataset contained 4,687 households. The empirical analysis uses all samples that reached the travel diary sections in both surveys because the investigation aims to analyze the respondents' decision to drop out of the travel diary section. **Table 1** summarizes key sample household socioeconomic statistics and uses the 2016 TTS as the benchmark. The relative trends of household size, dwelling types, and the number of vehicles matched reasonably well between COVHITS surveys and the benchmark dataset. It should be noted that the statistics of the benchmark datasets are clean samples weighted to match the 2016 Census (Data Management Group, 2018b). However, the samples from both COVHITS surveys contained incomplete responses and samples that might be removed in the data cleaning stage. As a result, a perfect match between the COVHITS survey samples used in this investigation and the benchmark dataset should not be expected.

Table 1. Summary of key sample household socioeconomic statistics

	2020 COVHITS	2021 COVHITS	2016 TTS (benchmark)
Household size			
1	31.3%	34.8%	24.8%
2	38.0%	38.9%	28.2%
3	15.7%	14.0%	17.4%
≥4	15.0%	12.2%	29.7%
Household dwelling types			
House	61.4%	55.7%	46.4%
Townhouse	13.3%	11.3%	9.6%
Apartment	23.1%	31.6%	44.0%
Movable dwelling & Other	2.1%	1.3%	-

Number of vehicles			
0	9.8%	13.5%	17.4%
1	44.9%	49.4%	40.7%
2	34.5%	29.6%	31.6%
3	7.8%	5.2%	7.6%
≥4	3.0%	2.2%	2.7%

3.2 Dropout rates at the travel diary questions

In both COVHITS cycles, the dropout rates at the travel diary question are nontrivial. **Figure 6a & 6b** indicate the flow of each survey with the number of respondents who entered each section. In the 2020 survey, 11,092 self-respondents started the first question. 7,797 self-respondents started the travel diary question (section C1). Among them, 5,260 managed to pass the travel diary (section C1) and started the revealed preference questions (section D). Likewise, in the 2021 survey, 11,932 self-respondents started the first question. 8,870 started the travel diary question (section D). Among them, 6,906 passed the travel diary (section D) section.

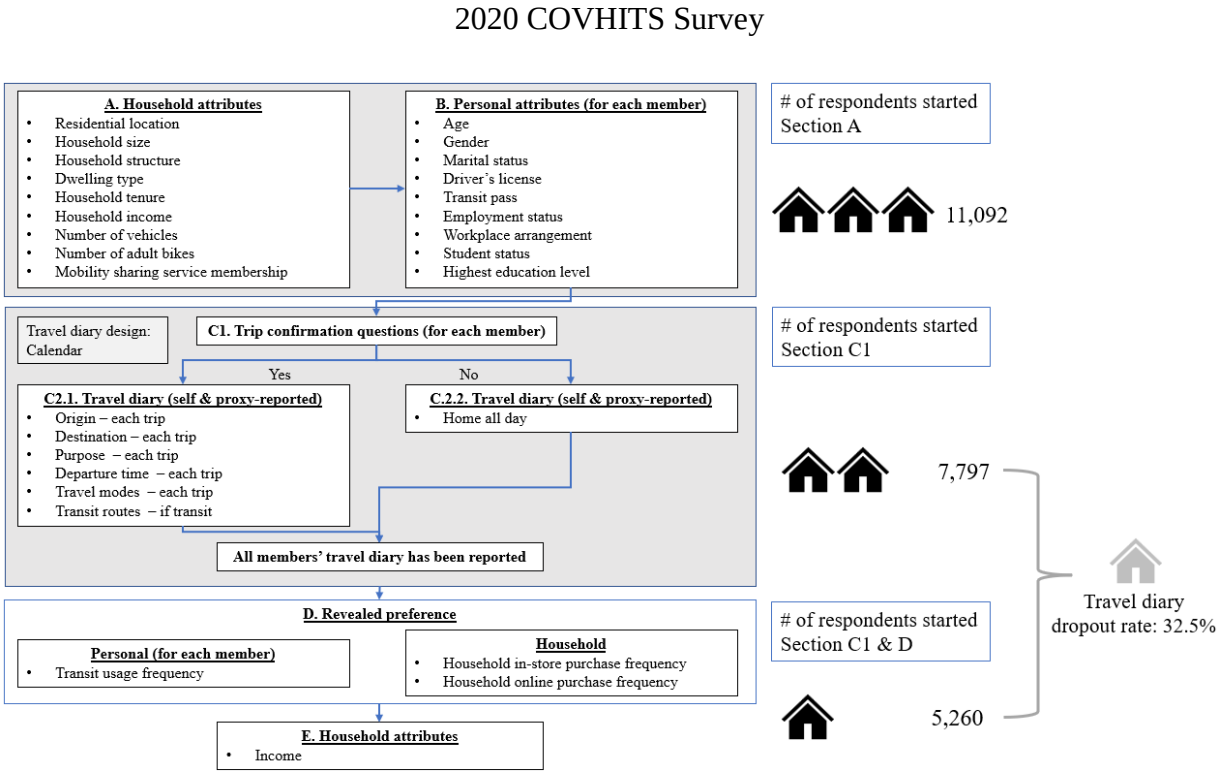


Figure 6a. Data models, survey flows and dropout rates for the 2020 COVHITS survey

In the 2020 survey, the dropout rate for travel dairy questions is 32.6%. However, the dropout rate is 22.1% in the 2021 survey. This reduction in the dropout rate is substantial. Survey fatigue and user-friendliness of the survey instrument are two primary causes of dropouts (Chung et al., 2021). In fact, before reaching the travel diary section, respondents in the 2021 survey endured higher fatigue than that in the 2020 survey. As presented in **Figures 5a & 5b,** both surveys placed household and personal attribute sections as the first two sections of the surveys. In addition, the 2021 survey also collected revealed transit usage frequency before the travel diary section. Compared to the 2020 survey, this could cause extra fatigue for respondents before answering travel diary questions. Nonetheless, the 2021 survey still demonstrates a lower dropout rate in the travel diary section. Therefore, it is safe to conclude that the relatively easier layout decreases the dropout rate in answering sequential travel diary questions.

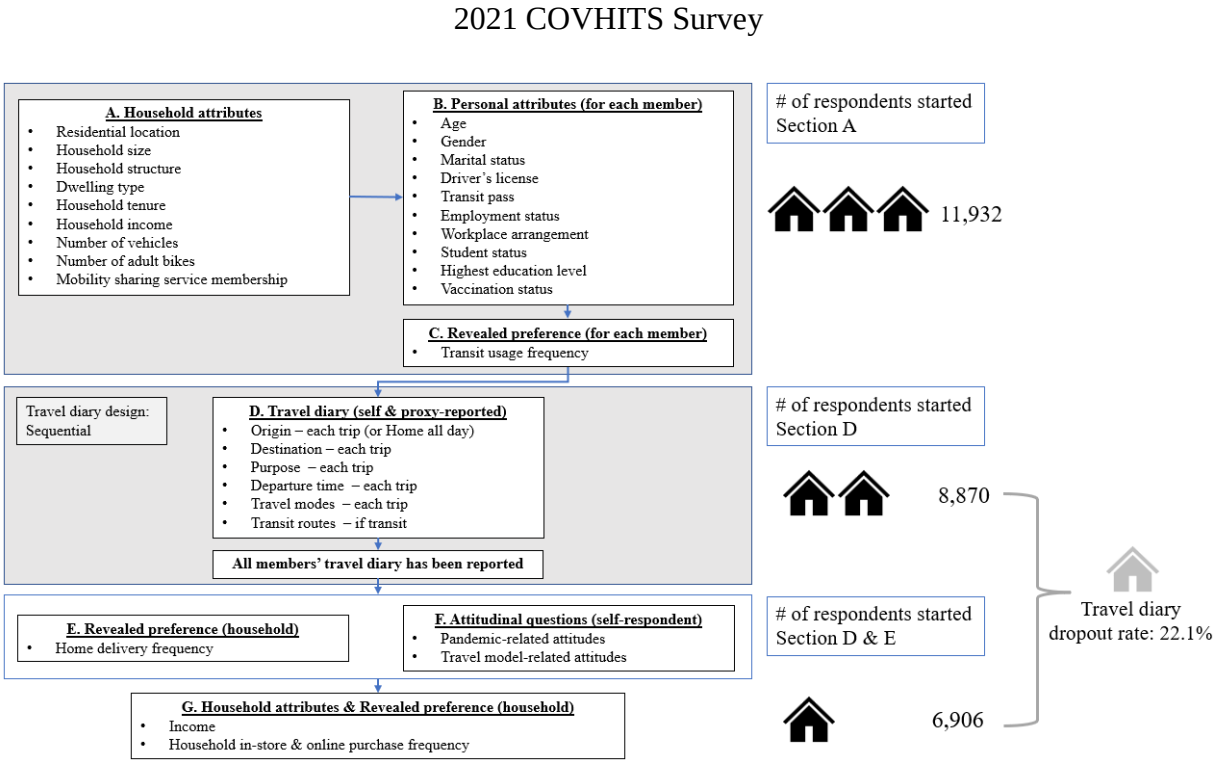


Figure 6b. Data models, survey flows, and dropout rates for the 2021 COVHITS survey

3.3 Binary logit model of respondents' decision to dropout out of travel diary

The binary logit model is used to capture the correlation between the decision to drop out of travel diaries and various socioeconomic variables (Hosmer & Lemeshow, 2000). For the binary outcome, dropout samples are marked as one, and samples that completed the diaries are marked as zero. The binary model is estimated using a pooled dataset containing samples from both COVHITS surveys. It reflects the average effects of independent variables on respondents' decision to drop out. **Table 2** reports the model estimation results.

The modelling results reveal that self-respondents' age and education levels are the most influential variables in their probability of dropping out of the travel diary. Compared to their older counterparts, respondents under 40 are less likely to drop out of diaries. Respondents with at least a bachelor's degree are less likely to drop out than those who are less educated.

On the household level, results indicate that household size is not statistically significant with travel diary dropout. Instead, indicators of mobility tools (e.g., number of vehicles) and mandatory travel demand during weekdays (number of workers and their workplace arrangements) contribute to dropping out of travel diaries. The probability of dropping out of travel diaries increases monotonically as the number of vehicles owned by the households increase. The dropout probability also increases as the number of workers who must travel to work increases. Conversely, the dropout possibility decreases as the number of work-from-home (WFH) workers increases. Literature found that household size contributed to travel survey dropout rates (Chung et al., 2021). Chung et al. (2021) viewed household size as a response burden measurement when completing travel surveys. However, household size is only a proxy for the burden. In fact, mobility tools and mandatory travel demands are more accurate indicators of the response burden to complete the travel diary section, especially when WFH is prevalent. Besides indicators of travel demands, the household structure will also affect dropout. The probability of dropping out of the survey at the travel diary section increases for non-family-member households. Aside from socioeconomic characteristics, the dummy variable indicating sequential diary design lowers the probability of dropping out of the travel diary questions. Lastly, surveys started during the weekend are more likely to drop out.

Table 2. Binary logit models for respondents' decision to drop out at the travel diary section during COVHITS surveys

	Estimate	Z value
Intercept	-0.89	-8.96
Personal attributes of self-respondents		
Age		
18 - 29	-0.51	-5.49
30 - 39	-0.17	-1.92
40 - 49	-	-
50 - 59	0.23	2.51
60 - 64	0.53	4.86
>= 65	0.80	8.75
Highest level of education		
Advanced degree (Master or higher)	-0.39	-4.79
Bachelor's degree	-0.17	-2.83
Diploma below bachelor's level	-	-
Occupation types		
Professional	-	-
Management	-	-

Technical & Paraprofessional	-	-
Household attributes		
Household size	0.003	0.11
Number of vehicles	0.07	2.57
Workplace arrangements of workers in the household		
Work-from-home exclusively		
full-time	-0.28	-5.49
part-time	-	-
Work-outside-from-home exclusively		
full-time	0.18	4.57
part-time	0.18	2.94
Living with non-family members	0.35	2.43
Living in movable dwelling & other dwelling types	-	-
Survey para-data		
Sequential diary design	-0.70	-13.00
Survey started during weekends	0.15	2.38
AIC (full)		8745.0
AIC (constant-only)		9261.7
Log-likelihood (full)		-4356.5
Log-likelihood (constant-only)		-4629.9

The findings discussed above have several implications for future household travel surveys. Firstly, age substantially impacts dropping out of web-based travel diaries, underscoring the importance of using mixed survey modes in any large-scale household travel survey. Data collected through household travel surveys, especially large-scale ones, need to represent the entire population. This study suggests that older self-respondents do not receive web-based travel diaries well, regardless of the diary designs. Alternative survey modes, such as the CATI survey, should be available to complement the web-based survey. Chung et al. (2021) also suggested providing alternative survey modes in household travel surveys to accommodate respondents' different technical capabilities.

Furthermore, data acquired through online travel surveys may still underrepresent certain sub-populations. Modelling results suggest that self-respondents living with roommates (non-family members) are more likely to drop their travel diaries. Adults who co-live together for financial motivation might lack knowledge of each other’s out-of-home activities and travel behaviours. Likely, co-livers would not coordinate travels with each other. Thus, self-respondents co-living with other adults might be reluctant to fill out proxy travel diaries. Future proxy household travel surveys might allow the option for respondents living with other non-family households,

especially those living in two-person households, only to report their own travel diaries. Respondents' burdens, dropout rates, and measurement errors might all be reduced if respondents in such circumstances were only asked to report their own dairies.

Secondly, special attention should be given to non-WFH workers to ensure the representativeness of future travel surveys. Workers' workplace arrangements are influential factors for respondents' likelihood of travel diary dropouts. The COVID-19 pandemic accelerated the adoption and reliance on telecommuting for privileged workers (Beck & Hensher, 2020; Habib, 2021; Wang et al., 2021). However, many workers still must commute and work on-site because of the nature of their work. The trend might persist to the post-pandemic era. Modelling results in **Table 2** show that having WFH workers in the household increase the likelihood of completing the travel diaries and vice versa. Completing travel diaries for WFH workers endure fewer burdens because of their decreased mobility. This might bias the sample representation. To ensure unbiased sample representation, future household travel surveys should give more weight to the non-WFH workers in their sample frames. Otherwise, travel demand revealed through future surveys might be underestimated.

Lastly, travel diary design for large-scale travel surveys should have shallow learning curves. Advanced and sophisticated designs might be unexpectedly counterproductive. The calendar design is supposedly more advanced than the classical sequential design in this study. The calendar design can automatically generate skeleton diaries to reduce the response burden. It is also more flexible and error-forgiving. Respondents can add and remove activities freely, whereas the sequential design constrains them to inject or remove activities chronologically. However, in the empirical study, it is found that the calendar design was not well received by respondents. The automation and judgments made on behalf of the respondents might also slow the initial learning curve to absorb the diary interface. Most respondents are first and only one-time users of the travel dairy design. They are impatient and lack the motivation to overcome the initial cost of reading instructions, learning, and exploring the dairy interface. This also relates to the risk to gamify travel surveys, as proposed in the literature (Verzosa et al., 2018). For every game, gamers must bear the initial learning cost before becoming familiar with the rules and operations of the game. Most likely, survey respondents will be reluctant to do so. Instead, classical sequential designs with stable repetitions and step-by-step guidance are favored by respondents. Indeed, the repetition might induce fatigue, as highlighted in the literature (Chung et al., 2021). But the repetition and guidance also reduce survey-takers learning curves and dropout rates.

4.0 Conclusion

This report documented the development of a web-based travel survey interface (TRAISI) equipped with two different designs of travel diary questions. The calendar design allows respondents to input their travel diaries as activity logs in digital calendars. Moreover, the design will automatically generate partial travel diaries, including all mandatory activities for

respondents. Alternatively, the sequential design allows respondents to report their travel diaries by chronologically walking through their travel day.

Then, this report provided a case study that analyzed respondents' dropout behaviours while reporting their trips using two travel designs in proxy-based household travel surveys. For socioeconomic variables, modelling results reveal that self-respondents' age and education levels are the most influential variables in their probability of dropping out of the travel diary. Respondents under 40 years old with at least bachelor's degrees are less likely to drop out at travel diary sections than their older and less educated counterparts. On the other hand, self-respondents' probability of dropping out of travel diary sections would increase with more household mobility tools, more workers in the household who must commute to work, and households made up of non-family members. For survey designs, the sequential diary design has been proven to reduce the respondents' probability of dropping out of travel diary sections compared to the calendar design. Recommendations are also made based on the above findings, which have critical implications for future household travel surveys.

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