A LARGE-SCALE TEST OF SMARTPHONE APPS FOR TRAVEL DATA COLLECTION

CITY LOGGER PROJECT

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Transportation Tomorrow Survey 2.0

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EXECUTIVE SUMMARY

In recent years, due to changes in communication technologies (increased use of smartphones, decreased use of landline phones), declining response rates and other methodological issues, new approaches are being sought to collect travel survey around the world. The TTS 2.0 R&D project aims to examine various methods of travel data collection including the use of smartphone apps. An evaluation of existing state-of-the-art in smartphone data collection and trace processing apps, done in TTS 2.0 project in 2016, highlighted the potentials of smartphone apps for travel data collection. Based on that initial study, a field test was devised to investigate the real-life applicability of smartphone apps for travel survey in Greater Golden Horseshoe (GGH) area. Two already developed apps, selected based on criteria developed in the initial study, were rebranded as "City Logger" for this purpose.

The field test was designed to examine two different methods commonly used in data collection conducted via smartphone apps: the real-time prompt approach and the travel diary approach. In terms of participant recruitment, two different methods were employed and later the reported travel patterns from individuals recruited from each method were compared. First, individuals who completed the 2016 TTS and expressed willingness to participate in further data collection efforts were sent an invitation via email. Next, other methods such as targeted ads on social media, traditional media coverage and contacting different advocacy organizations to disseminate the news about the app among their membership were used to investigate the effectiveness of crowdsourced methods. Data collection effort was carried out in October and November 2017. This report describes the design of the field test, a brief description of the apps, a descriptive summary of the collected data, and data analysis and discussion of the findings.

Overall, 2041 users downloaded and installed the app, 1082 on iOS and 959 on Android. However, only 1550 users completed the initial survey and made at least one trip. These participants were recruited through crowdsourcing avenues (389 participants) as well as email invitation to a group of 2016 TTS respondents (1191 participants). The results of the survey reveal that participants recruited from crowdsourced methods are considerably different in terms of sociodemographic and travel behaviour characteristics than the email invitation group and the observed population in the 2016 TTS. With respect to recruitment and crowdsourcing, more resources and greater lead time is needed to build a properly timed campaign that benefits from different partners and media coverages. The collected data indicate that while the crowdsourcing recruitment method is promising, it might not be yet the best way to capture a true representation of the population.

Regarding app design and processing, several findings can be highlighted and added to the design recommendations of the 2016 technical evaluation pilot. The field test results clearly justify recommendation of a single step onboarding process (user account creation and survey response) for any future smartphone app travel data collection. Further, an event log and a periodic recording of lower accuracy traces is recommended to be able to distinguish between missing traces, whether the users deleted the trace, or manually stopped the recording, or the app stopped recording due to lack of signals or low battery. This will increase the reliability of the trace processing feature and improve the quality of generated trip dataset.

The comparison between the two different design approaches- i.e. real-time prompt and travel diary validation – provide interesting results. Overall both approaches yield an acceptable quality of data.

The travel diary approach provides a higher validation rate while the real-time prompt approach, because of the lower survey burden, results in more days of run. A combination of the real-time and travel diary approach is recommended for future work. An ideal app would prompt users real-time and create a travel diary so users have the ability to validate, edit or delete the recorded information. Overall, the City Logger project demonstrated that with proper app and survey design, as well as a streamlined process for quality assessment and corrections, there is potential to cost-effectively collect travel dairy data using smartphone apps.

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TRANSPORTATION TOMORROW SURVEY 2.0

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1 INTRODUCTION

The Transportation Tomorrow Survey (TTS) is a household travel survey collecting travel information which has been carried out every 5 years since 1986. The TTS has historically been carried out as a large-scale Computer Assisted Telephone Interview (CATI) survey. However, changes in communication technologies (increased use of smartphones, decreased use of landline phones), declining response rates and other methodological issues have presented challenges to the current TTS method. This has led to new approaches being sought to collect the information required for long-range, evidence-based transportation planning.

Smartphones can provide a means by which to collect high quality information on the travel patterns of individuals without burdening these individuals by asking them to recall and report every detail of their travel. With the use of smartphones' location-logging capacity, smartphone apps can provide a tool with a user interface that make it possible to ask for validating trip information, real-time or after-the-fact at the end of the day. Use of smartphone apps for travel diary might also potentially solve some of issues with traditional survey methods such as respondent memory, proxy bias, mode bias, and rounding of travel times in self-reporting survey modes.

The TTS 2.0 project aims to examine various methods for travel data collection including use of smartphone apps. The evaluation of the use of smartphones for travel survey collection began with an initial phase in 2016 with the conduct of an experiment that assessed the design and performance of the existing state-of-the-art in smartphone data collection and trace processing apps (Harding, Srikukenthiran, Habib, & Miller, 2017; Harding, Srikukenthiran, Zhang, Habib, & Miller, 2016). This experiment used multiple apps and compared them against a ground truth to evaluate how well they performed over a range of metrics. These included their accuracy in recording and inferring leg and trip end location and time, mode inference, and battery drain. It also provided an assessment of best practices with respect to the design of apps.

Based on this initial study, a field test was devised to investigate the real-life applicability of smartphone apps for travel surveys in the Greater Golden Horseshoe (GGH) area. Two already developed apps, selected based on criteria developed in the initial study, were rebranded to "City Logger" for this purpose. This report describes the design of the field test and the logic behind the choice of the smartphone apps used in the field test. It presents a brief description of the apps, a descriptive summary of the collected data, and data analysis and discussion of the findings.

The remainder of this report is organized as follows. After a brief review of large-scale smartphone travel surveys, Section 2 describes the City Logger app design, survey design, and recruitment methods. Section 3 discusses the data collection effort. Section 4 presents the analysis of the data collected by City Logger app. Finally, section 5 concludes by summarizing the lessons learnt and proposing recommendations for future efforts.

2 DESIGN OF CITY LOGGER FOR THE FIELD TEST

2.1 Overview of smartphone travel survey apps

This section presents a brief discussion of earlier works on the use of smartphone apps for data collection. With advances made in smartphone technology in recent years, there have been several studies investigating the potential of smartphone apps for different purposes, including data collection for travel surveys. However, there are only few efforts that have studied the use of smartphone apps for collection at a large scale and for a long period. Recently, several regions in United States have used smartphone apps in conjunction with their traditional household travel surveys. For example, along with a one-day web-based travel survey, the 2017 Puget Sound Travel Survey in Seattle, Washington, employed a one-week travel diary using a smartphone app for all the household members (RSG, 2018). Other examples of using a smartphone app for travel survey data collection, all of which provided incentives to recruit participants, are as follows:

- Metropolitan Phoenix Area's two-day travel survey of about 7000 households (Maricopa Association of Governments, 2016)
- Ohio 7-day travel survey of 617 households (Anderson et al., 2016)
- Indiana 7-day travel survey of about 240 participants (Greene, Flake, Hathaway, & Geilich, 2016)
- A 14-day travel survey of 550 participants, which was part of the Dutch Mobility panel study (Geurs, Thomas, Bijlsma, & Douhou, 2015)
- A 14-day travel survey of 793 participants in Singapore, which was part of Singapore national household travel survey (Zhao et al., 2015)

Recently, the City of Montreal conducted a large-scale data collection using a smartphone app. In the project, the City of Montreal was specifically interested in the impacts of many construction works that were happening at the same time around the city on the transportation system. The collected data were used to quantify the impact of construction works on travel time. In addition, the data were useful to better understand people's travel behavior and to better plan detours and traffic lights ("Move and win | Mtl Trajet," 2017). The recruitment was done through crowdsource approaches such as ads on traditional and social media and email invitations through different organizations and advocacy groups. Participants were entered into a raffle after confirming at least 25 trips in 30 days.

Another research effort used a smartphone app to investigate travel satisfaction in the San Francisco Area. The purpose of the study was to assess the quality of users' travel experience (Carrel, Sengupta, & Walker, 2017). The recruitment was done through various methods, including email, postcards, in-person hiring, and fliers. As an incentive, participants were given a monthly transit pas provided they reported the quality of their travel experience for one day and ran the app to collect location data for at least 5 days.

A combination of the use of smartphone app and a web-based diary for travel data collection was carried out in Australia (Greaves et al., 2015). By giving incentives and recruiting via phone, in-person and through advocacy organizations and telemarketing firms, travel data from 641 participants for 7 days were collected. Another study in Montreal, in a university setting, was able to collect 14 days of travel data of 892 individuals by sending out emails to students, faculty, and staff. There are also

several studies that have investigated different dimensions of using smartphone apps for travel data collection with fewer number of participants (Patterson & Fitzsimmons, 2016).

The abovementioned studies vary in two key areas: i) app design and user input, and ii) recruitment method and incentives. In the following sections, these areas are discussed, leading to the presentation of the approach used in the City Logger project.

2.2 App design and user input

For the City Logger project, a global request for proposals was launched. The RFP specification is presented in Appendix 7.1. A total of 11 proposals from 6 countries including ones from commercial firms, start-up companies, and research labs. After a rigorous assessment of the proposals and considering the budget, two different apps for iOS and Android were chosen and labelled as City Logger. As a smartphone app for travel survey is expected to do, both apps function by running in the background and recording location information. As such, there is no need to turn the apps on and off, which tends to lead to incomplete reporting of travel. The apps automatically upload the initial sociodemographic survey, validation and location information.

The two apps selected make the use of the two main approaches exist to validate travel survey data collected by smartphone apps: real-time prompt and retrospective travel diary. In the real-time prompt approach, as soon as the trip end is detected, the app either prompts for the entry of trip details, such as mode and purpose or asks the user to validate the inferred information. In the travel diary approach, instead of prompting throughout the day as trips are detected, the app asks for trips to be validated collectively in the form of a travel diary at the end of the day.

Both approaches have advantages and disadvantages. In the real-time prompt approach, a user might ignore the prompt, resulting in missing information for that trip. Also, the user might confuse the prompt's request for trip destination information with that for the trip's origin and mistakenly provide information for the origin rather than the destination. On the other hand, in the travel diary approach, there is an increased reliance on user memory to remember all the trips made during the day. Also, validating all the trips at the same time might increase the perceived burden of the survey. In this project, both approaches are evaluated in order to see how people respond to each method. The iOS version of the app follows the real-time prompt approach while the Android version of the app collects data in the form of travel diary validation.

2.2.1 City Logger – iOS version

The City Logger app for iOS is a modified version of the Itinerum app ("Itinerum™ Platform," 2017), downloadable from the Apple app store. The first time that users run the app, they must answer an initial survey, which asks some typical travel survey questions such as questions related to age, gender, household characteristics, having a driver license and vehicle ownership (the list of questions is presented in Appendix 7.1). The app then runs in the background and records the user's movements through the location service of the smartphone. It has a geo-fence (spatial) and time (temporal) threshold to detect trip ends.

Once a trip end is detected, a prompt is displayed on the screen: "You seem to have stopped. Have you reached a destination?". The user then has three options to respond: "Yes, I've arrived", "No,

haven't arrived yet" and "No, I'm not traveling". If the user's answer is yes, then the app asks for trip purpose and mode.

The iOS version is designed to be simple. The app only shows traces location points on the map with counters (displayed) for number of trips validated and days participating. The app stops using the location services and collecting data when the battery level falls below 15%. When the battery is charged, the app automatically continues recording the traces. Figure 1 shows an overview of the iOS version of City Logger.

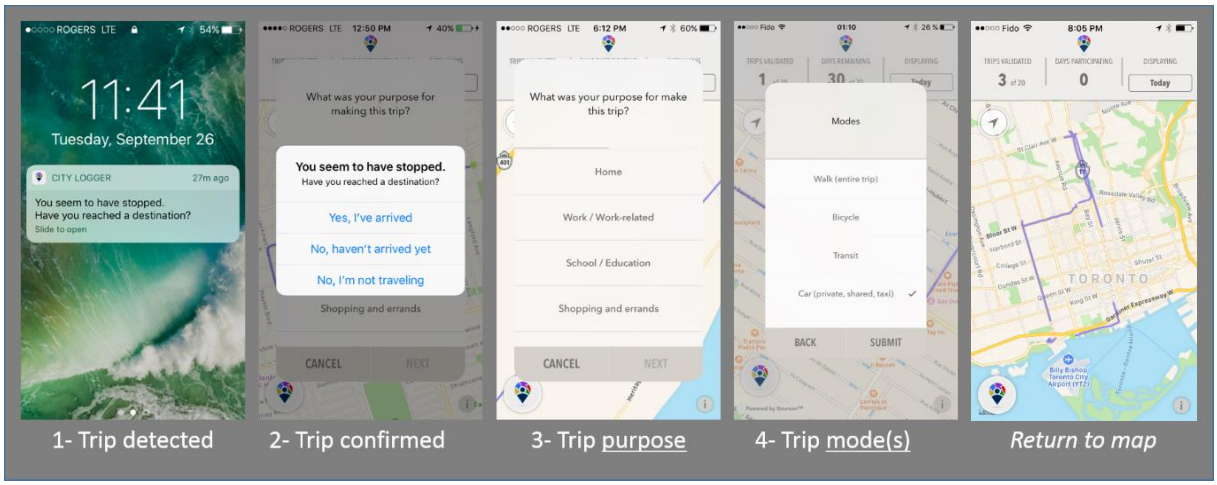

FIGURE 1 CITY LOGGER REAL-TIME PROMPT VERSION FOR IOS

2.2.2 City Logger – Android version

For the Android version of the City Logger app, the Modalyzer app ("Modalyzer," 2017) was adapted. Unlike the iOS version, the Android version has a registration procedure. After users install the app and run it for the first time, they must register. The registration asks for username, password, and an email address. An activation email is sent, and users must go to their emails and activate the account. Once the account is activated, users can go back to the app and login using their credentials. In the Android version, in order for the app to start recording the movements, users must first press the start recording button. They can toggle recording any time using the same button. The app stops collecting data in low-battery mode (when the battery level drops below 15%). If that happens, after the battery is charged, the users must manually turn the recording on again as the app does not automatically resume recording. The app does, however, send a notification to remind the user that

the recording is turned off. Figure 2 shows the required registration steps for City Logger Android version.

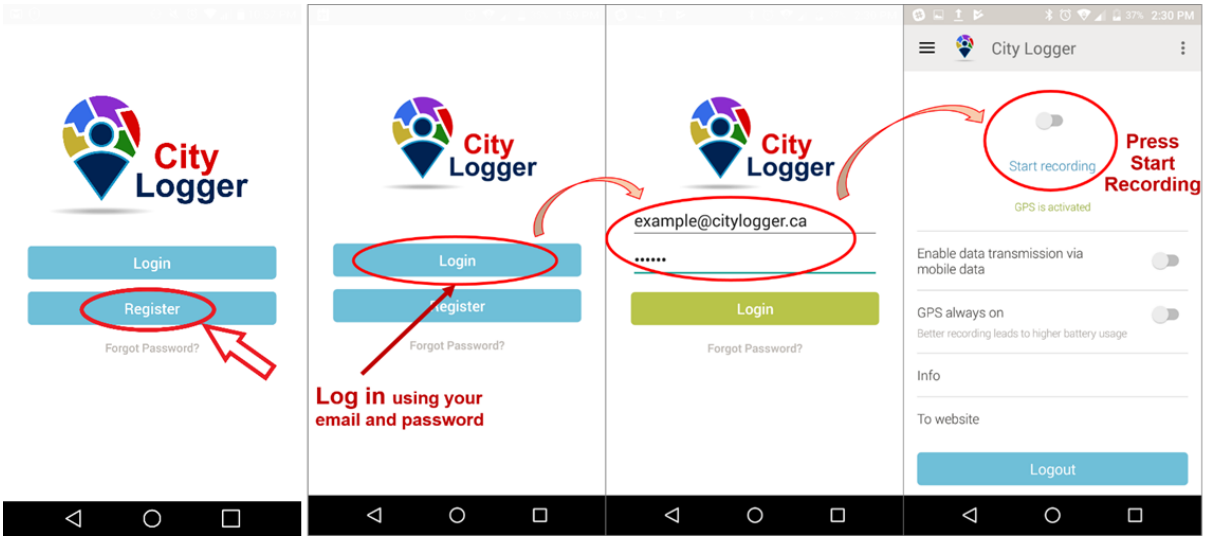

FIGURE 2 CITY LOGGER ANDROID VERSION REGISTRATION

In the Android version, the survey of individual and household characteristics is not mandatory. Users must go to the survey tab using the sidebar of the app. The app shows a notification if the survey has not been completed. However, users can ignore the notification or prevent the app from showing the notification. Figure 3 presents the steps to complete the individual and household characteristics survey in the Android version.

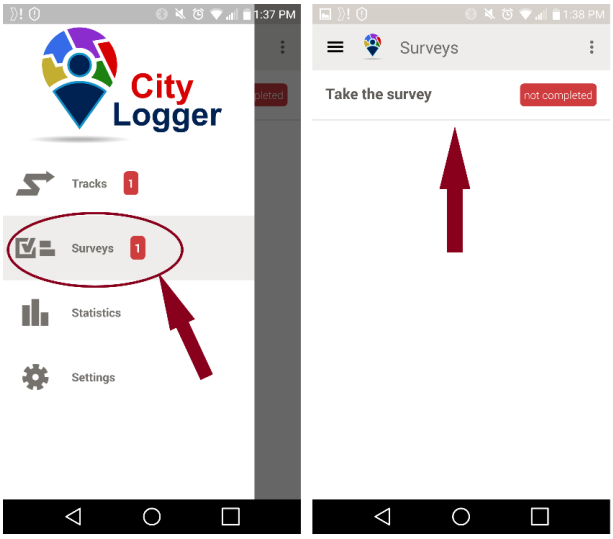

FIGURE 3 CITY LOGGER ANDROID VERSION TAKE THE SURVEY

Compared with the iOS version, the Android version has a more graphic interface with the ability to see daily statistics and mapped trip legs. In the Android version, users can see their daily travel diary. The app also automatically infers the travel mode. While convenient, this also means that errors can occur. Therefore, users are asked to validate and confirm their trips. They can edit the mode, merge

trip legs, or delete trip legs. The Android version does not ask for the trip purpose. Figure 4 shows an overview of the travel diary interface of the Android version.

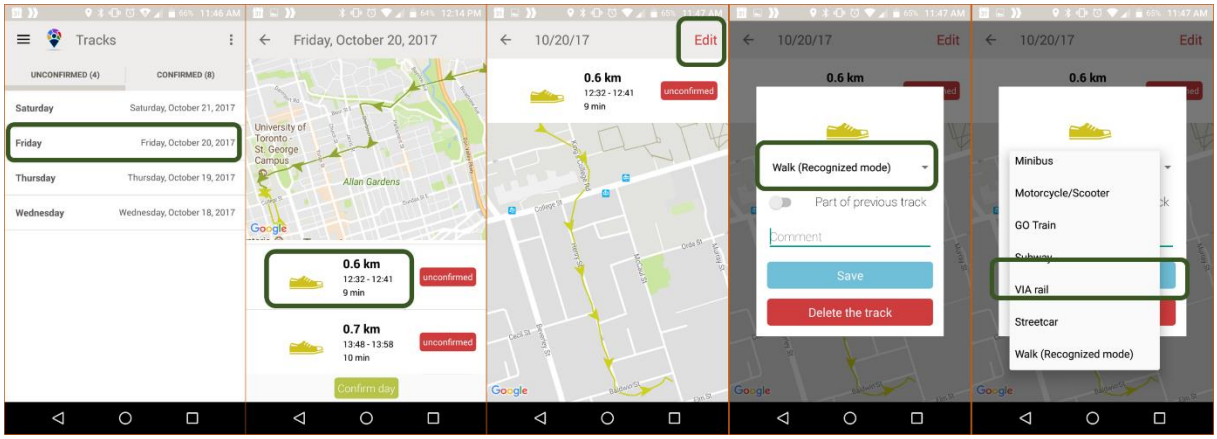

FIGURE 4 CITY LOGGER TRAVEL DIARY VERSION FOR ANDROID

2.3 Recruitment method and incentives

For the City Logger field test, participants were recruited from a subset of the 2016 TTS respondents. Participants in 2016 TTS were selected from address-no-landline and address-with-landline lists, and random digital dialing of cellphone area codes. Those who were willing to be contacted for future travel data collection surveys provided their email addresses. A random selection of these email addresses was the base for City Logger field test recruitment. In addition to this email list, different crowdsource methods were employed to recruit participants. These included traditional media, social media, blogs, disseminating the website URL among advocacy organizations membership and flyer at events. The effectiveness as well as the sample representativeness of these methods are evaluated in this report.

Incentives and messaging are reported as important factors to motivate people to participate in smartphone app based surveys (Maruyama, Sato, Nohara, & Imura, 2015). While traditional travel surveys in the region have not had incentives, smart phone apps present additional privacy concerns surrounding installing an app that collects traces of every trip made and can cause battery drain. These justify the use of incentives for attracting participants to install the City Logger app. Raffle draws were used as incentive for the field test. The prizes included one pair of tickets to the Rogers Cup, a foursome of golf at a ClubLink golf course, 50 KM of free travel on Highway 407 ETR, an Enterprise Carshare prize pack consisting of two application fees, a family membership and a 100$ driving credit, a free bike tune-up at CycleMania and two (2) $100 CAD Amazon.ca gift cards. In order to be eligible for the prize draw, users had to complete the sociodemographic survey within the app, provide a valid email address and validate either 5 travel diary days for the Android version or 20 trips for the iOS version during the data collection period.

Proper messaging to attract participants is also an important factor in motivating individuals to participate in the survey. In order to be able to evaluate such impacts, two different versions of welcome messages were randomly shown to the users. One version emphasized the contribution of

users by participating in the survey to have a better city while the other version focused on winning prizes by participating in the survey. The two versions were as follows:

- A: (Emphasizes BETTER CITY)
  YOUR help in this project will contribute to the design of improved data collection methods in the region. Your invaluable contribution will trickle down to enhance the quality of datasets used every day by government agencies and industry analysts to plan transportation improvements for all – whether driver, cyclist, pedestrian or public transit user. To show our appreciation, after confirming 5 days of travel diary, you will qualify for our various prize draws.
- B: (Emphasizes PRIZE)
  You can WIN PRIZES by answering this survey and confirming 5 travel diary days - $100 Amazon.ca gift cards and other prizes provided by the 407 ETR, Enterprize carshare and Cyclemania. Whether you win a prize or not, however, your input will provide invaluable data for use in shaping the data collection tools in the region and ultimately improve transportation infrastructure planning at the local and regional scale.

2.4 Initial Survey Questions

While smartphone apps are very effective in recording users' movements using the location services of the phone, the socio-demographic information of the users must be collected through a questionnaire. As previously mentioned, this survey was mandatory for iOS users, while Android users needed to go to the sidebar tab of the app in order to answer the survey. The questionnaire was based on the TTS survey with some additional questions related to shared mobility, bicycles and app recruitment. The Android and iOS versions had predominantly similar surveys. The following data were collected via the survey:

- Both Android and iOS versions: age, gender, home location, work/school location, dwelling type, tenancy type, student status, employment status, occupation type, free parking at place of work, frequency of telecommute, having driver license, shared mobility membership, ridehailing app, or transit pass, number of household members and children, number of fulltime and part-time workers in household, number of vehicles and driver licenses in the household, household annual income, and how hearing about the app.
- Only Android version: Having a landline at home (because of a glitch, this question was not asked in iOS version).
- Only iOS version: Primary and alternative usual mode of travel, ability to invite other household members within the app.

The list of questions for both Android and iOS versions is presented in Appendix 7.1.

3 CITY LOGGER DATA COLLECTION

The City Logger data collection campaign ran from October 1 to November 30, 2017. The website (citylogger.ca), social media pages (Facebook and Twitter) and a press release were released on the launch day. The first month of data collection was mainly used to recruit participants from crowdsource approaches, while the second month was used to send out email invitations to the TTS email list. The Android version was available on the Play Store for download a couple of days earlier than October 1, 2017. However, the iOS version was delayed and was available on the App Store on October 6, 2017. From October 1 to 6, 2017, the users who visited the City Logger webpage were able to subscribe with their email address to be notified when the app was ready for release on iOS.

3.1 Crowdsource campaign

Several crowdsourcing tactics were used to recruit participants. A detailed report on the crowdsource campaign and content is provided in Appendix 7.3. The first related piece was published on September 22, 2017 on University of Toronto's news webpage, describing the project and the app. This piece of content was quite successful as both a tool to use in pitching to advocacy groups and media, as well as getting as much social media traction as possible prior to the launch. Many referrals in the pre-launch days of the campaign were from this article and it remained one of the top tweeted and shared pieces outside of the mainstream media. Following that, a press release was published by Canadian Press on the launch day (October 2, 2017) and published by many of the media such as CBC, CTV, Global News, Toronto Star, etc. It was estimated that the press release reached an audience of 2.14 million. The main effort on social media was focused in October of 2017. Tweets and Facebook posts were posted every day to draw attention to the app. On October 25, 2017, the City Logger app was the main topic of TVO's The Agenda as part of an interview with Prof. Eric Miller on how data can help improve transportation. The Agenda typically has a broadcast viewership of approximately 125,000 viewers with additional viewers online through YouTube, Facebook and Twitter (more than 2000 views in total). At the end of the project, 389 participants reported that they heard about the app through crowdsource methods.

3.2 Email Invitations

Email invitations were sent out starting October 23, 2017 and evenly distributed over a 20-day span. A total of 17,804 emails were sent. Out of these email addresses, 7,804 addresses had been previously contacted in summer 2017 for the web survey field test in which 7,411 of the emails did not generate a response. However, 393 out of 7,804 had agreed after the summer test to be contacted again for future studies. In addition, starting November 10, 2017, a joint invitation (with a parallel web-survey field test) was also sent out to 5000 new email addresses with the option of participating in either City Logger project or completing a web survey. The joint invitation was evenly distributed over 7 days. For all email invitations, there were two reminders sent 4 and 8 days after the first email invitation.

Overall, these 22,804 email invitations led to 4,692 page-views of the City logger website linked through the emails. To be able to easily differentiate general web traffic in the City Logger site from traffic received as a result of email invitations, a non-published page was created on the site, such that only persons with the link could reach the page. This yielded a click-through rate of 20.6%. In addition to this, some persons, upon receiving the invitation, may have instead chosen to use a search

engine to look-up City Logger or head directly to the App or Play stores; no data are available on this. While a 'where did you hear about' question was available on the Android version, as it was not mandatory, it is impossible to determine the exact number of participants recruited by each method. For iOS, on the other hand, this question was answered by all respondents. It is estimated that about 1687 users installed the app because of the email invitations, representing an install rate of roughly 7.4% from the 22,804 emails, or 10.9% if emails from the summer that elicited no response at that time are removed. In comparison, the click-through rates on the email invitations is roughly 20%. This means that a significant portion of individuals who received the email and clicked on the link actually followed-through on installation. In the initial survey, 1314 users reported that they installed the app because of the email invitation, i.e. an install rate of 5.8% from all the email addresses or 8.5% if the 7411 email addresses that provided no response in the summer field test are removed. Table 1 presents a summary of the email invitation effort, with a more detailed report provided in Appendix 7.4.

TABLE 1 EMAIL INVITATION SUMMARY

	Count	**Note**
New email, test on Oct 22	350	
Used in summer – no response	7,411	evenly distributed over 20 days, starting Oct 23
Used in summer – agreed to participate	393	
New email	9,650	
Joint Invitation	5,000	evenly distributed over 7days, starting Nov 10
Total	22,804	
	Count	**Rate**
Unique page view	4,692	20.6% (30.5%)
Installed	~1,687	~7.4% (10.9%)
Installed and responded to survey	1314	5.8% (8.5%)

4 ANALYSIS OF COLLECTED DATA

During the two-month campaign, 2041 users downloaded and installed the app, 1082 on iOS and 959 on Android. All users of the iOS app responded to the initial survey; however, only 1006 of the users recorded at least one trip. Out of 959 downloads of the Android version, 906 users activated their account by following the activation link sent to their email addresses during the registration procedure, but only 572 of these users recorded at least one trip. As the initial survey was not mandatory, 621 of users completed the survey and 544 of those who completed recorded at least one trip. Overall, 1550 users completed the initial survey and made at least one trip.

4.1 Descriptive analysis of socio-demographic characteristics

This section presents an analysis of City Logger users' personal and household characteristics. As a benchmark, the socio-demographic attributes of users are compared with of those from the 2016 TTS. Further, an analysis is done of City Logger users separated by the recruitment method, namely, crowdsource methods (389 users) or email invitation (1314 users).

Comparing to TTS respondents, the City Logger users are more heavily younger men with full-time jobs, especially in professional, management and technical occupations. They tend to be from higher income households with fewer vehicles and drivers. The home and work locations of City Logger users are spread across the Greater Golden Horseshoe region with greater concentration in the City of Toronto.

Socio-demographic characteristics of City Logger users who heard about the app through crowdsource methods can also be compared to those who received an email invitation. Crowdsourced users are more heavily male and younger individuals. The number of students is higher and the number of fulltime workers is lower in the crowdsourced group. Crowdsourced users have fewer driver licenses and vehicles, as well as a higher chance to use a ride-hailing app or enroll in a shared mobility service program. Also, this group of users tend to be located in Toronto and in households with lower income than email invited users. Table 2 and Table 3 present a descriptive summary of individual and household characteristics of City Logger users, respectively. Figure 5 maps the home, work and school locations of City Logger users across GGH region.

TABLE 2 CITY LOGGER USERS - INDIVIDUAL CHARACTERISTICS

FREQUENCY (%)	CITY LOGGER			TTS 2016	
	Email Invitation	Crowd-sourced	Total	Unweighted	Expanded
GENDER					
Male	58.4	63.2	59.5	48.0	48.7
Female	40.9	35.2	39.6	52.0	51.3
AGE					
16-24	3.2	9.3	4.1	9.6	14.2
25-34	24.4	28.8	24.9	12.9	16.7
35-44	28.2	23.4	28.0	15	16.5
45-54	19.0	14.7	18.2	17.7	18.7
55-64	16.4	14.1	15.3	18.4	16.1

65-74	8.0	7.7	8.1	15.2	10.8
75-84	0.8	1.8	1.1	8.1	5.0
85+	0.2	0.3	0.2	2.9	1.8
STUDENT STATUS					
Not student	94.2	87.1	92.6	82.2	78.1
FT student	2.6	9.5	4.2	16.2	19.9
PT student	3.2	3.3	3.2	1.6	1.9
EMPLOYMENT STATUS					
FT worker	74.1	69.4	73.0	37.5	39.1
PT worker	9.4	8.2	9.2	7.8	8.9
Not employed	16.4	22.4	17.8	54.7	52.0
OCCUPATION TYPE					
General office/ clerical	10.6	9.6	10.4	13.7	13.3
Manufacturing/ construction/ trades	4.7	3.3	4.4	13.5	14.7
Professional/ management/ technical	79.3	81.1	79.7	47.8	45.0
Retail sales and service	5.4	6.0	5.5	25.1	27.0
OTHER ATTRIBUTES					
Having a driver license	93.8	85.6	92.0	70.8	67.6
Having a ridehailing app	55.9	62.0	57.0	-	-
Having a landline*	38.4	33.9	61.6	-	-

***ONLY ASKED FROM ANDROID USERS**

TABLE 3 CITY LOGGER USERS - HOUSHOLD CHARACTERISTICS

FREQUENCY (%)	CITY LOGGER			TTS 2016	
HH INCOME	**Email Invitation**	**Crowd-sourced**	**Total**	**Unweighted**	**Expanded**
$0 to $14999	1.7	2.6	1.9	4.0	4.8
$15000 to $39999	5.1	6.9	5.5	14.6	14.8
$40000 to $59999	6.2	8.5	6.7	14.2	14.3
$60000 to $99999	22.0	19.0	21.3	20.8	21.5
$100000 to $124999	14.2	13.4	14.0	9.8	10.0
$125000 and above	34.6	33.7	34.4	17.4	17.0
Decline / don't know	16.2	15.9	16.1	19.2	17.8
HH SIZE					
1	21.8	20.8	21.6	25.3	24.6
2	36.5	39.3	37.2	37.7	30.4
3	16.8	16.2	16.7	15.8	17.0
4	17.4	15.7	17.0	13.9	16.8
5	5.3	4.9	5.2	4.8	7.6
6+	2.2	3.1	2.3	2.4	3.5
NB VEHICLE					
0	16.7	31.1	20.0	12.2	13.8

1	42.6	39.3	41.9	40.8	38.7
2	33.0	21.9	30.5	35.6	34.7
3+	7.6	7.7	7.6	11.3	12.8
NB DRIVERS					
0	20.5	16.2	19.6	6.4	6.6
1	31.6	31.6	31.6	31.5	31.0
2	40.9	44.7	41.8	48.5	45.0
3+	6.9	7.5	7.1	13.6	17.4
NB FT WORKER					
0	15.8	21.6	17.1	36.0	29.3
1	39.3	32.4	37.8	34.2	37.2
2	40.9	40.9	40.9	25.9	28.4
3+	4.0	5.2	4.3	3.8	5.2
DWELING TYPE					
House	51.3	49.4	50.9	61.2	55.1
Apartment	35.2	38.8	36.1	29.2	35.4
Townhouse	11.5	10.5	11.3	9.6	9.5
HOME LOCATION					
Toronto	55.1	67.1	57.8	33.4	33.4
Outside Toronto	44.9	32.9	42.2	66.6	66.6
OTHER ATTRIBUTES					
HH Having membership of shared mobility services	15.5	32.1	19.3	-	-

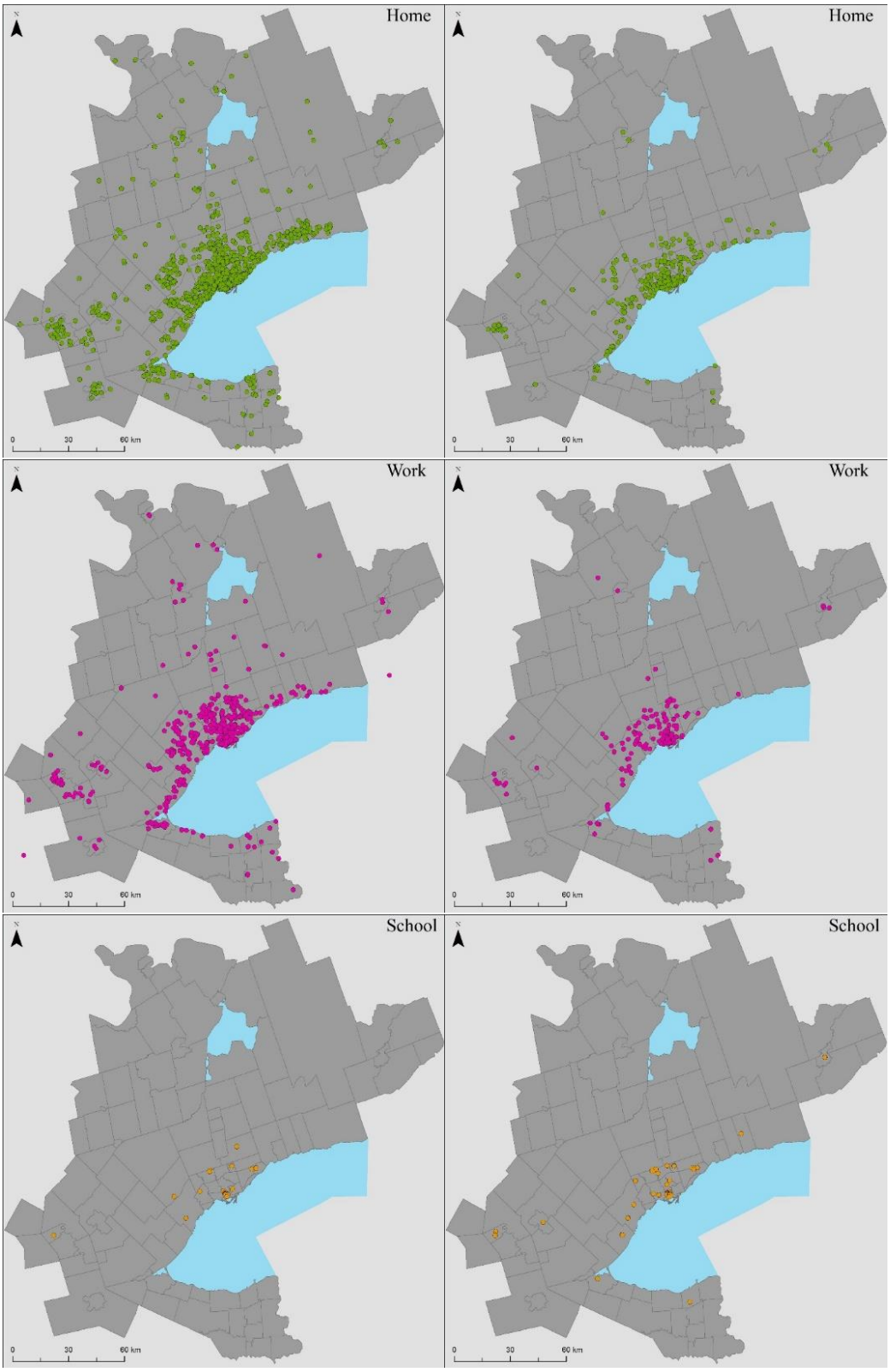

FIGURE 5 HOME, WORK, AND SCHOOL LOCATION OF CITY LOGGER USERS (LEFT: EMAIL INVITATION, RIGHT: CROWDSOURCE)

4.2 City Logger Trips

In the City Logger project, two different apps were used for the Android and iOS smartphone platforms in order to compare the two design approaches. Both versions have their own native (app-specific) algorithm to identify trips based on the recorded GPS traces. A generic trace processing suite (Tdx) previously developed in the TTS 2.0 project (Harding et al., 2017) was also used to detect trips from the GPS traces, regardless of the app version, to be able to consistently compare the trips. Further, the Tdx algorithm helps to remove noise and ensure legs of trips are merged together. In this report, trips reported by this travel diary extractor is referred to as Tdx while the app-specific trips are labeled as Native.

In addition, during data processing, there was also work carried out to make mode responses uniform (Android and iOS making use of slightly different response alternatives), associate trip ends with provided anchors locations (which needed to be converted to coordinates in Android), correct for cold starts on trip start times and locations and label any issues identified. However, given that neither app recorded data on such problematic events, it was not possible to differentiate most issues. These range from location recording suspension caused by manually pausing recording in-app, device shut down, app crash, entering low-battery mode (which disables background location trace recording), absence of sufficient quality location information (too few GPS satellites in line of sight) or location services accuracy or permissions being changed (some persons manually disable location services to reduce battery drain when immobile, a behaviour especially prevalent among persons with older handsets). All these issues can lead to spatial and temporal gaps in location recording, but without information on the events that precede and follow gaps in recording, these are indistinguishable from stationary episodes.

Overall, City Logger users made 131,012 trips in the two months of the campaign. Out of these trips, the users validated (trip confirmation in Android and responding to prompt in iOS) the trip information for 65,925 trips; this is about half of all trips made. About 91% of the trips by Android users are confirmed compared to only 33.3% of the prompts in the iOS version. It is interesting to see that the Android version which used the travel diary approach provides more confirmation in trip reporting than the iOS which used the real-time prompt approach. The result was expected as the chance to miss/ignore a prompt is higher than forgetting to later validate trips.

While the results indicate a higher certainty in trips reported by Android, two aspects should be considered. First, trips deleted in Android version were not saved in the dataset. These could include trips that the app mistakenly detected, leading to a deletion by users. For the iOS version, however, if the user ignored the prompt for such trips, those were still reported in ignored prompt trips. Second, the travel diary confirmation in Android does not necessarily mean that users who confirmed the diary had actually checked the information for all legs. Table 4 summarizes the trip validation for the two different versions.

TABLE 4 TRIP VALIDATION

Android	Frequency	Percent
Confirmed trip	28674	85.9
Edited (changed mode)	974	2.9
Edited (merged into)	755	2.3
Unconfirmed trip	2973	8.9
Total	33376	100.0
iOS	Frequency	Percent
Responded Prompt	32549	33.3
Ignored Prompt	65087	66.7
Total	97636	100.0

Given the differences between the Android and iOS versions of the app, the requirement for users to complete the survey and be eligible for prizes were based on the number of days confirmed and number of prompts responded for the Android and iOS versions, respectively. Android users were asked to confirm at least five days of travel and iOS users were required to answer at least 20 prompts. On average, Android and iOS users run the app for12.3 and 18.7 days, respectively. Both type of users on average validated more trips than required, indicating that the use of the app is not significantly burdensome. On average Android users validated about 11 days of travel diary (or 4.59 validated trip per day which results in about 50.5 overall validated trips) and iOS users responded to about 34 prompts (or 1.95 responded prompts per day which results in about 17.5 days). iOS users kept the app running for more days than the Android version. This might suggest that the real-time prompt approach is perceived to be less burdensome for users; however, it is important to note that other factors such as battery drain and data usage might influence this decision. Figure 6 shows the cumulative distribution of the number of users by the number days run for Android and iOS. Figure 7 presents the frequency of users by number of days confirmed for Android and by number of prompted responded for iOS.

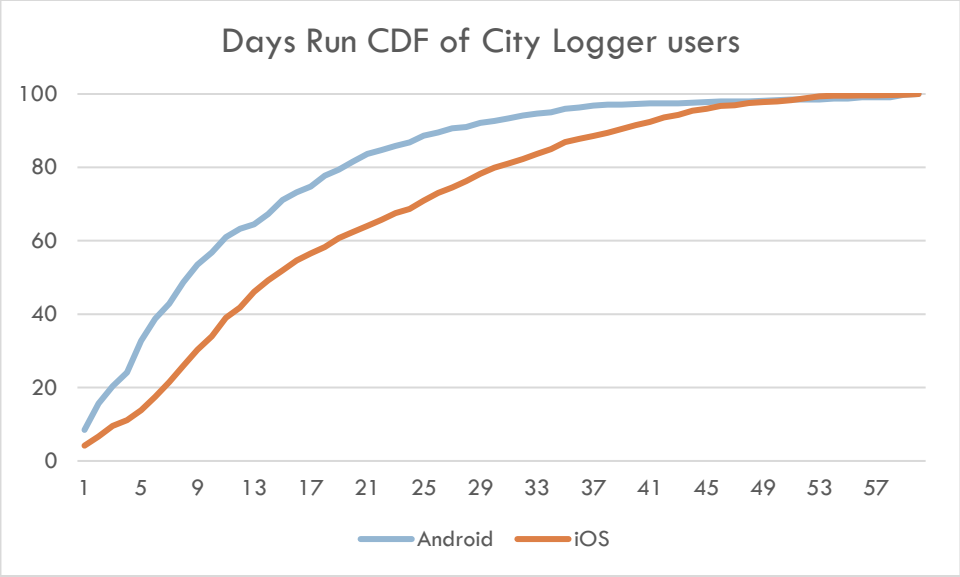

FIGURE 6 NUMBER OF DAYS RUN BY CITY LOGGER USERS

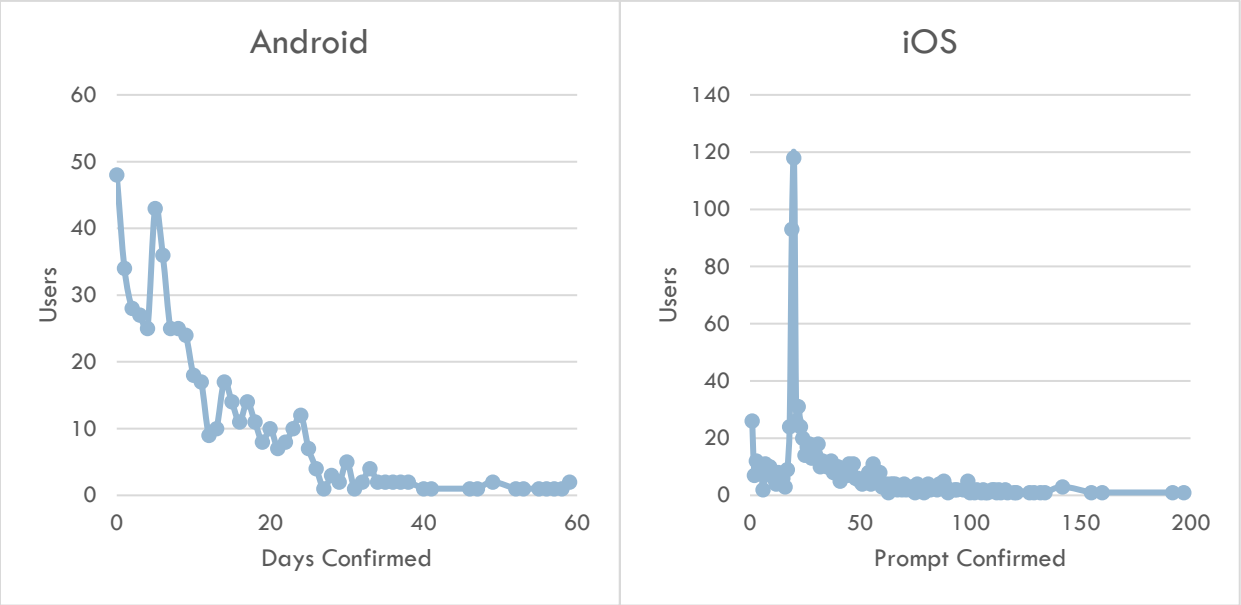

FIGURE 7 FREQUENCY OF CITY LOGGER USERS

This examination is furthered by exploring the breakdown of user retention and persistence. This involves dividing users into those that install the app but do not report any trips, those who install but run the app for only one or two days, and those that comply with the prize protocol (five days of confirmed trip for Android or 20 responded prompts for iOS) (Table 5). Overall, nearly 70% of users fulfill the prize protocol with lower compliance rates from the crowdsourced subgroup and users outside of City of Toronto. The higher percentage of crowdsourced users who only run the app for one or two days might be indicative of this subgroup either finding the survey burdensome or finding the incentives inadequate to continue keeping the app running. A higher rate of Android users install the app but do not report trips or only run the app for one or two days. This indicates that the Android

design is more complicated than the iOS design. The difference in these rates most likely comes from the "start recording" button in the Android design, in contrast with the automatic recording of trips following installation in the iOS design.

TABLE 5 COMPLETION RATE

	Overall	Android	Android TTS Email	Android Crowdsource	iOS	iOS TTS Email	iOS Crowdsource	Toronto	Not in Toronto
Installed but not reported	9.2	12.2	12.5	11.5	7.5	7.7	6.7	8.6	10.0
Installed, ran 1-2 days	8.7	14.9	14	17.1	5.4	5.1	6.7	7.5	8.5
Complied Protocol	68.9	70.1	71.4	66.4	68.2	70.2	60.8	70.1	67.2

4.2.1 Trip Rates

The information regarding trips and trip rates is summarized in Table 6. As mentioned before, trips are labeled by the type of algorithm used as Native and Tdx. Tdx is expected to report higher number of trips as it is applied after data collection in post processing using all the information recorded by the app. Further, in calculation of trip rates, it is important to not consider incomplete days. Thus, first day, last day, and any day with a big gap in reported traces are removed. Overall, City Logger users on average report about 80 trips (Native) and use the app for 16 days. The average trip rate is 5.1 trips per day (Native) or 5.6 trips per day (Tdx). It is interesting to note that the trip rates for TTS 2016 is 2.26 indicating that the smartphone apps reported significantly higher trip rates.

iOS version users report higher trip rates. Assuming there is no inherent difference in travel behavior between Android and iOS smartphone users, this difference in trip rate comes from the different design of the two versions of the app. Specifically, since users validated more than 90% of their trips on Android but only responded to about one third of prompts on iOS, this means there is a higher chance that users merged legs to one trip or deleted wrong trips on Android. Different legs of one trip might be reported as several trips on iOS. It must be noted that in the cleaning process, the Tdx algorithm automatically tries to detect such mistakes but still there might be trips mistakenly reported by the app without a confirmation from the users. The crowdsourced group of users kept the app running slightly more than other users. Interestingly, the trip rate of the crowdsourced group is lower than the email list group, indicating that users who hear about the app from crowdsourced approaches might have different travel behavior.

TABLE 6 TRIP RATES

		Users	Minimum	Maximum	Median	Mean	SD
Total							
	Days	1550	1	61	13	16.4	12.9
Native	Trips	1550	1	599	59	82.8	76.5
	Trips, incomplete days removed	1368	1	591	56	79.9	73.9
	Trip rate	1550	1	16	4.59	4.7	1.9
	Trip rate, incomplete days removed	1368	1	22	5.00	5.1	2.0
Tdx	Trips	1574	1	703	72	98.5	89.8
	Trips, incomplete days removed	1361	1	576	46	66.7	64.6
	Trip rate	1574	1	16	5.24	5.4	2.1
	Trip rate, incomplete days removed	1361	1	16	5.25	5.6	2.1
Android							
	Days	544	1	60	9	12.3	11.2
	Days Confirmed	544	1	59	8	11.1	10.9
	Days Not Confirmed	544	0	32	1	1.2	2.2
Native	Trips	544	1	569	35	57.7	67.0
	Trips, incomplete days removed	429	1	405	27	47.1	56.6
	Trip rate	544	1	13	4.00	4.24	2.0
	Trip rate, incomplete days removed	429	1	15	4.25	4.58	2.1
Tdx	Trips	561	1	703	41	67.4	79.6
	Trips, incomplete days removed	434	1	506	31	52.8	65.0
	Trip rate	561	1	13	4.75	4.99	2.4
	Trip rate, incomplete days removed	434	1	14	5.00	5.25	2.4
iOS							
	Days	1006	1	61	15	18.7	13.3
	Prompts Responded	1006	1	197	24	34.3	26.9
	Prompts Ignored	1006	1	518	43.5	64.3	63.3
Native	Trips	1006	1	599	75	96.4	77.8
	Trips, incomplete days removed	939	1	591	72	94.8	76.0
	Trip rate	1006	1	16	4.88	5.01	1.8
	Trip rate, incomplete days removed	939	1	22	5.14	5.40	1.9
Tdx	Trips	1013	1	698	94	115.8	90.6
	Trips, incomplete days removed	927	1	576	55	73.2	63.4
	Trip rate	1013	1	16	5.50	5.70	1.9
	Trip rate, incomplete days removed	927	1	16	5.40	5.71	2.0
Crowdsourced							
	Days	359	1	60	12	17.0	14.9
Native	Trips	359	1	569	56	81.7	83.0
	Trips, incomplete days removed	305	1	405	56	79.8	76.2
	Trip rate	359	1	15	4.40	4.52	1.9
	Trip rate, incomplete days removed	305	1	15	4.75	4.86	1.9
Tdx	Trips	361	1	703	64	98.4	98.9
	Trips, incomplete days removed	300	1	506	50	74.3	77.5
	Trip rate	361	1	14	5.10	5.27	2.1

	Trip rate, incomplete days removed	300	1	15	5.08	5.40	2.1
TTS email list							
	Days	1191	1	61	13	16.3	12.3
Native	Trips	1191	1	599	59	83.2	74.4
	Trips, incomplete days removed	1063	1	591	55	79.9	73.3
	Trip rate	1191	1	16	4.64	4.80	1.9
	Trip rate, incomplete days removed	1063	1	22	5.00	5.22	2.0
Tdx	Trips	1213	1	698	73	98.6	87.0
	Trips, incomplete days removed	1061	1	576	46	64.6	60.3
	Trip rate	1213	1	16	5.30	5.50	2.1
	Trip rate, incomplete days removed	1061	1	16	5.31	5.61	2.1

To further investigate the influence of the app design, recruitment method and age on the number of day runs and trip rate reported by City Logger users, a three-way ANOVA analysis was conducted. Thus, the dependent variables in the ANOVA analysis are the trip rate (Tdx to be consistent between the two app) and the number of day runs. Independent variables are operating system (iOS and Android), recruitment method (Crowdsourced and TTS email list), and age groups. Table 7 presents the results of ANOVA analysis for number of day runs and trip rates.

The following observations can be made from the ANOVA analysis. First, the design approach (operating system), i.e. the real-time prompt or travel diary validation, has statistically significant impact on both number of day runs and trip rate. Second, the recruitment method does not have any significant effect on either the number of day runs or the trip rate. Age group has statistically significant impact on both dependent variables, as expected. There are no significant interaction effects except for the joint effect of the three independent variables- operating system, recruitment method, and age- on the number of day runs. Overall, the analysis shows that even after controlling for the impact of users' age, trip rates and days of run are statistically influenced by the differences of the two apps employed and their design approaches (real-time prompt vs travel diary validation).

TABLE 7 THREE-WAY ANOVA ANALYSIS

	DAYS OF RUN				**TRIP RATES (TDX)**			
VARIABLE	**SS**	**F**	**P-value**	**Sig**	**SS**	**F**	**P-value**	**Sig**
OS	3944.7	25.0	0.000	**yes**	45.6	10.6	0.001	**yes**
RECRUITMENT	26.0	0.2	0.685	no	1.5	0.3	0.555	no
AGE	5822.1	5.3	0.000	**yes**	115.3	3.8	0.000	**yes**
OS * RECRUITMENT	539.1	3.4	0.065	no	0.3	0.1	0.792	no
OS * AGE	1701.6	1.8	0.096	no	40.4	1.6	0.154	no
RECRUITMENT * AGE	1820.6	1.7	0.117	no	20.8	0.7	0.681	no
OS * RECRUITMENT * AGE	2643.5	2.8	0.010	**yes**	20.9	0.8	0.562	no
ERROR	243366.7				6645.9			
TOTAL	735977.0				53765.3			

Trip Mode and Purpose

The City Logger Android version automatically identifies the travel mode for every leg of a trip. Users then have the option to confirm or edit the mode in the travel diary. In contrast, the iOS version asks about the mode and purpose of the trip in the prompts presented when a trip end is detected. Since the iOS version mode is specified at the trip level, while the Android version's mode is specified at the trip leg level, the mode alternatives presented are slightly different between the two apps. They were, however, designed in a way to allow them to be aggregated to an acceptable set of common modes. The Android version did not, however, report the trip purpose.

Overall, there were nearly 66,000 trips collected with mode information. Table 8 presents a summary of mode share for all users, as well as groups by operating system type and recruitment method. Overall, the car mode has the highest share of the trips, which agrees with the overall mode share in the region. The transit mode share is about 13.4% which is close to the observed share in 2016 TTS. The walk mode share, however, is significantly higher than the typical reported share in the region. The reason for this big difference is that the trips from the smartphone survey include all the trips made by users, even very short walk trips. On the other hand, in typical travel surveys, short walk trips are not collected or usually omitted. The mode share between the Android and iOS version is also significantly different. One possible reason is the missing mode information from ignored prompts in the iOS version. Further, there is a clear difference between the mode share of crowdsourced and TTS email users. The crowdsourced users have lower car mode share, and higher transit and active modes of travel. Overall, the results indicate that the crowdsourced group has a significantly different travel behavior than the email list group or the TTS-based expected observed behavior in the region.

TABLE 8 MODE SHARE

Mode	Frequency	Share						
	Total	Total	Android	iOS	Crowdsource	TTS Email	TTS 2016	TTS 2016 Online
Car	33945	51.5	42.0	61.2	31.8	58.4	76.9	75.0
Car + Transit	743	1.1	2.2	0.0	1.8	0.8	12.3	13.3
Transit	8833	13.4	11.4	15.4	18.9	11.7		
Bicycle	3726	5.7	7.7	3.5	11.5	3.4	1.4	1.7
Walk	17856	27.1	35.5	18.5	34.6	24.5	6.6	7.4
Intercity	483	0.7	1.1	0.4	1.0	0.6	2.8	2.8
Motorcycle	282	0.4	0.1	0.7	0.2	0.5		
Other	60	0.1	0.0	0.2	0.1	0.1		
Total	65930	100	100	100	100	100	100	100

Trip purpose was only reported for the responded prompts in the iOS version. Table 9 presents the trip purposes for iOS version users in total and by recruitment method; the purposes from TTS 2016 are presented as a benchmark. Overall, trip purposes are similar for the two groups of users by recruitment type. Shopping and other trips are significantly higher in City Logger than the TTS 2016 data. The comparison indicates that the TTS data under-reports shopping and other trips. The lower

share of home trips also indicates that these under-reported trips are most likely done as stops within trip tours.

TABLE 9 TRIP PUTPOSE - iOS VERSION

iOS	Frequency	Percentage	Crowdsource	TTS Email	TTS 2016	TTS 2016 online
Home	9736	29.9	30.3	29.8	42.4	42.5
Shopping and errands	8217	25.2	24.3	25.5	8.8	8.3
Work / Work-related	7726	23.7	23.2	23.9	21.7	23.5
School / Education	863	2.7	3.0	2.5	6.1	6
Pick someone up	289	0.9	0.9	0.9	7.7	7.8
Drop someone off	212	0.7	0.5	0.7		
Recreation, sports, leisure, arts	1637	5.0	5.0	5.0	13.3	11.9
Restaurant, bar, coffee shop	1495	4.6	4.9	4.5		
Visiting friends or family	1078	3.3	3.4	3.3		
Health and personal care	758	2.3	2.6	2.3		
Services	218	0.7	0.8	0.6		
Worship, religion	117	0.4	0.4	0.4		
Other	209	0.6	0.7	0.6		
Total	32555	100	100	100		

4.3 Comparing City Logger with a Web Survey

In the TTS2.0 project, a web-based household travel survey, conducted using the TRAISI platform, was also conducted at the same time of the City Logger project (Chung, Srikukenthiran, Habib, & Miller, 2018). The participants of the web survey were also from the pool of individuals who completed the 2016 TTS and expressed willingness to participate in further data collection efforts. This section presents a comparison between the main characteristics of the data collected from the two different method: smartphone app and the web survey. It must be noted that there were two version of the web survey with the differences only in the detail collected concerning trip routes; the first collected routes for all trips while the second collected routes only for transit trips.

Table 10 presents a comparison of the main socio-demographic characteristics of participants in the smartphone and web surveys, as well as their trip rates. CityLogger users compared to web participants are more heavily young females coming from larger households. The web survey was a household travel survey, and therefore has a higher burden for larger households. The lower size of the household in the web survey might be due to this fact. City Logger users report higher household income compared to the web survey. Further, the share of participants who declined to answer the income question is higher in the smartphone survey. This shows that there might still be privacy concerns regarding the smartphone survey compared to a web survey. A comparison of the City Logger TTS email group with the web survey participants (as both groups were drawn from same pool of email addresses) indicate a significant difference in socio-demographic attributes of participants. Further, as expected, the smartphone trip rates are significantly higher than trip rates reported via the web survey.

TABLE 10 SMARTPHONE AND WEB SURVEY COMPARISON

	Smartphone Survey			Web Survey	
Variable	Total	Crowdsource	TTS Email	routes for all trips	routes only for transit
Female	39.6	35.2	40.9	52.0	47.0
Age	44.39	42.73	44.88	49.21	50.82
HH Size	2.55	2.55	2.55	2.14	2.11
HH Income					
$0 to $14999	1.9	2.6	1.7	2.0	1.0
$15000 to $39999	5.5	6.9	5.1	7.0	9.0
$40000 to $59999	6.7	8.5	6.2	11.0	12.0
$60000 to $99999	21.3	19.0	22.0	26.0	24.0
$100000 to $124999	14.0	13.4	14.2	16.0	16.0
$125000 and above	34.4	33.7	34.6	23.0	28.0
Decline / don't know	16.1	15.9	16.2	15.0	11.0
Trip Rates					
Native	5.1	4.9	5.2	2.9	3.0
Tdx	5.6	5.4	5.6		

5 CONCLUSIONS

In the Fall of 2017, this City Logger project tested on a large scale the potential of location-logging smartphone apps to better understand what role they may play within a broader portfolio of data collection instruments. Two different designs for the app, namely real-time prompt and travel diary, were selected based on the lessons learned from the 2016 pilot study, where the technical potential of the apps was explored. The goals of the City Logger project were to assess the travel data produced by smartphone apps in a large-scale real-world field test, to better understand recruitment avenues, and examine differences in the travel behaviour of respondents reached through crowdsourcing methods. In addition, there was a desire to validate earlier findings regarding differences between reported and passively inferred travel behavior, and compare (demographics and trip rates?) TTS2 web survey, TTS2016 and City Logger app respondents. The City Logger involved recruiting individuals from both the TTS 2016 list of respondents who agreed to participate in the further studies, as well as a broader recruitment effort where social media, traditional media, targeted advertising and in-person (event) recruitment were put to use. Incentives, in the form of raffles, were also employed.

5.1 Findings

Overall, 2041 users downloaded and installed the app, 1082 on iOS and 959 on Android. However, only 1550 users completed the initial survey and made at least one trip. These participants were recruited through crowdsourcing avenues as well as email invitation to a group of 2016 TTS respondents. The overall click-through and response rates for email invitations were 20.6% and 7.4%-10.9%, respectively, indicating that a significant group of individuals who received the email and clicked the link actually followed through on installation. The crowdsourcing campaign also provided a reasonable number of users given the budget, and available resources and time, resulting in 389 participants by the end of project, relative to an initial anticipated target of 500 responses.

Users recruited from crowdsource avenues are significantly different than the email invitation group and the observed population in the 2016 TTS. Specifically, the crowdsourced users are more heavily male and younger individuals. The proportion of students is higher, and the number of fulltime workers is lower in the crowdsourced group. Crowdsourced users have fewer driver licenses and vehicles, and a higher chance to use a ride-hailing app or be enrolled in a shared mobility service program. Also, this group of users are more likely located in Toronto and in households with lower income compared to the email invited users. They also have lower completion rates and report lower trip rates, while being more likely to travel using sustainable modes of transport.

The comparison between the two different design approaches- i.e. real-time prompt and travel diary validation – provide interesting results. Overall both approaches yield an acceptable quality of data. The travel diary approach provides a higher validation rate while the real-time prompt approach, because of the lower survey burden, results in more days of run. The error in the real-time prompt approach, due to a low response rate, can be decreased for users with multiple days of data using post processing techniques; this is because a portion of the ignored prompt information can be inferred. The mode share between the Android and iOS version is also significantly different. One reason for that can be the ignored prompts in the iOS version while mode information is reported/inferred for all of the trips in the Android version.

Comparing the characteristics of smartphone users to the web-based household travel survey and TTS 2016 data, the differences are mostly in age, gender, occupation type and household income attributes. The smartphone users are younger, more heavily male individuals with professional occupations, and from larger households with higher incomes. The smartphone users are mostly from higher density parts of the GGH region. Thus, to better represent the actual population in the region, proper weighting methods should be exercised.

5.2 Lessons learned and recommendations

Overall, the City Logger project was a relative success. Both at the recruitment stage, as well as the data processing stage, lessons were learned that can help in maximizing the quantity and quality of data collected.

With respect to recruitment and crowdsourcing, comparing the City Logger experience to MtlTrajet has allowed for a better understanding of the minimum amount of resources that must be allocated in order to gain traction and successfully recruit respondents. Greater lead time must be given to allow for a campaign to build, partners to be brought on board and media outlets to organize coverage, properly timed with launches and key dates. Additional time is also needed if any advertising is to be purchased on transit vehicles or billboards. Another broader lesson is to not focus efforts too narrowly on one date or event, but aim to have multiple points at which the story can be picked up, with important milestones and cross-promotional opportunities in addition to a launch.

Having the City Logger app be released subsequent to the 2016 TTS as a pilot project, instead of an integral part of the actual data collection effort, also was a problem that limited the potential for recruitment. As faced in all field tests of the TTS 2.0 research programme, the messaging is less effective if it cannot be said that the data collected will be put to use in modeling work that will determine which infrastructure projects and policies go forward. With a public-facing recruitment effort, such as was attempted with City Logger, having explicit buy-in from government and being able to state that data would be put to use would clearly be advantageous and would increase the potential for recruitment effectiveness. Regarding the socio-demographics and travel behavior (trip rate and mode share) of participants recruited by crowdsourcing methods, the results clearly indicate that while the crowdsourcing recruitment method is promising, it might not be yet the best way to capture a true representation of population. The question of merging crowdsourced and other sample frame respondents is one of weighting and data fusion, the mechanics of which needs to be explored in future research.

Regarding app design and processing, several lessons can be highlighted. Given the experience of the City Logger project, some of the app configuration and design recommendations from the 2016 technical evaluation pilot should become requirements for future smartphone travel survey projects. The issues with the registration procedure in the Android version of the app results in loss in response rate. The multi-stage user account creation process results in a loss of hundreds of users. Further, the non-mandatory socio-demographic survey within the app results in having trips of participants without knowing their personal and household characteristics. This can be used to strongly justify the case for a single step onboarding process (user account creation and survey response). Further, the lack of any information on deleted traces, whether the user stopped the recording manually, due to low battery or lack of signals did not allow for these events to be distinguished. The absence of event records has led to hundreds or thousands of travel days that carry considerable uncertainty regarding their

completeness. An event log and a periodic recording of lower accuracy traces will increase the reliability of the trace processing feature and improve the quality of generated trip dataset.

In terms of limitations of the collected data, while the Android version of the City Logger app collected the mode of travel, it did not ask for the purpose of the trip. This resulted in daily travel diaries that lacked an important information for modeling purposes. Any future effort to collect travel information should ask for trip purpose as well as mode of travel. On the other hand, while the iOS version of the City Logger app prompted users for both mode and purpose of a trip, users could ignore the prompts. This resulted in trips collected without mode and purpose information.

A combination of the real-time and travel diary approach is recommended for future work. An ideal app would prompt users real-time and create a travel diary so users have the ability to validate, edit or delete the recorded information. The City Logger project, therefore, confirms the design recommendations of the 2016 pilot report.

The City Logger project demonstrates that with proper app and survey design, as well as a streamlined process for quality assessment and corrections, there is potential to cost-effectively collect travel dairy data using smartphone apps. The data collected, in turn, can be used to better understand the limitations of other methods of travel data collection, generate trip correction factors and carry out research regarding different travel behavior dimensions such as intra-personal travel variability.

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7 APPENDICES

7.1 City Logger RFP

(Text reproduced, not layout)

Dear colleagues,

As part of a broader initiative to modernize the Transportation Tomorrow Survey (Toronto's regional OD survey), a series of pilot tests and field experiments investigating core and satellite solutions for data collection will be conducted. One of the field tests set to begin in the coming months is an **assessment of the potential of smartphone applications for collecting resident travel data**. This is a follow-up to a pilot test conducted in 2016, where a controlled experiment assessing the strengths and weaknesses of multiple location logging smartphone apps, as well as trace processing algorithms and software, was conducted.

The **goal** of this field test is to **better understand what are cost-effective recruitment methods**, as well as appropriate messaging and user feedback mechanisms to be employed to maximize the volume and quality of smartphone data that can be collected. The simplest way to obtain realistic information on these aspects is to roll out apps that allow for randomized assignment of treatments and use these as data collection instruments, keeping track of how respondents were recruited and observing the effect of each variable or treatment on participation, retention, and quality of data.

To recruit participants for our project, **we will attempt to replicate a public roll-out**, but at a more manageable scale. Certain avenues will be explored for recruitment of individuals, including targeted ads on social media, traditional media coverage and contacting different advocacy organizations to disseminate the website URL among their membership. Next, individuals who completed the 2016 TTS and expressed willingness to participate in further data collection efforts will be sent an invitation via email. The latter group of respondents will generate travel data which we can compare with self-reported TTS 2016 travel. Raffles will be used to incentivize participation.

Our team will publicize the data collection effort and handle creation of all promotional material, as well as maintenance of a project website. Support on a technical level will be required, but any emails or other communication will initially be fielded by UTTRI/UofT project members.

Why participate: If your lab or company believes it has a great location logging app, this is the perfect opportunity to demonstrate this. Resources will also be expended to better understand the effect of certain treatments using a particular app. The field test will seek to recruit participants in a broad manner, allowing for significant data to be collected and thus put to use to improve your app and ecosystem.

Important dates: Candidate submissions to be received no later than **May 20**, selection of participants to be confirmed **June 11**. Apps need to be ready for rollout **August 1.**

Apps and processing suites can be commercial or from academe, but **the test environment will focus on real-world application**: the apps must not only be able to provide high quality data, but must be

designed in such a way as to be compatible with real-world respondents' lifestyles (i.e. battery drain cannot be excessive, nor can the app place the burden of starting and stopping location logging on respondents). To submit a bid, one need not have both an Android and iOS app.

More information: For those interested or further information, please contact Chris Harding at chris.harding@mail.utoronto.ca or Ahmadreza Faghih Imani at a.faghihimani@utoronto.ca. If the question cannot be answered by Chris or Ahmadreza, you can contact me directly.

Sincerely,
Khandker M. Nurul Habib, Ph.D.
Professor, Department of Civil Engineering
University of Toronto
Tel: 416-946-8027
E-mail: khandker.nurulhabib@utoronto.ca

Invitation to Quote for Services, TTS2 Smartphone apps

A. Background

Travel data collection apps for Android and iOS are sought - both are needed for the project, but need not come from the same research lab or company. Separate bids should be placed for Android and iOS apps, even if the materials that describe the app and bidding entity are identical.

Apps must be capable of running in the background (not require respondents manually start and stop logging at beginning and end of travel episodes), generating high quality traces without causing excessive battery drain. Apps must also make possible the collection of additional information on trips made, either in real time or periodically via validation of travel diaries.

B. Minimum Requirements

The proposed app must satisfy the following criteria:

a. Passive location logging
b. Trip and/or leg detection
c. Simple installation that does not require individual token or multi-platform account creation process
d. First-install survey (in-app) that allows branching (alternative sets of questions)
e. Easy to use interface with automatic upload of traces and trip information that privileges Wi-Fi (no upload button)
f. Real-time trip end prompts OR travel diary with simple to use validation component
    i. Must be available in-app or link to a very simple, mobile-friendly web interface if not built into app: should not require user to log on to a website on a tablet or desktop
    ii. Efficient input method for requesting mode and purpose information
g. White labelling, such that the Android and iOS apps can be referred to by the same name. App designers will be recognized in Play/App store description, project web page and in-app 'About' section. The requirement is merely placed to simplify communications and avoid any confusion.

This particular requirement can *potentially* be disregarded if the same company or team submits the chosen bids for both Android and iOS.

B.1. App A – Android App

Must be compatible Android OS 4.4 and up

B.2. App B –iOS App

Must be compatible on iPhone 5 and above

C. Desired or Optional Requirements

a. Option for user to consult travel information collected and correct at a later date if errors are found (travel diary feature for apps that request trip information in real time)

b. Pop-ups for clarification of definitions for mode, purpose or other questions and response alternatives – if deemed a valuable addition
c. Validation-specific:
    i. Mode and purpose suggestions, to speed up validation
    ii. In the case of an app with real-time trip end prompts: capability of disabling trip end prompts after X responses have been given (to allow for longer duration survey with lower burden)
    iii. In the case of an app with travel diaries and validation within that format: capability of sending daily reminders to users to fill out their day's diary until X number have been submitted (to allow for longer duration survey with lower burden)
    iv. Possibility to merge trips or legs incorrectly inferred as being separate
    v. Possibility to divide legs or trips incorrectly inferred as one
d. Option to invite participants for a follow-up survey after validation requirements are complete (in-app or via email)
e. Option to invite other household members that enables linking of household level data (in-app or web)
f. 'Lagged' features, i.e. features that are desired, but MUST ONLY be made available to respondents AFTER validation information has been received for a given amount of days (if using travel diaries for validation) or a given amount of trips (if using real-time prompts to collect mode and purpose information) - these cannot be presented to users beforehand, as they would promote a change in travel behavior:
    i. Badges or other rewards that appear for 'greener' modes of transportation (walking, cycling, transit)
    ii. Feedback provided in terms of GHG emissions, trip/distance mode split, etc.

D. Delivery Requirements

a. Must make a current version of the app available to the survey team at time of bid. Language, not a concern initially, but must be translated to English by launch.
b. At end of project, must deliver data in database format or series of csv/json files with unique IDs for users, days, trips and/or legs. Raw or processed/filtered location points will also need to be delivered, not uniquely trip tables.
c. An admin portal, or equivalent, is required such that a UofT staff member can monitor the incoming stream of data and flag problems should they occur
d. Legs/trips shapefile or equivalent format nice to have, but not a requirement.

E. Warranty and Post-Installation Service

Respondent support will be taken care of by University of Toronto staff, but technical issues, should they arise, will be required to be addressed within 1 business day during the data collection period. UofT staff will review any incoming emails or communications and only relay issues if they are of a technical nature.

F. Timelines

Project is on tight timeline: must be ready to roll-out, with modifications, by August 1, 2017.

Quotes will be evaluated May 20 to June 11, with June 12 to July 31 for modifications and any testing required.

The TTS 2.0 team are to be provided a means by which to access and test 'roll-out ready' app(s) by July 10, so as to find bugs or look for any issues that may exist in the functioning of the app or wording of any of the prompts or questionnaires.

Data collection will begin August 1 and run to September 30, 2017.

Raw location traces and user IDs must be delivered within 14 days of the close of data collection – October 14, 2017. Processed data (trips and/or legs) must be delivered within 31 days of the close of data collection – October 31, 2017.

G. Ownership and Security

The project can be referred to by the winning bidder in promotional materials and collaboration on analysis of the data, as well as joint publications, will be encouraged. The data collected will remain property of UofT, however, and is to be stored after October 31, 2017, on servers at the Data Management Group (DMG) at University of Toronto. The developer must delete all the collected respondent and location data upon delivery of the data to the DMG at University of Toronto.

H. Payment Terms

The University's payment terms will be payable to 50% after the app(s) have been installed, tested and accepted by the University's authorized designate from the Department. The remaining 50% will be paid upon delivery of the collected data.

Also, the University's standard payment terms are net thirty-five (35) days which means that payments will be issued thirty-five (35) days from the date of each invoice.

Material Disclosure

Due to budgetary constraint, one or more app(s) may not be pursued if the total price of all items exceeds the available total budget.

Evaluation

Bids will be evaluated based on prior experience and qualification of applicant, compliance with minimum requirements, presence of additional or optional requirements, proposed warranty and post-installation service, and finally pricing.

Apps having been previously rolled out to a large number of users (e.g., not only a handful of research assistants or students in a pilot study) will be given preference.

In order to assist the University in its evaluation, **it is strongly recommended that proponents submit separate proposals for each app**.

How to submit a Quote

If you wish to have your app(s) considered for the TTS 2.0 smartphone app field test, please send the following to *Chris Harding* at chris.harding@mail.utoronto.ca or *Ahmadreza Faghih Imani* at a.faghihimani@utoronto.ca.

1) Contact information
- Name
- Title
- Organization
- Telephone number
- Email

2) Product description

- List of project-related conference, journal or white papers published, with the most relevant highlighted
- Link to your app/company/lab's website
- Download link for your app
- Short description of the largest rollout of your app
    - The number of users who ran the app, as well as the number of person-days of travel for which data were collected and, if available, the number of trips identified.
- List of requirements (sections B, C, and D above) that can be met
- List of requirements (sections B, C, and D above) that cannot be met

3) Quote

- Indicate bid for modification to, and use of, your app, for the period of data collection (August 1 to September 30)
    - Includes app modifications, technical support, data processing and delivery of final data product

7.2 Questionnaire

The following table is the list of questions and response alternatives for the app initial survey.

Question item	**Question?** *[type]*	**Response alternatives/type**	**Conditionals/ Notes**
Age	What is your **age**? *[numerical entry]*	0-125	
Gender	What is your **gender**? *[radio buttons]*	Male Female Non-binary/ third gender Prefer not to say	
Hear about app	How did you **hear about [appName]**? *[radio button, with Other triggering a text entry]*	TTS 2016 opt in Household member invited me within app Advocacy organization (email) Media (eg. Star, Sun, Metro) Friend / Family (in person or online) Advertisement on Social Media Blog Other (specify)	If TTS 2016 opt-in, the next screen shown should be a short apology message saying that while information was collected for the TTS, a few similar questions will need to be asked again in case conditions changed. 'Household member invited me within app' only asked in iOS.
Household code	What is the **code** provided for your household?	text entry, with check against a database.	Only applicable for iOS. **Once code is validated, trigger skipping household questions**
Home location	Please indicate the **location of your home (primary residence).** *[map/text input]*	Pin drop with map or validated address entry/valid 6 character postal code	Android
Dwelling type	What **type of dwelling** do you live in? *[radio buttons]*	House Apartment Townhouse	

		Other I don't know	
Tenancy	Do you **own or rent** your home? *[radio buttons]*	Own Rent	
Landline	Does your household have a **home phone line**? *(i.e. land line)* *[radio buttons]*	Yes No Don't know	
Student status	Are you currently attending **school**? *[radio buttons]*	Not a student Full-time student Part-time student	Only ask if respondent is over 13 – assumption being they have to be attending if younger
School location	Please indicate the **location of your school.** *[map/text input and alternative radio button for 'N/A']*	Pin drop with map or validated address entry/valid 6 character postal code Not applicable (distance learner)	Only ask if person is a full or part time student Android Only.
Employment status	What is your **employment status**? *[radio buttons]*	Full-time worker Part-time worker Not Employed Retiree Homemaker	
Occupation type	How would you **characterize your occupation**? *[radio buttons]*	General Office/Clerical Manufacturing/Construction/Trades Professional/Management/Technical Retail Sales and Service	Only ask if person is employed full or part time
Free parking	Is there **free parking** at your usual place of work? *[radio buttons]*	Yes No No usual place of work	Only ask if person is employed full or part time
Habitual work location	Please indicate the **location of your usual place of work.** *[map/text input and alternative radio button for 'No usual place of work']*	Pin drop with map or validated address entry/valid 6 character postal code No usual place of work	Only ask if person is employed full or part time Android Only.
Frequency telecommute	How many **days per week** do you typically **work from home** *instead* of travelling to the office or work site? *[numeric entry OR likert-type button layout]*	0-7	Only ask if person is employed full or part time
Driver's license status	Do you have a **full driver's license**?	Yes No	Hide if person age<16

	This can be a G, G2 or unrestricted license issued outside Ontario, but NOT a G1 *[radio buttons]*		
Shared mobility	Are you or another member of your household members of a **carshare** (*ZipCar, Enterprise Carshare, Car2Go*) or **bikeshare** (*Toronto BikeShare, Hamilton SoBi, Dropbike*) program? *(check all that apply)* *[checkbox]*	Carshare member (personally) Carshare member (other household member) Bikeshare member (personally) Bikeshare member (other household member) None of the above	Hide (personally) alternatives if person age<16
Ridehailing	Do you have a **ride hailing** app installed on your smartphone? (**UBER**) *[radio buttons]*	Yes No	While not supposed to exist on the phone of a minor, entirely possible a parent installed for them
Ownership of a monthly transit pass	Do you currently have a MONTHLY or ANNUAL **transit pass**? (check all that apply) *Do NOT take Presto*, tickets or weekly passes into account.* *Can be TTC, GO, VIVA, MiWay, etc.* *[checkbox]*	GO Transit Pass Metropass (monthly local transit pass) Combination or Dual Pass Other Agency Pass Do not own transit pass	Hide if person age<11
Presto owner	Do you own a **Presto** card?	Yes, with fares loaded or autofill Yes, but with no fares loaded or autofill No	
Nb hh members	**How many people** live in your household? (**including yourself**)	0-15	
Nb children	How many **children** younger than 16 live in your household? [present an '(including yourself), if the respondent is under 16']	0-15	Hide if HH size =1
Nb FT workers	How many **full-time workers** live in your household? (including yourself)	0-15	Hide if HH size =1
Nb PT workers	How many **part-time workers** live in your household? (including yourself)	0-15	Hide if HH size =1
Nb members with full license	How many people in your household have a **G2 (or equivalent)** driver's license? *(do not include G1 or learner's permit)*	0-15	Hide if HH size =1

Nb hh vehicles	How many **vehicles** does your household have available for personal use?	0-15	
Household income	What is your **household income**? *(**not** mandatory)* *[radio buttons]*	$0 to $14,999 $15,000 to $39,999 $40,000 to $59,999 $60,000 to $99,999 $100,000 to $124,999 $125,000 and above I decline to answer/ I don't know	
raffle email	If you would like to be entered into our monthly raffle for 100$, please enter a valid email address:	Text field, non-mandatory	
Invite hh others	Finally, do you think another member of your household might be interested in contributing to the [appName] project? If so, we will give you a survey code to link your responses and unlock a shortened version of the survey. We can also email you the code.	Yes, show me the code Yes, show and email the code *[triggers request for email address for the invitation IF email address above is blank]* No thanks	Only show if HHsize>1

The following table presents the response alternatives for the purpose and mode prompts of iOS version of the app.

Purpose **Choose main purpose at destination*	**Modes** * *Check all that apply to the current trip*	**2nd level modes**
Home	**Walk (entire trip)**	
Work / Work-related	**Bicycle**	
School / Education	**Transit**	
Shopping and errands	**Car (private, shared, taxi)** *(nesting)*	Driver, alone
Restaurant, bar, coffee shop		Driver, with passenger
Services		Passenger in private car
Health and personal care		Motorcycle, moped, scooter
Visiting friends or family		Uber
Recreation, sports, leisure, arts		Taxi
Worship, religion	**Intercity (coach, train, plane)**	
Drop someone off	**Other**	Ferry
Pick someone up		Rollerblade
Other		Skateboard/Longboard
		Motorcycle, moped, scooter
		Other

7.3 Crowdsource campaign

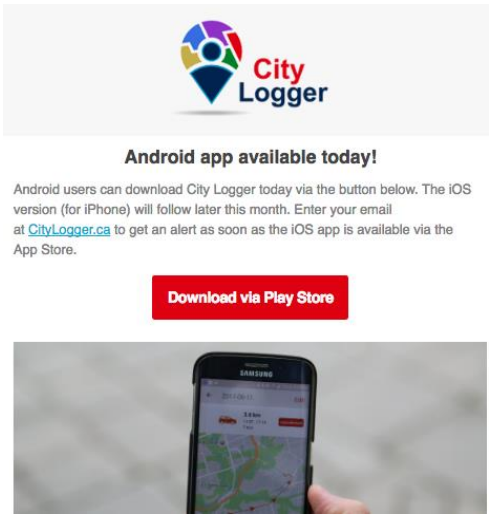
The City Logger campaign consisted of three phases: preparation (4 weeks), execution (2 weeks) and follow up (2 weeks). Overall, given the resources, the team put forward a solid media campaign. Of course, there are areas to improve for future outreach and those insights are detailed throughout this appendix.

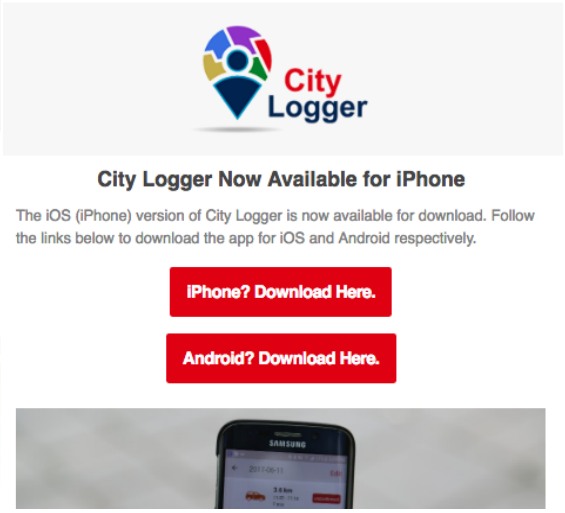
There were a few key limitations that may have impacted outreach success including building stakeholder and media contact lists from scratch; budgetary limits; time allotted to build relationships with sponsors and mostly with municipalities; graphics and design resourcing. The cities targeted would have been ideal to get on side to help promote and act as partners in promotion, however, these relationships take several months to build and I think given our timeline and budget, the sponsorship partners and media placements that were secured put a good foot forward.

7.3.1 Content and Design

It is important that in future campaign, a dedicated graphic and content design resource would be considered to create even more consistency and professionalism to the campaign. The followings are the sample of items created for the project.

Content Executed	Worth Noting
"About" video	The video is used on City Logger website. LINK: https://www.youtube.com/watch?v=99QXeSmH8K4
"How to" video	Two separate videos were created for how to use the app in iOS and Android. iOS: https://www.youtube.com/watch?v=B3l85sQbgfU Android: https://www.youtube.com/watch?v=5f_Am43c2kI
Press Release City Logger FOR IMMEDIATE RELEASE **University of Toronto Researchers Launch App to Improve Regional Transportation**	The Press Release was to act as a support to the main media relations effort, the targeted media pitching. As the University of Toronto does not do routine press releases over PR wires (the cost is thousands of dollars), a list independently was created. Ultimately, the targeted pitching resulted in the majority of the media pickup.
Newsletters:	

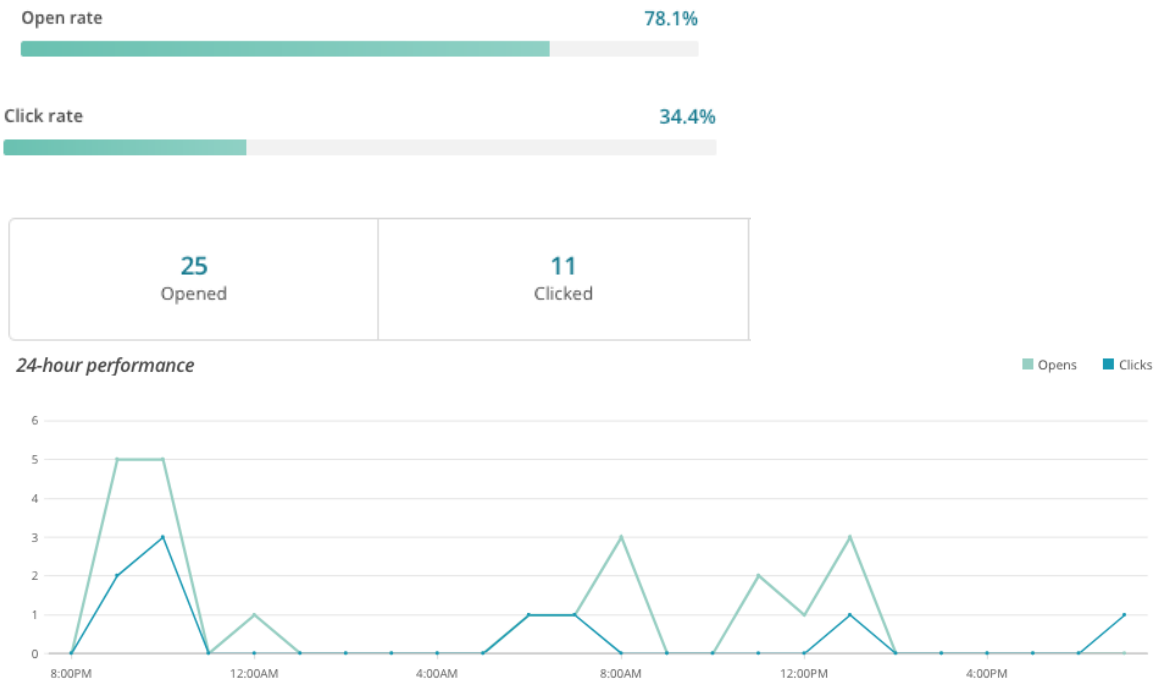




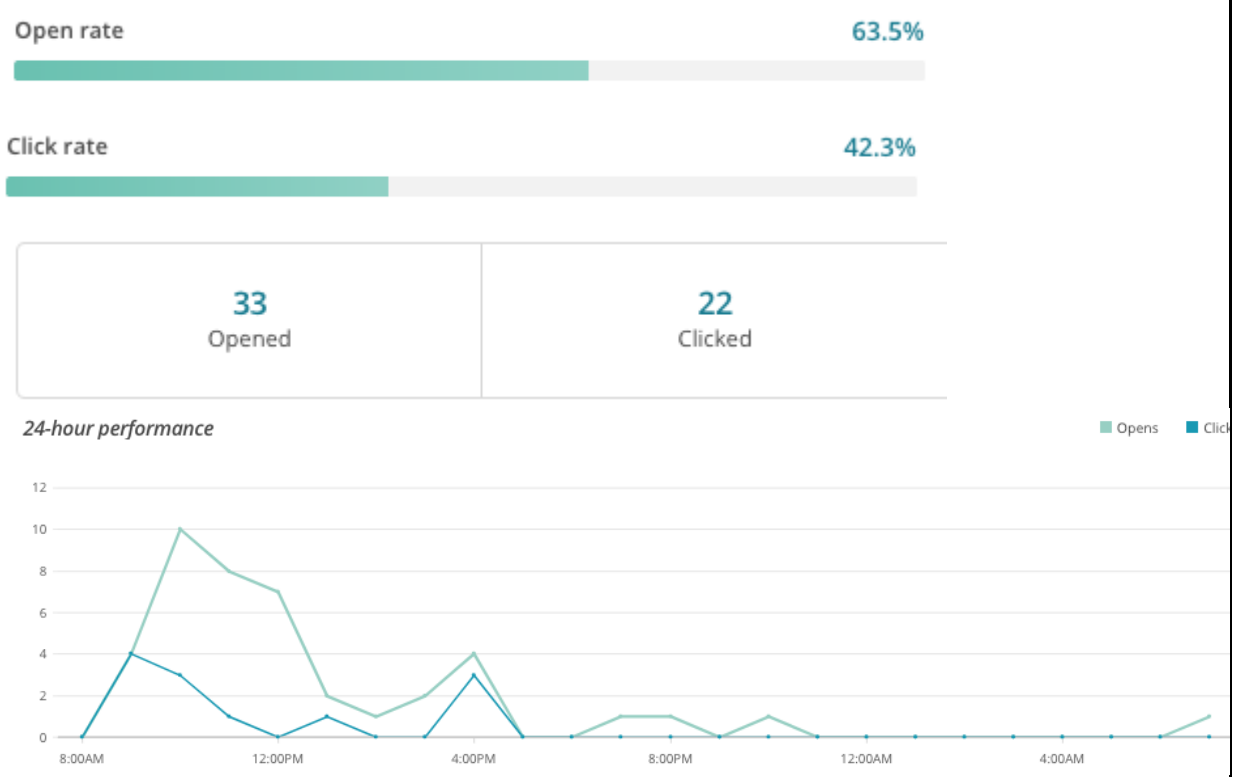
The newsletters were created for a few reasons:

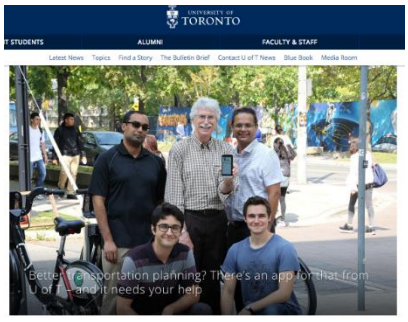
1. To reach out to those who wanted to be notified when the app was ready, and;
2. To reach out to advocacy groups and interested parties with something they could share with their networks via email.

Android mailout results:

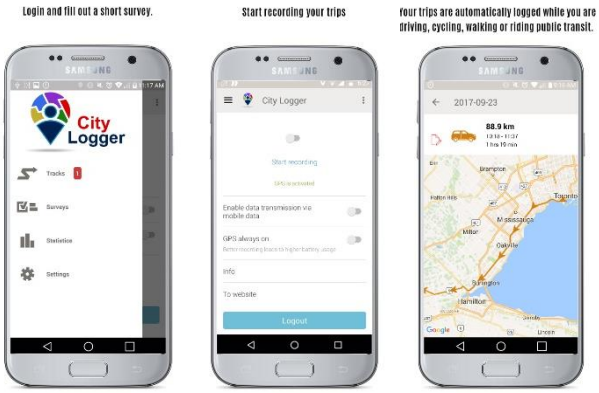


iPhone mailout results:



U of T News Article by Tyler Irving 	This piece of content was quite successful as both a tool to use in pitching to advocacy groups and media as well as getting social media traction as much as possible prior to the launch. Many referrals in the pre-launch days of the campaign were from this article and it remained one of the top tweeted and shared pieces aside from mainstream media.
Flyer 	The flyer was created as a tangible item we could hand out to engage citizens on the launch date at Sheppard West station. Less geared toward downloads and more toward awareness building, approximately 450 flyers were handed out on the morning of October 2, 2017. It is recommended that this be a QR code in future with budget, recruiters could get people to download the app on the spot. Also having something free right there (food, giveaways that are small) might help.

Play Store page	The download page at Android Play Store and iOS App Store is designed with proper images to better attract users.



7.3.2 Media Campaign & Promotional partners

Given that this is a specific interest / "beat" story (transportation), the widespread coverage of this story can be considered as a success. It's possible that we could have had a bit more pickup on October 3rd and 4th with CTV and CP24 on their broadcasts, but two factors contributed to a lost opportunity:

1. Primarily the two terror attacks (Las Vegas terrorist attack and the Edmonton terror attacks) being the lead story for several days.
2. The iOS version of the app not being launched just yet.

The first item really impacted our opportunities on broadcast networks because networks fill their news hour with several angles of a key story, such as a terrorist attack. There is thus not much room to pivot easily to another topic, even if a producer thinks you have an important story. Nothing can really prevent news stories from happening, but given circumstances, we still got significant coverage with media.

Transportation as a topic is not likely to be a top billed story unless the government is adding or taking away funding. Or if there's a large infrastructure announcement that is particularly timely. In City Logger's case, the main opportunity was getting media coverage within the first few days of the launch. Despite the fact that the campaign continued on until November, journalists were less likely to care the more that time goes on because the story was no longer new from their perspective. Exceptions, of course, are niche outlets or current affairs offerings such as Spacing or TVO. Still, question remains on to what extent media coverage is the most useful tool in getting downloads for such an initiative in future. Media helps generate word of mouth, but word of mouth isn't the final stop of what City Logger needed. We needed a changed behaviour, we needed to ask our audience to do something.

The message, in this case, is most powerful when it comes from a friend, family member or colleague. This might explain why more niche publication coverage (The Agenda for policy issues and Transit blogs for transportation issues) generated more traffic for City Logger. In future, I would recommend

that media still be in the mix, but that a longer timeline and bigger government and private partnerships be forged to add budget for outreach and relationship development before the launch date. The following is a list of media coverage of City Logger project. In future, some type of media monitoring tools should be used to track these items in greater detail for longer campaigns.

Placements	Date	Analysis
Start up Here Toronto	September 20, 2017	Shared U of T Engineering news story (republish)
Toronto Transit Blog	September 28, 2017	Toronto Transit Blog was an early interested party and helped by sharing the link to their story about City Logger and telling their followers about us.
Times Colonist Global News National Post Toronto Star Hamilton Spectator Toronto Sun Toronto Star CTV CBC Humbolt Journal	October 2, 2017 **Launch Week Reach estimate: (2.14m)**	*Canadian Press wire piece also appeared in:* 570 News (Online), Brandon Sun (Online), Sudbury (Online), Bay Today (North Bay) (Online), CP24 (Online), Metro News (Online), News 1130 (Online), 660 News (Online), The Daily Courier (Online), Penticton Herald (Online), 680 News (Online), Inside Halton (Online), Inside Toronto.com (Online), Sachem (Online), Hamilton News (Online) iPhone in Canada Blog (Online) Perhaps reach was expanded as the Toronto Star article reached the widest audience and got pickup from Toronto Mayor John Tory: 

AM640	October 3, 2017	The morning show with Stafford & Supriya interviewed Chris Harding about the City Logger project.
Radio Canada	October 2, 2017	The coverage from Transit Wire, CUTA, and Toronto Transit Blog also reached wider audiences by being shared through newsletter or RSS feed updates.
Transit Wire	October 3, 2017	
CUTA Blog	October 18, 2017	
The Varsity	October 22, 2017	
The Agenda (TVO)	October 25, 2017	The Agenda gets a broadcast viewership of approximately 125,000 viewers, but also reaches viewers on periscope through live streaming on twitter and Facebook and posts to a unique video player as well as YouTube. YouTube hits are more than 800, nearly 1400 views of The Agenda's Facebook teaser clips alone. It is estimated that at least 150,000 reached with this interview, perhaps more given that Steve Paikin & The Agenda tweeted about the program: 
Ryersonian	November 3, 2017	A short interview with Chris Harding, the program is produced by Ryerson school of journalism

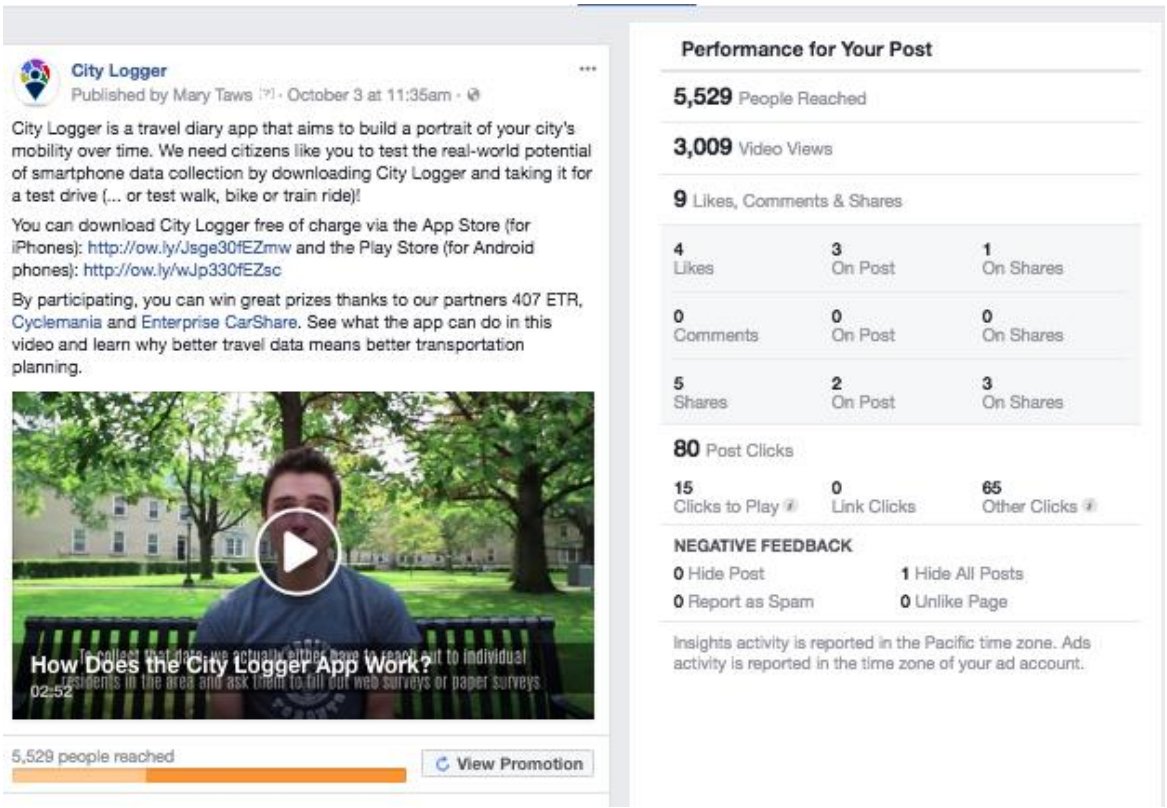
As part of crowdsource campaign, a sponsorship outreach plan within the first preparation week is developed. The types of prizes were chosen based on the previous initiatives (StudentMoveTO and MTLTrajet) and considering a range of organizations to cover interests of those who walk, bike, drive or use transit. These conversations were not one exchange but many phone conversations back and forth with various team members to secure sponsorship. Some other outreach items were a dead end,

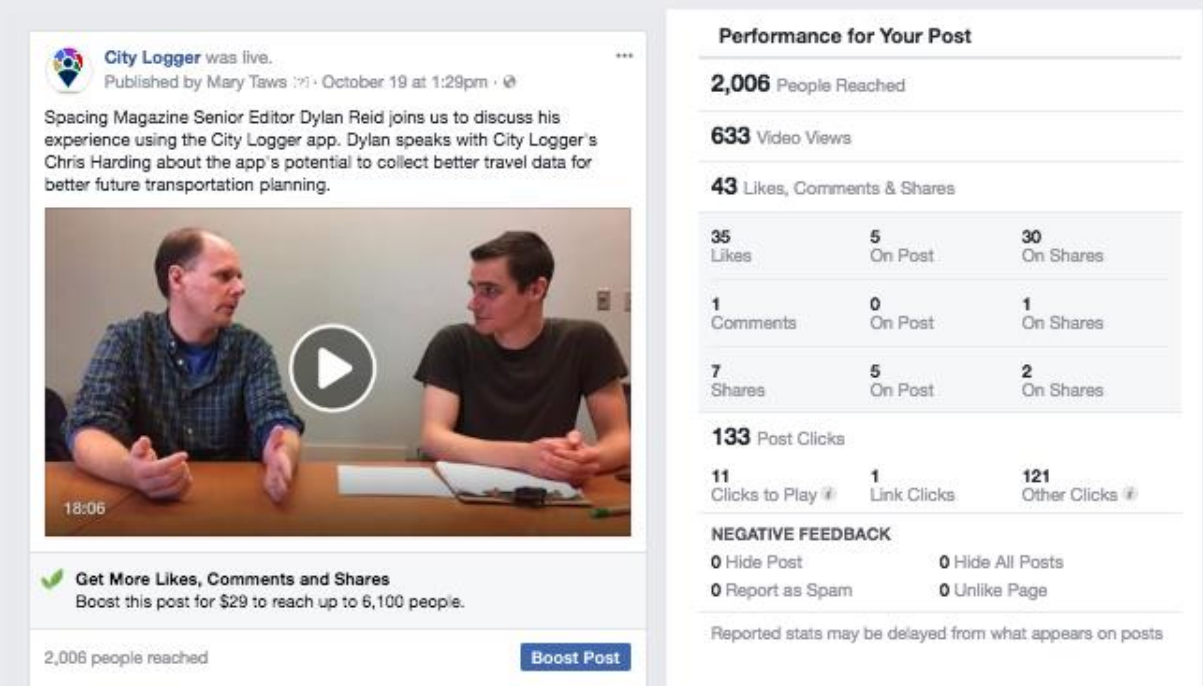
but at the end, we had prizes that reflected different modes of transportation. Partnerships made for the City Logger project include 407 ETR, Enterprise Carshare, and Cyclemania. Given the experience and lesson learnt in this project, it is recommended to allocate a longer lead up time to develop relationships. This would also allow sponsors to sign more official contracts and might mean that they could actively help promote with consistent messaging and professional graphics design.

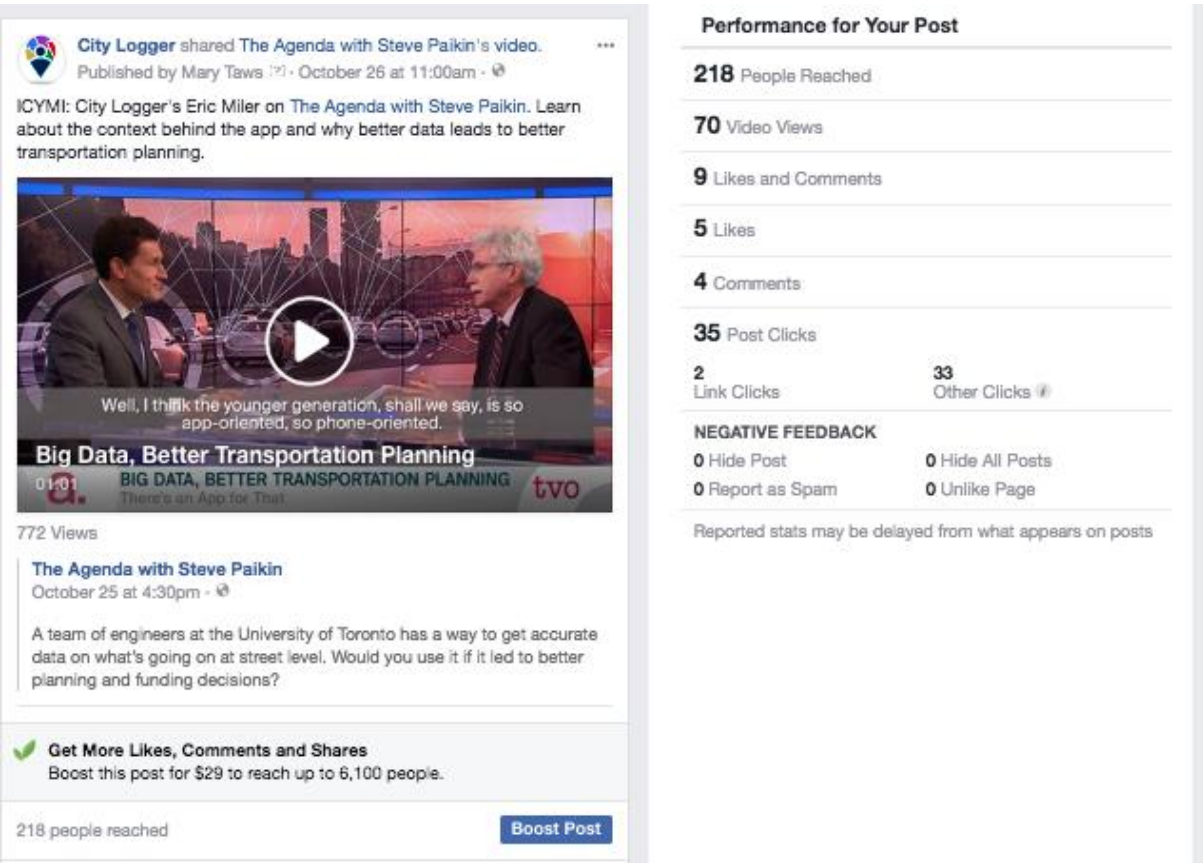
7.3.3 Social Media and Website

Facebook and Twitter were used as the primary social media tool. The followers and page likes while not stay consistent, showed a steady growth after the launch of the campaign. Most of the Facebook followers were women and from age group of 25-45. The followers were mostly found the Facebook page by searching City Logger in the Facebook search field.

The top performing posts on both Facebook and Twitter all happened to be videos. (one due to paid promotion, but the other two were solid pieces of content that involved other organizations). One of the post on Facebook was an "about video" had a paid promotion valued at $56.00 CAD. This allowed us to reach a wider audience but not with much follow through. Since City Logger is a new page, the key is getting a built in audience already there and then promoting to boost proven success. Perhaps a paid promotion in future would be more useful on U of T's main Facebook channel.




City Logger was live.
Published by Mary Taws · October 19 at 1:29pm ·
Spacing Magazine Senior Editor Dylan Reid joins us to discuss his experience using the City Logger app. Dylan speaks with City Logger's Chris Harding about the app's potential to collect better travel data for better future transportation planning.
18:06
Get More Likes, Comments and Shares
Boost this post for $29 to reach up to 6,100 people.
2,006 people reached
Boost Post
Performance for Your Post
2,006 People Reached
633 Video Views
43 Likes, Comments & Shares
35 Likes
5 On Post
30 On Shares
1 Comments
0 On Post
1 On Shares
7 Shares
5 On Post
2 On Shares
133 Post Clicks
11 Clicks to Play
1 Link Clicks
121 Other Clicks
NEGATIVE FEEDBACK
0 Hide Post
0 Hide All Posts
0 Report as Spam
0 Unlike Page
Reported stats may be delayed from what appears on posts


City Logger shared The Agenda with Steve Paikin's video.
Published by Mary Taws · October 26 at 11:00am ·
ICYMI: City Logger's Eric Miler on The Agenda with Steve Paikin. Learn about the context behind the app and why better data leads to better transportation planning.
Well, I think the younger generation, shall we say, is so app-oriented, so phone-oriented.
Big Data, Better Transportation Planning
BIG DATA, BETTER TRANSPORTATION PLANNING
There's an App for That
tvo
772 Views
The Agenda with Steve Paikin
October 25 at 4:30pm ·
A team of engineers at the University of Toronto has a way to get accurate data on what's going on at street level. Would you use it if it led to better planning and funding decisions?
Get More Likes, Comments and Shares
Boost this post for $29 to reach up to 6,100 people.
218 people reached
Boost Post
Performance for Your Post
218 People Reached
70 Video Views
9 Likes and Comments
5 Likes
4 Comments
35 Post Clicks
2 Link Clicks
33 Other Clicks
NEGATIVE FEEDBACK
0 Hide Post
0 Hide All Posts
0 Report as Spam
0 Unlike Page
Reported stats may be delayed from what appears on posts

Twitter was a helpful secondary platform to promote this app, especially in reaching out directly to some users and advocacy groups. Twitter saw more upward trending content and gained a small but mighty following. There were large swings in traffic to the twitter page, meaning City Logger page was not a destination for the followers. However, when they were on our page or reading one of our tweets, they were indeed engaging. Again, much like Facebook, video content that involves a partner did well for us. The other tweet is on launch day and we had help from internal partners (UTTRI, U of T Engineering) drawing attention to our social posts.

Website was designed to be simple and executed in a simple manner due to lack of resources. In future events, it would be a good idea to have a dedicated resource to build the site and have that and/or design be a complete focus. Several peak can be observed from the website traffic, including a peak on launch date and the day after with media hits being executed and the Agenda interview. The traffic were mostly coming to the website directly or by finding it through a search engine.

It is important to remember that users are not going to website to consume content or browse. They're going to get the link to the app or a quick piece of info and leaving. They are not hanging around to find out any new information for the most part. This does somewhat make the case for a more highly designed sophisticated website that is one page rather than overloading with too many new content or media hits pages.

7.3.4 Context around a similar initiative

The City Logger media specialist did speak with Elisabeth Faure [elisabeth.faure@concordia.ca] who worked on the MTLTrajet campaign that got about 6,800 users. Comparing the both campaigns, the key takeaway here is that a longer timeline, more resourcing, and a bigger budget is necessary to pull off this scope of campaign.

Just to put things in perspective, the Concordia effort for MTLTrajet had at least eight employees at the University with different skill sets collaborating. The University was working on building the partnership with the City at least 10 months before the launch. Elizabeth was the communications advisor, assigned to the faculty executing the app. She was in charge of an online news story, electronic newsletter to university pre-existed and supplemented lists and running a hero banner on the homepage of university. These actions were to coincide with the launch and she had a graphics design person on their news team to assist with development of these assets. One person was entirely dedicated to media relations. She also strategically contacted media. Our effort on the media relations side could be described as comparable in both approach and results. Overall, the Concordia team working on this several months out included: a communications faculty specialist, communications advisor, media relations person, newsletter team (digital team), graphics designer, photographer, city hall liaison, and social media team (comparing to City Logger's one communication specialist and two researchers).

This does not include the tasks of the website design, development, graphics for the digital ads for the city transit or promotional partner engagement. This means there is likely more resourcing from the City of Montreal to have executed these things over the months leading up to the launch either with external hiring or internal resources dedicated.

7.4 Email invitation analysis

Email volume was as follows, evenly distributed over 20 days, starting October 23:

- 393 emails to persons who agreed to participate in further studies when they filled out the TTS2 web survey in summer of 2017;
- 7,411 emails sent to addresses where no response was obtained during the summer;
- 9,650 sent to addresses not previously used during the summer.

In addition to the above, 350 emails (never before used) were sent as a test on October 22. Finally, emails were also sent as a joint invitation to 5,000 addresses, evenly spaced over 7 days, starting November 10, 2017. Respondents who received the joint invitation were invited to either follow the link to install the app or click the link to answer the web survey. The order of app or web survey was flipped in initial invitations and reminders, as well as overall halfway through the project.

Because of a glitch in mailgun's built-in analytics, it is impossible to decipher whether the 7,411 emails previously used during the summer added anything to the effort. This, in turn, means there is a significant level of uncertainty to the click-through rates associated with each type of invitation. Making matter more complicated, the 7,411 email addresses used during the summer were only contacted once, not sent reminders. One would assume that anyone potentially interested would click after 3 reminders, while those not interested would write emails from TTS2 and web-survey off for good. With only one invitation, it is not possible to state this. What we can differentiate are click-through rates from those emails where only the app was proposed, from the click-through rate when a choice was given between app and web survey. To be able to easily differentiate general web traffic in the City Logger site from traffic received as a result of email invitations, a non-published page was created on the site, such that only persons with the link could reach the page.

In total, 1,979 users installed during the period October 1 to December 10, 2017. 186 of these installs occurred before email invitations began, while one of the major press efforts overlapped with the email invitation period. Assuming 300 installs were unrelated to the TTS email list (186 before the start, 75-100 for The Agenda appearance and the remainder from social media), this would mean an install rate of roughly 7.4% occurred from the 22,804 emails, or 10.9% if we ignore the emails from the summer that elicited no response at this time. In comparison, the click-through rates on the email invitations was roughly 20%, which would mean a significant portion of persons who receive the email and click the link actually follow-through on installation.

Looking more closely at the application store clicks on the website, what we see is that a considerable amount of potential users were lost. It means that a significant portion of those persons who clicked on the links to the App and Play stores did not install the apps (total installs 1,082 iOS and 897 Android installs, which includes those recruited through other means). In turn, this is an indication that the content on the App and Play stores may have benefited from more attention. This is a good reminder that the page where users ultimately choose to install or not is the App/Play store. The messaging and images presented should be as professional and inviting as possible.

TABLE 11 - APP STORE CLICKS ON THE CITY LOGGER.CA SITE BY DEVICE TYPE AND OS

Link	Mobile	Desktop	Tablet	Total
iTunes	1207	156	113	1476
Play	893	249	42	1184
Link	**Mobile**	**Desktop**	**Tablet**	**Total**
iTunes	45.4%	5.9%	4.2%	55.5%
Play	33.6%	9.4%	1.6%	44.5%

While the email-link page did account for over half the project traffic, the CityLogger.ca landing page also accounts for over 1,300 views, which the FAQ, About Us and Prize information pages collectively accounted for nearly 20% of all traffic. Designing an intuitive, attractive and informative website can both help current users find information desired to better understand how to make the most of the app they've installed, and also help convince potential users the project is worth allocating a bit of time for.

URL	Page Views	Percent Traffic
/email-invitation/	4692	53.4%
/	1363	15.5%
/faq/	669	7.6%
tts2.ca/app*	570	6.5%
/about/	637	7.3%
/prizes/	330	3.8%
/partners/	164	1.9%
/contact/	153	1.7%
/media/	72	0.8%
/better-transportation-planning-theres-an-app-for-that-and-it-needs-your-help/	33	0.4%
/android-app-now-available/	23	0.3%
/download-city-logger/	22	0.3%
/city-logger-now-available-on-app-store/	21	0.2%
/listen-to-city-loggers-chris-harding-on-am640/	11	0.1%
Others	21	0.2%
Total	8781	100

In an effort to quantify the effect of emails on website traffic, installs and days logged, three linear regression models are estimated. Install numbers and days of reported travel have been associated with days, which in turn have been associated with the number and type of invitations sent out.

TABLE 12 - REGRESSION MODEL ESTIMATE FOR WEBSITE TRAFFIC (EMAIL LINK) AS A RESULT OF INVITATIONS

Source	SS	df	MS
Model	742119.318	5	148423.864
Residual	21602.6819	31	696.860708
Total	763722	36	21214.5

Number of obs	= 36
F(5, 31)	= 212.99
Prob > F	= 0.0000
R-squared	= 0.9717
Adj R-squared	= 0.9672
Root MSE	= 26.398

cl_emailtr~c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
solo_i	.0802432	.0124382	6.45	0.000	.0548753	.1056112
solo_r1lag	.07062	.0169009	4.18	0.000	.0361504	.1050896
solo_r2lag	.0714478	.0140175	5.10	0.000	.042859	.1000365
joint_ilag	.0741142	.0207116	3.58	0.001	.0318727	.1163557
joint_r2	.0409921	.015787	2.60	0.014	.0087942	.0731899

In Table 12, the dependent variable is the number of page views on the email-only webpage. In such a construct, the coefficient stands for the number of website hits for every invitation sent out. 'Solo' indicates an invitation sent with only the app as an option, while 'joint' indicates both the app and web survey are presented as alternatives. The suffixes "i" and "r" are for initial and reminder email. Different specifications were run to try and best represent the relationships, with lagged effects included for emails (invitations counted the day following their receipt). The wording for emails is presented in this appendix, as this will have an impact on user behavior.

A few interesting differences can be observed. First, the non-lagged solo initial invitation was found to be more statistically significant, whereas the lagged reminders, in turn, were found to be more significant. Respondents not knowing that they would be sent another invitation acted more quickly upon the initial email, whereas the reminders were more likely to be left in the inbox for another day. In all cases, however, there appears to be a benefit to sending multiple emails to the same person. In the case of the joint invitation, the lagged effect of the initial invitation was more statistically significant than the actual invitation. This could be interpreted as a result of being asked not simply to install an app, but rather presented with a choice between an app and a web survey. Providing alternatives would appear to have the effect of delaying a decision. This can be problematic, as a potential respondent may put off choosing between app and web survey and simply forget or later choose to participate in neither effort.

The overall effect of presenting an option would appear to halve the website traffic (sum of coefficients) with the joint invitation, but whether this is good or bad is not clear cut. If we take a middle-ground 9% value for installs as a result of TTS emails to be the true value (which would translate to 450 installs over 5,000 emails), then the effect of providing an alternative would be to reduce by 225 the number of users who *install* the City Logger app, while bringing 800 people to the web survey, with 438 actually completing it. Without having a dollar value to assign to an app install or a completed web survey, it is not possible to state with certainty that this trade-off implies, but it would not appear to be an overall flawed approach to recruitment.

TABLE 13 - REGRESSION MODEL ESTIMATE FOR COMBINED IOS AND ANDROID INSTALLS AS A RESULT OF INVITATIONS AND MEDIA EFFORTS (THE AGENDA)

Source	SS	df	MS		
Model	107209.756	6	17868.2926	Number of obs =	35
Residual	3403.24426	29	117.35325	F(6, 29) =	152.26
Total	110613	35	3160.37143	Prob > F =	0.0000
				R-squared =	0.9692
				Adj R-squared =	0.9629
				Root MSE =	10.833

installs	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
solo_i	.0255537	.0064269	3.98	0.000	.0124092	.0386982
solo_r1	.0297716	.0070653	4.21	0.000	.0153214	.0442217
solo_r2lag	.0244188	.0050967	4.79	0.000	.0139949	.0348428
joint_ilag	.0313155	.008533	3.67	0.001	.0138636	.0487675
joint_r2lag	.0122779	.0060046	2.04	0.050	-2.95e-06	.0245587
comms	60.26194	11.39151	5.29	0.000	36.96369	83.56019

Next, model estimation result for installs is consistent with the model estimates for website traffic. Adding up the coefficient estimates for solo invitations, there would appear to be a 7.9% install to invitation rate, to the 4.3% install rate for joint invitations. The lagged effect is also observed with installs, such that one could interpret this as potential respondents delaying their decision to act on the invitation to install the app or answer the web survey because of the choice presented. A control introduced in this model, as well as the subsequent model, is that of 'comms', which represents Eric Miller's appearance on The Agenda with Steve Paikin. When interpreting aggregate values reported earlier, it is important to note that 38 users installed the app after email invitations ended.

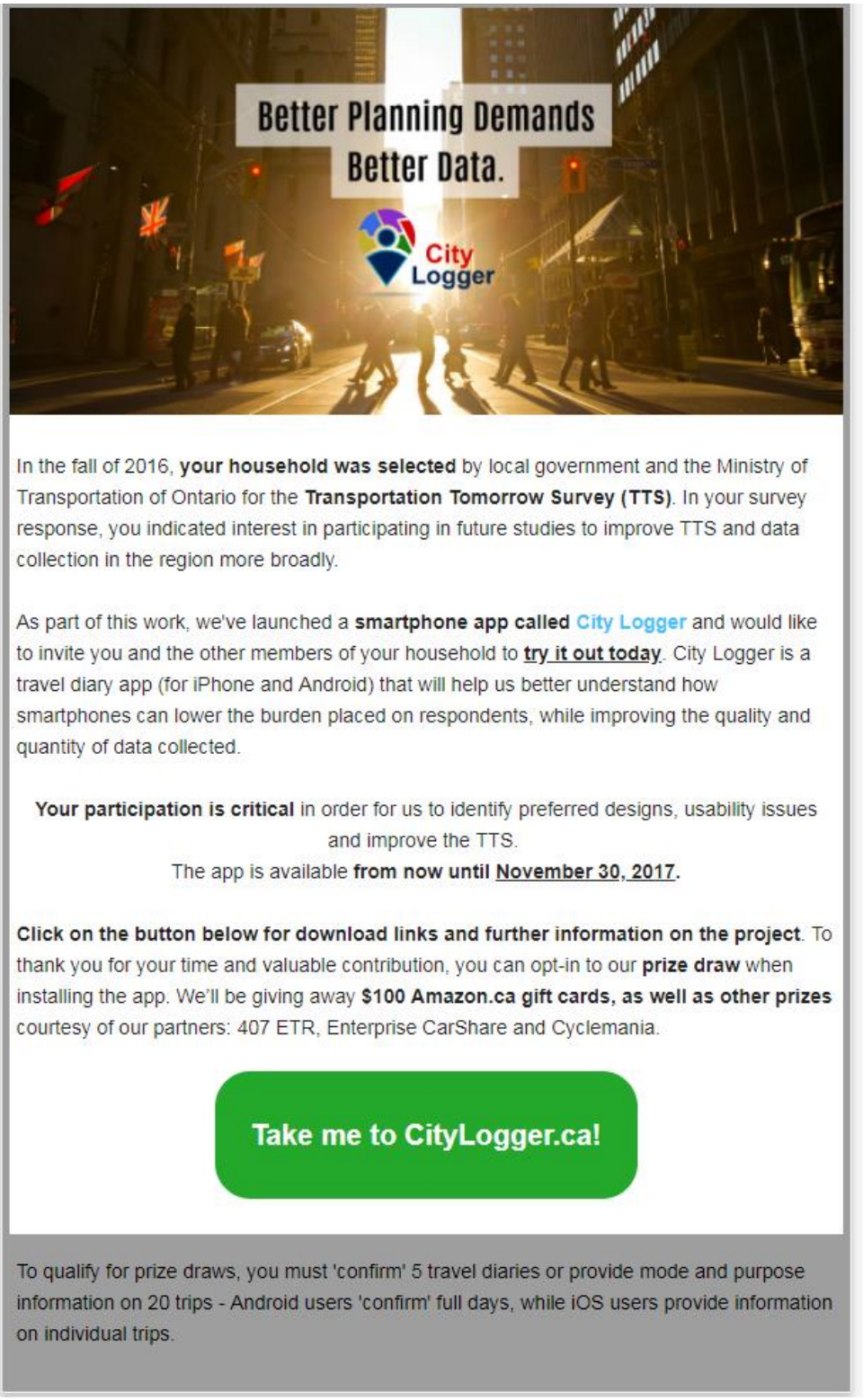
TABLE 14 - REGRESSION MODEL ESTIMATE FOR SUM OF DAYS RUN AS A RESULT OF INVITATIONS AND MEDIA EFFORTS (THE AGENDA)

Source	SS	df	MS		
Model	6275333.54	6	1045888.92	Number of obs =	35
Residual	197518.464	29	6810.98152	F(6, 29) =	153.56
Total	6472852	35	184938.629	Prob > F =	0.0000
				R-squared =	0.9695
				Adj R-squared =	0.9632
				Root MSE =	82.529

daysrun	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
solo_i	.2982437	.0489621	6.09	0.000	.1981049	.3983825
solo_r1	.1039432	.0538254	1.93	0.063	-.0061422	.2140286
solo_r2lag	.2130944	.0388282	5.49	0.000	.1336819	.292507
joint_ilag	.2418369	.0650068	3.72	0.001	.1088831	.3747908
joint_r2lag	.0612119	.0457448	1.34	0.191	-.0323468	.1547706
comms	487.0078	86.78377	5.61	0.000	309.5151	664.5005

Finally, Table 14 presents a model estimate for the number of filtered user-days recorded per email, with controls applied for the media appearance referenced above (*Filtered days do not include first and last if the install or uninstall was partway through the day, nor do they include persons who did not fill out the survey in-app (Android-only) or those who reside outside the TTS study area*). Consistent with the two prior models, solo invitations are estimated to lead to 0.615 user-days per invitation, whereas for joint invitations this is roughly halved at 0.303 user-days. In actuality, the raw data account for a much larger amount of trips, but much the same way that an incomplete web survey is not necessarily valuable, a partial user-day is not either. Lagged effects would also appear to again be more significant on the joint invitation side.

7.4.1 Solo Invitations



(If you already downloaded the app, ignore this email - this is reminder 1 of only 2 that will ever be sent to you. Sorry for pestering!)

In your **Transportation Tomorrow Survey (TTS)** response last fall, you indicated interest in future studies to improve data collection in the region.

As part of this TTS work, we've launched **City Logger** and would like to invite you and the members of your household to try it out. **City Logger is a smartphone-based travel diary app** that helps us better understand what role apps and crowdsourced data can play in the planning process. **The app lowers the burden placed on respondents** as you don't need to recall and report all trips, but merely confirm the mode and purpose for trips detected by the app.

Your participation is critical and the app is only available until November 30!

Click on the button below for download links and further information. **To thank you for your time and invaluable contribution**, you can opt-in to our **prize draw** when installing the app. We'll be giving away **$100 Amazon.ca gift cards, as well as other prizes** courtesy of our partners: 407 ETR, Enterprise CarShare and Cyclemania.

Take me to CityLogger.ca!

To qualify for prize draws, you must 'confirm' 5 travel diaries or provide mode and purpose information on 20 trips - Android users 'confirm' full days, while iOS users provide information on individual trips.

After this email, you will receive only one last reminder. We apologize for the inconvenience of this, but will not send any emails after the second reminder.

(Note: If you already downloaded the app, please ignore this email - this is the last time you will ever be contacted about the project.)

In your **Transportation Tomorrow Survey** response (fall of 2016), you indicated interest in future studies to improve transportation data collection in the region.

As part of our TTS work, we've launched the **City Logger app** and would like to invite you and the other members of your household to try it out on your Android or iOS devices. **City Logger is a smartphone-based travel diary app** that helps us better understand how crowdsourced data can be used to further evidence-based planning. **Instead of having to remember and report all your trips**, City Logger allows you to quickly and easily confirm the mode and purpose for trips detected, cutting down on survey time and effort.

Your participation is critical and the app is only available until November 30!

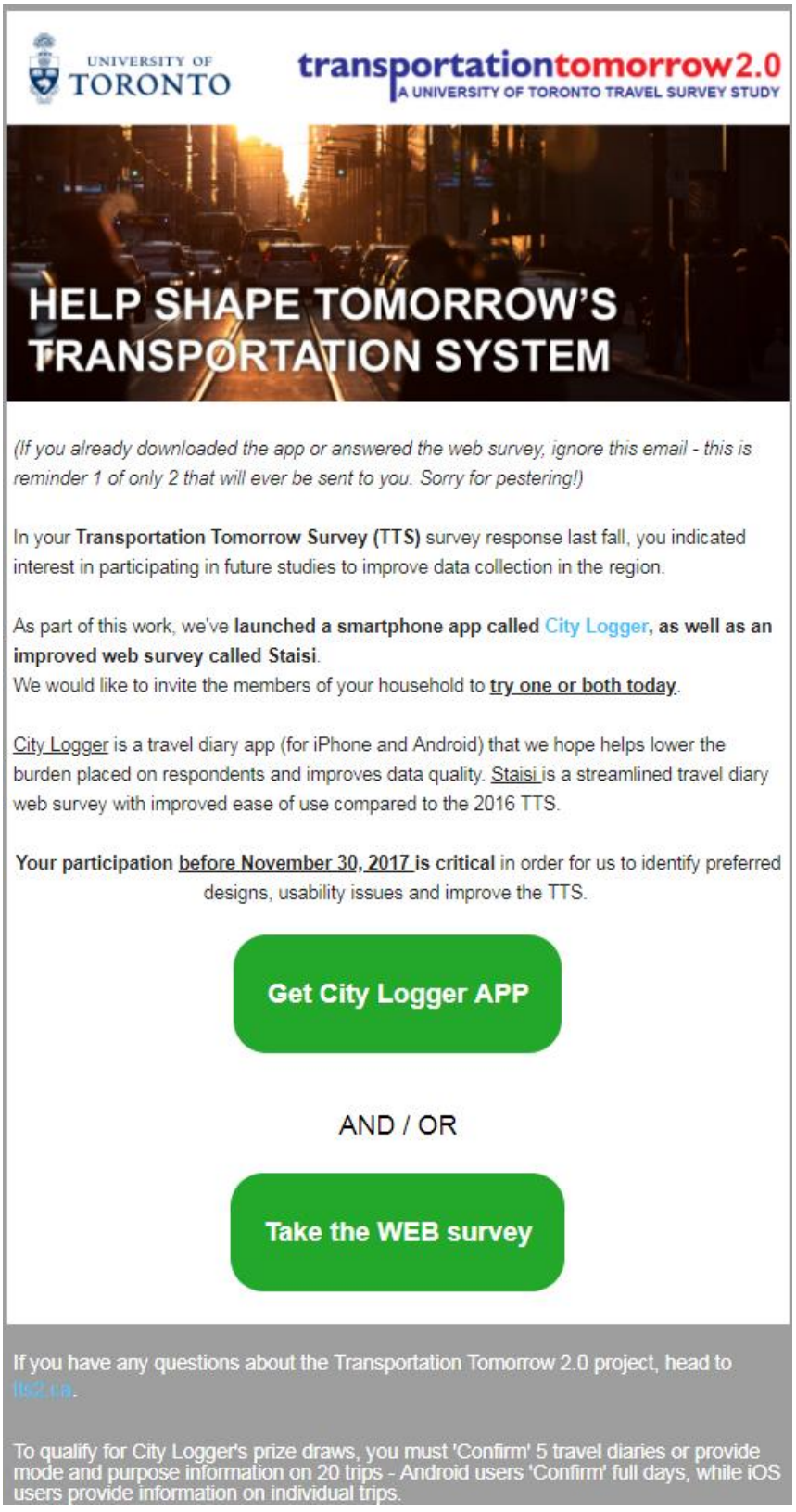
Click on the button below for download links and further information. **To thank you for your time and valuable contribution**, we'll be giving away **$100 Amazon.ca gift cards, as well as other prizes** courtesy of our partners: 407 ETR, Enterprise CarShare and Cyclemania.

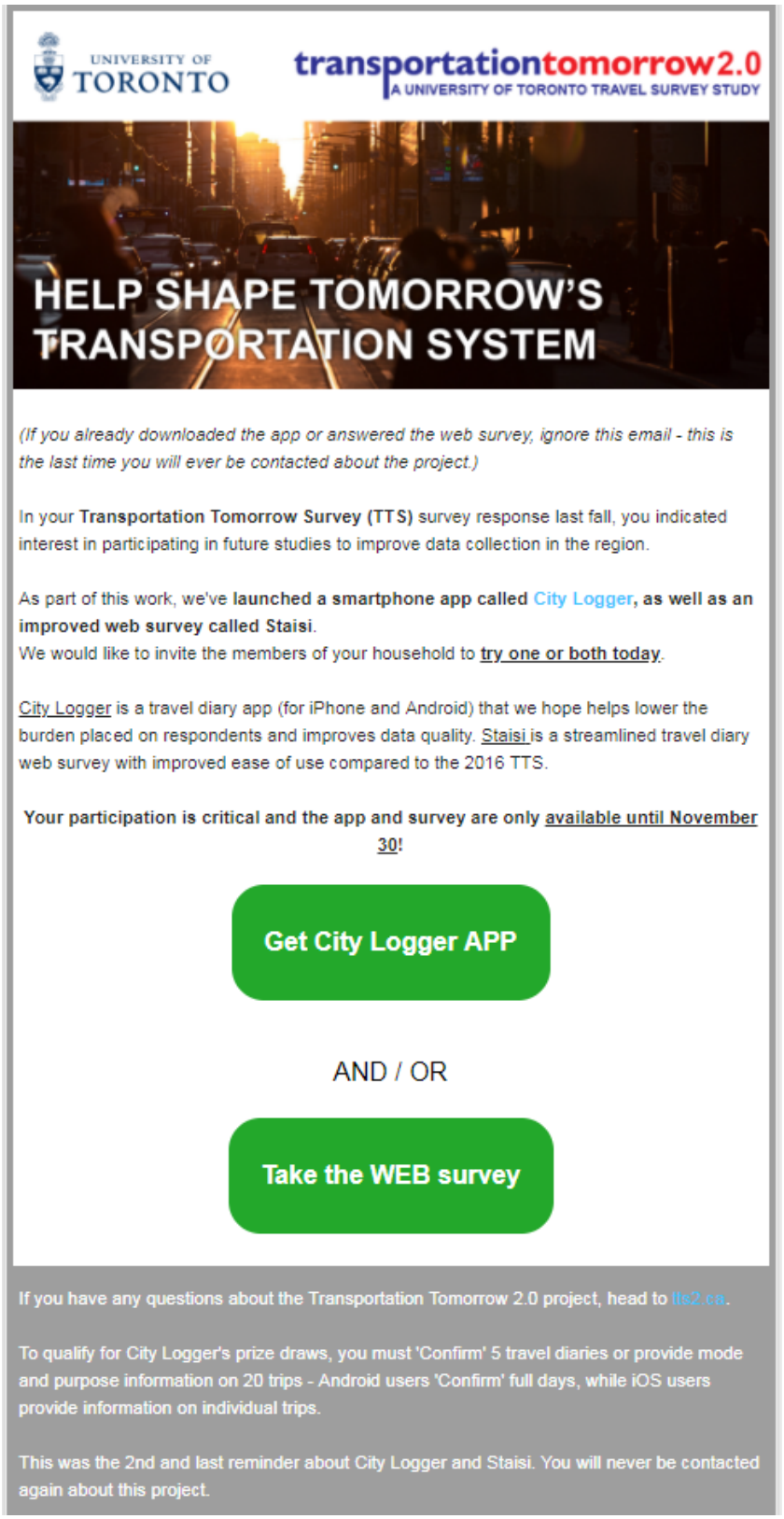
Take me to CityLogger.ca!

To qualify for prize draws, you must 'confirm' 5 travel diaries or provide mode and purpose information on 20 trips - Android users 'confirm' full days, while iOS users provide information on individual trips.

This was the 2nd and last reminder about City Logger. You will never be contacted again about this project.

7.4.2 Joint invitations




UNIVERSITY OF TORONTO
transportationtomorrow2.0
A UNIVERSITY OF TORONTO TRAVEL SURVEY STUDY
HELP SHAPE TOMORROW'S TRANSPORTATION SYSTEM
(If you already downloaded the app or answered the web survey, ignore this email - this is the last time you will ever be contacted about the project.)
In your Transportation Tomorrow Survey (TTS) survey response last fall, you indicated interest in participating in future studies to improve data collection in the region.
As part of this work, we've launched a smartphone app called City Logger, as well as an improved web survey called Staisi.
We would like to invite the members of your household to try one or both today.
City Logger is a travel diary app (for iPhone and Android) that we hope helps lower the burden placed on respondents and improves data quality. Staisi is a streamlined travel diary web survey with improved ease of use compared to the 2016 TTS.
Your participation is critical and the app and survey are only available until November 30!
Get City Logger APP
AND / OR
Take the WEB survey
If you have any questions about the Transportation Tomorrow 2.0 project, head to tts2.ca.
To qualify for City Logger's prize draws, you must 'Confirm' 5 travel diaries or provide mode and purpose information on 20 trips - Android users 'Confirm' full days, while iOS users provide information on individual trips.
This was the 2nd and last reminder about City Logger and Staisi. You will never be contacted again about this project.

7.4.3 Uninstall notice

When data collection was set to wrap, an email to active users was sent telling them they should uninstall the app.