Survey Burden and Trip Underreporting in Smartphone App-Based Travel Surveys (They Aren't Just CATI & Web Problems)

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TxDOT Travel Survey Program Highlights

- Research began 1960s, Travel Survey Program (TSP) started in 2000

- Goal: data collection/analysis consistency across all 24 TX MPOs

- TTI's Role: survey oversight, technical assistance, QA/QC, data analysis, integration of passive data

- Randomly-selected HHs mailed invitation postcard

- Residents asked to record travel for 24 hrs (3am-3am)

- Initial random address-based sample may be supplemented with convenience sampling later in project, if needed

- Travel data collected by

  - **Web** - trips self reported, no positioning data or prompted recall,

  - **CATI** - trips self reported, no positioning data or prompted recall… but interviewer can probe for missed stops

  - **App** - includes travel evidence (positioning data) and prompted recall component… but can still be susceptible to trip underreporting

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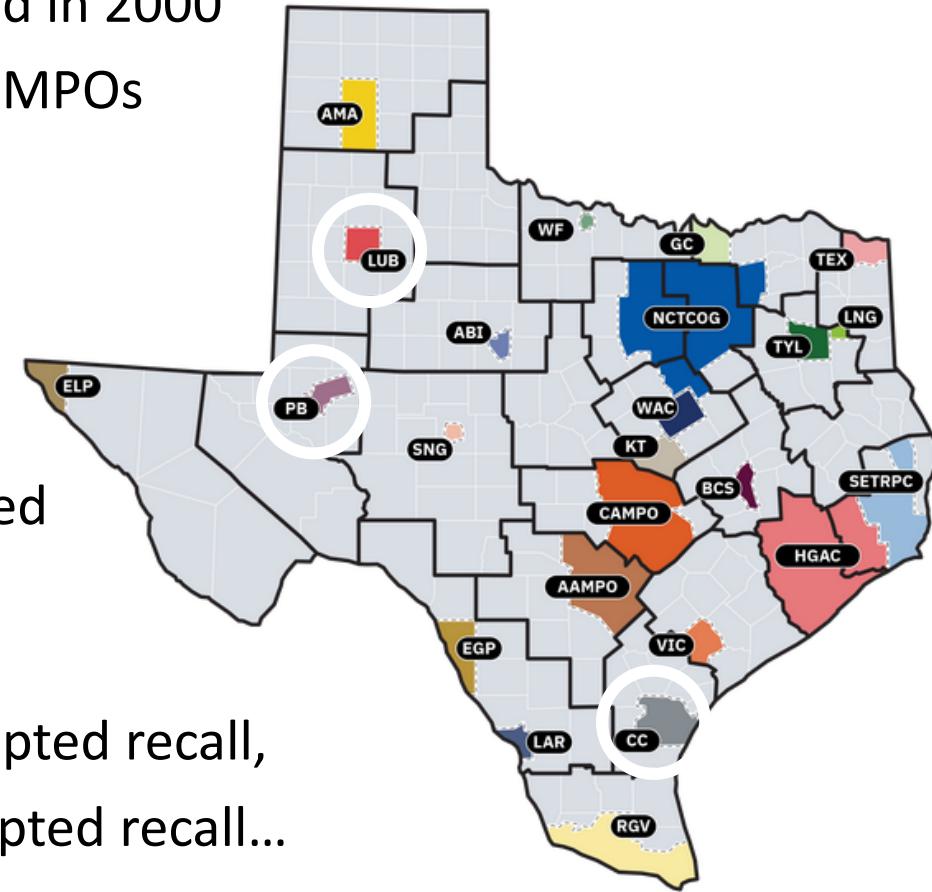
# Comparison of Traditional Data Collection Methods
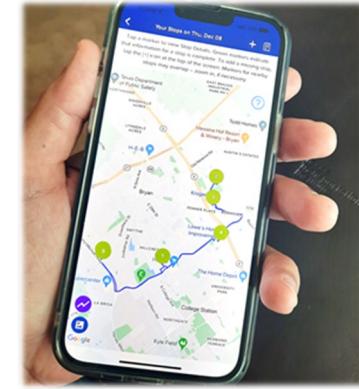
Web
(most prone to trip under reporting due to unsupervised self reports)

CATI
(slightly more accurate due to interviewer probing...and greater respondent honesty with interviewer)

App
(most accurate, especially for higher trip makers, but requires learning curve and can be costly to field and involve burdensome trip inspection/editing)

Easiest
Cheapest
Least Accurate

Hardest
Costliest
Most Accurate

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App Participation Process

1. App Downloaded and Installed by HH Member on their phone

2. Participant Activates App and Grants Permissions
   - Cellular Data and Location Services for travel tracking,
   - Motion & Fitness for position accuracy and battery preservation,
   - Notifications for survey instructions, reminders and alerts

3. Participant goes about their activities on survey day and positioning data are passively collected in background and processed into suspected trips by algorithm

4. Participant reviews algorithm-generated trips in real time or after survey period...confirms, adds, deletes or edits tripends, and answers questions about each stop in Prompted Recall module

   - Travel trace and suspected stops/times presented to participant
   - Can toggle between trip list and satellite/street map views
   - Designed to prompt for accurate recall, review and editing of stops

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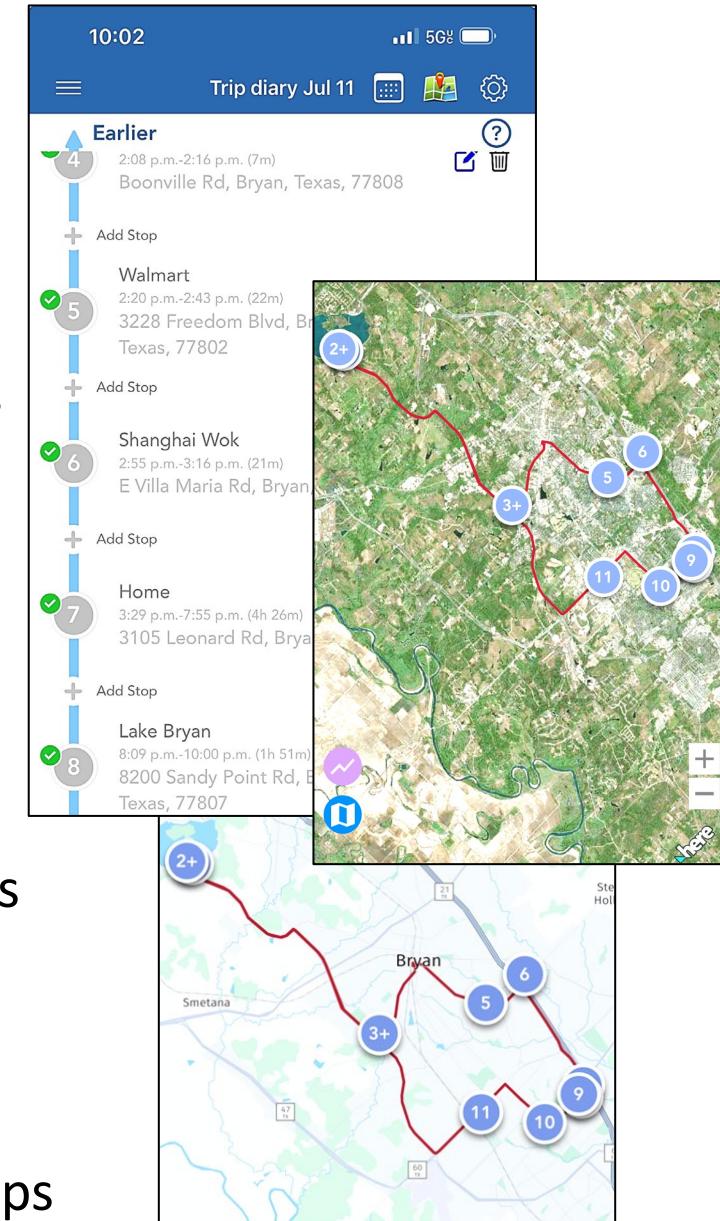
Case Studies to Better Understand App Data and Burden

- 3 Areas Examined: <u>Corpus Christi 2023-2024</u>, <u>Lubbock 2023-2024</u> and <u>Midland-Odessa 2024-2025</u>

- Case Study Criteria: recently completed project, non-border area, single TxDOT data contractor

- 20 App users randomly selected for analysis in each area

- GIS assessment of overlap between reported stops and recorded travel traces (inspection of tripend travel patterns and point clustering, timestamps, speed/accuracy metrics)

- App burden quantified based on user editing statistics from vendor and extensive TTI App testing

- Non-App user data not examined in this effort – no basis for determining level of underreporting

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Household Survey Participation by App, 2021-2025

- Trend of increasing App use among survey respondents, particularly in large urban areas
- Variation in vendor capabilities can affect data collection mode preference (e.g. call center and App development service provided in-house or sub-contracted out, etc.)
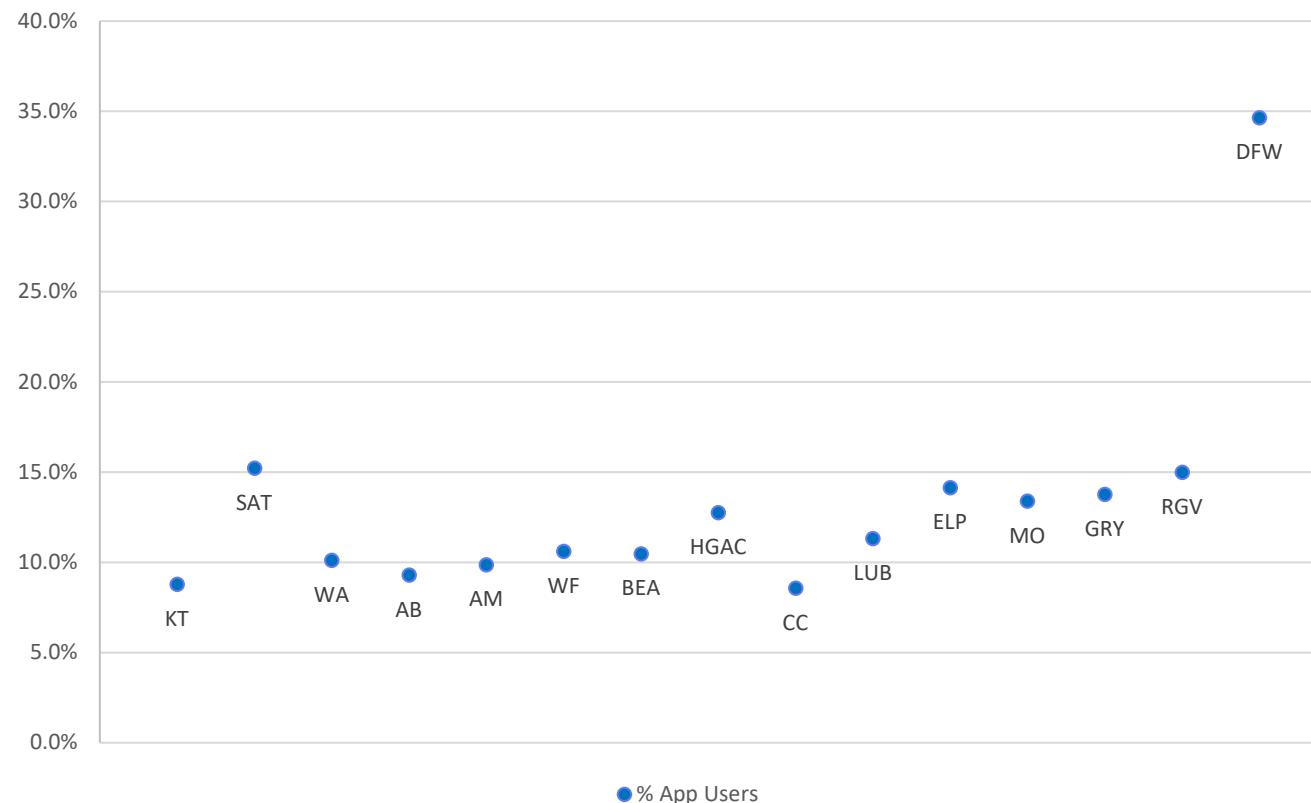
Data Collection Mode calculations are based on all members of sampled households (including children and non-Smartphone owners). Data includes ongoing surveys in GRY, RGV and DFW.

App User vs Non-App User Trip Rates

How Do We Know App Trip Rates Aren't Artificially Inflated?

- Respondents instructed to review and remove erroneous algorithm-generated tripends, if found

- Extra effort would be required to answer questions about fictitious stops (easier/quicker to just delete erroneous algorithm-generated tripends)

- Most common scenario: App-user travel traces ("breadcrumbs" or "pings" shown in yellow, below) match the reported stops (shown in red, below)

- Assessment of reported stops vs travel traces didn't indicate any obvious trip overreporting, but <u>some App trip underreporting was identified</u>
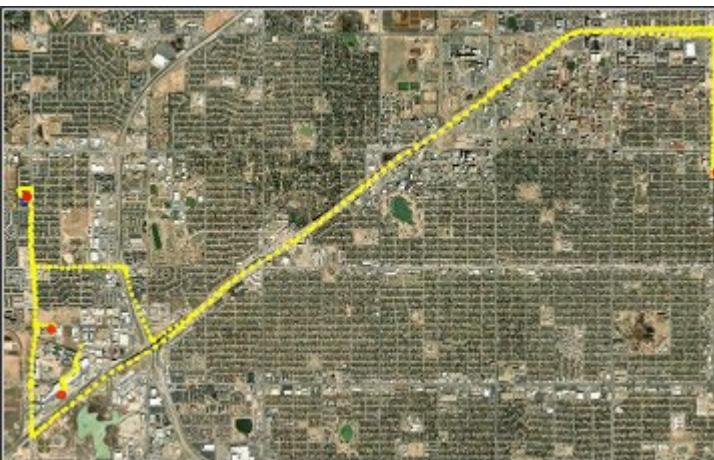
Reported App User Trip Rates are Already Very High… How Do We Know They Should Actually Be Higher?

Case study examples: Travel Traces (yellow)   Reported tripends (red)   Missed stops (green)

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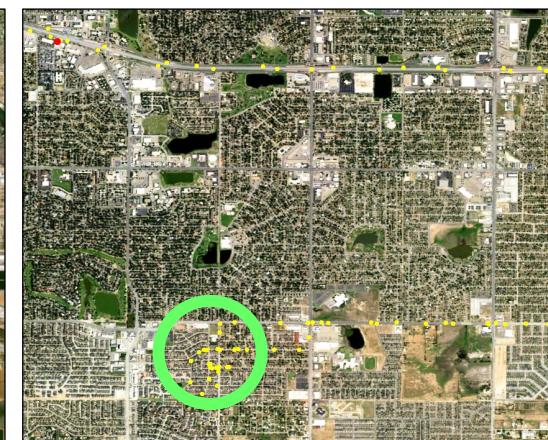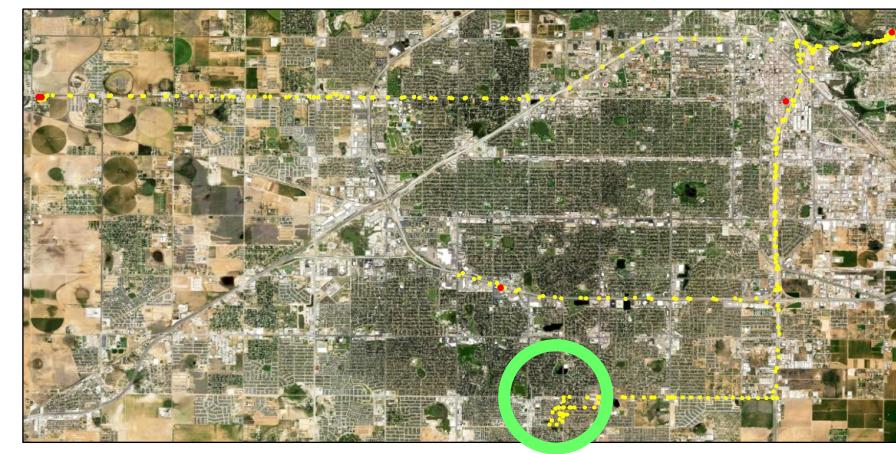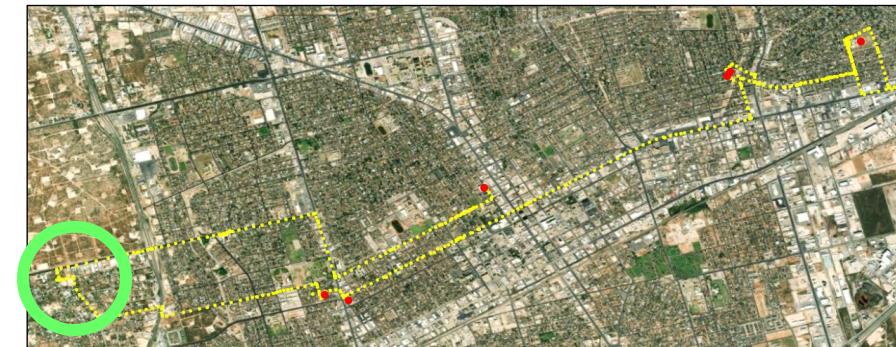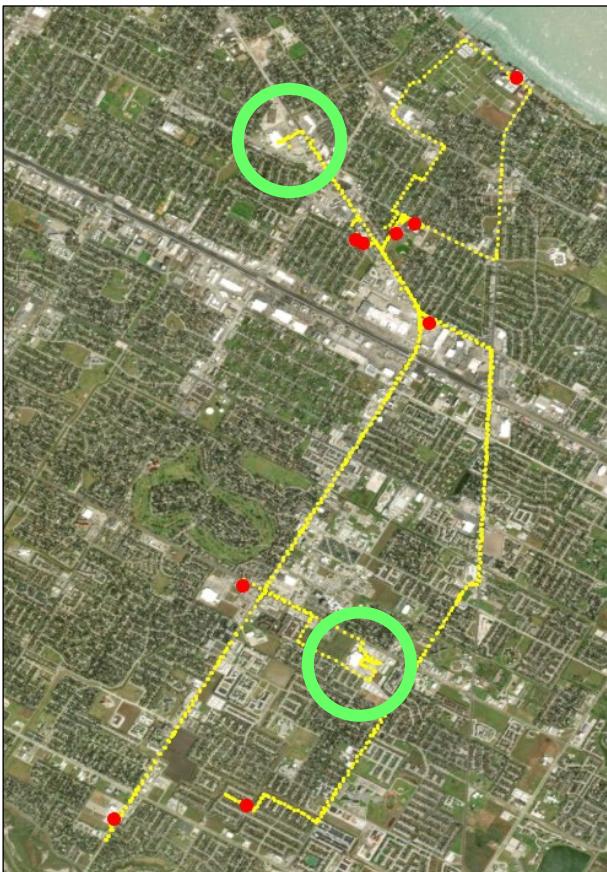
Why App Data Don't Always Include Every Stop Made

- Algorithm-generated stops are not perfect:
  - Rely on phone's GPS and motion sensors (can be disabled or phone can be turned off)
  - Raw positioning data can be noisy, movement at stop may prevent algorithm insertion of tripend
  - Speed and time thresholds are utilized to determine if participant was stationary
  - Values change depending on data granularity (in case studies, stops <3 mins duration were hidden from participants, only reported if manually identified)

- Some respondents may ***not***:
  - View missing stops as important (notwithstanding instructions to contrary)
  - Remember survey instructions or understand editing tools (despite efforts to make them streamlined and intuitive)
  - Have or take the time to scrutinize traces/stops and make necessary tripend edits/additions
 - Complete the survey ethically - may attempt to shorten the survey by deleting legitimate stops
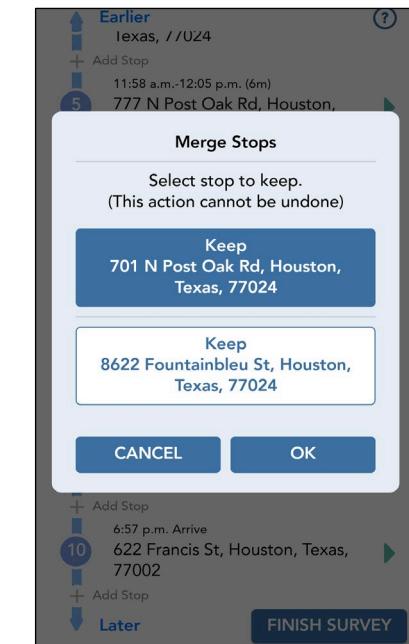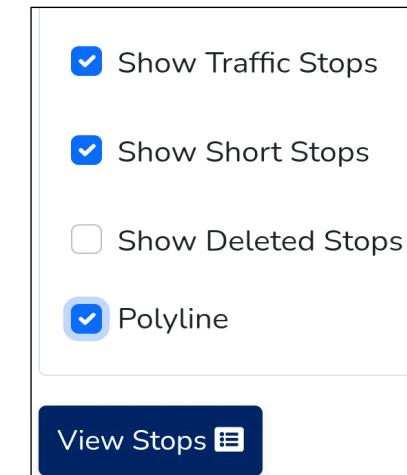
App Participation and Survey Burden

- Recruitment has become a major challenge in recent years (legitimate public agency survey requests have suffered from a large increase in spam, junk mail, donation requests, scams)

- When HHs are contacted and recruited, some may be more reluctant to engage in a lengthy survey (even when provided with a monetary incentive)

- App user data are not typically reported by proxy – all questions for all stops are answered by traveler for survey to be considered complete and participant to receive their incentive

- Downloading, activating and learning a travel survey App and then reviewing and confirming trips or adding/deleting/merging stops can be time consuming (but efficiencies for higher trip makers)

- Traditional self-reporting options such as Web/CATI do not involve trip review/confirmation/editing – travel information entered directly from memory/diary notes

- Although the App is designed to facilitate and streamline accurate travel reporting, it cannot complete the survey for the respondent

- This realization may contribute to trip underreporting among some App participants wishing to speed up the survey

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Quantification of App Survey Burden: Participant Edits of App-Generated Data/Associated Burden

	Corpus (n=445)	Lubbock (n=488)	Midland-Odessa (n=598)	Total	Avg Estimated App Setup and Stop Editing Time Penalty (secs	
App Download and Authorization					120	per user
App Familiarization					90	per user
1. Avg # Total App Tripends identified:	14.53	14.31	15.50	14.84		
2. Avg # App Tripends Identified by Algorithm as Traffic Signals:	1.84	1.32	1.55	1.56		
3. Avg # App Tripends that were Hidden due to <3min Dwell Time:	0.92	0.84	1.24	1.02		
4. Avg # Other Erroneous App Tripends that were Manually Deleted (Row 1 - (Rows 6 + 2 + 3)):	3.01	3.27	4.31	**3.60**	10	per trip
5. Avg # Total Tripends that were Manually Added by Respondent:	1.68	1.62	1.64	**1.65**	120	per trip
6. Avg # Valid App Stop Locations identified:	8.77	8.88	8.39	**8.66**		
7. Percent of Valid Tripends Detected by App (Row 6 - Row 5)/(Row 6):	80.8%	81.8%	80.5%	81.0%		
8. Avg # of Additional Trips/App User based on Case Study:	0.60	0.80	0.45	**0.62**	120	per trip
9. Avg # Valid App Stop Locations identified if Case Study Corrections Applied:	9.37	9.68	8.84	9.28		
10. Updated Percent of Valid Tripends Detected by App (Row 9 - Row 5)/(Row 9):	75.7%	75.0%	76.4%	75.6%		
Avg Missed Tripends as a % of Valid Stops Submitted (Excluding Base Location)	7.72%	10.15%	6.09%	8.10%		
Avg Missed Tripends as a % of Valid Stops Submitted (Including Base Location)	6.84%	9.01%	5.36%	7.16%		
					518	Total (secs)
					8.63	Total (mins)

- 31.7% of case study app participants had unreported travel
- Apple: 5-sec ping rate, vendor reduced Android ping rate to 19-20 sec to reduce battery drawdown
- 73% of all app participants in these 3 study areas deleted stops; 60% manually added stops

Missed Stops and Participant Burden

- Sample shows missed trips in 5-10% range for App users

- App user Notes report algorithm-detected, validated, hidden, deleted, user-added stops

- Hidden stops: less than 3 minutes or in close proximity to traffic signal

- Positioning data files include timestamps, point accuracy, heading, velocity

- TTI testing typically found ~2 erroneous algorithm-generated stops/user that had to be deleted

- Average number of tripend deletions among App users in case study areas was 3.6

- Could indicate that some App users are deleting legitimate tripends to speed up App survey completion

An average of 1.56 traffic stops per person were hidden by the App

TTI stop validation utilized speed (mph), timestamps (stop dwell time), and point accuracy data

Case Study: Original vs Updated App-User Trip Rates

- Sample of 60 App participants (20 from each area): average 8.1 daily person trips reported
- Avg trip underreporting rate for case study examples examined: 0.61 daily person trips
- Corrected trip rate for case study examples examined: 8.71 daily person trips
- NHB represented largest share (35%), followed by HBO (20%)

35% of missed tripends were Residential

Median dwell time of missed stops: 2 min 47 secs

Frequency Distribution of Missed Stops

Missed Stops As Share of Reported Stops

Dwell Time of Missed Stops

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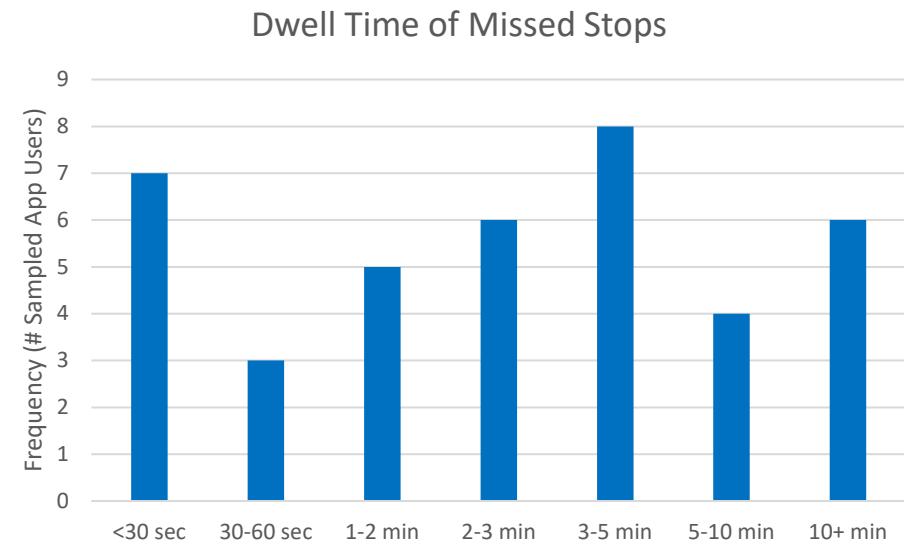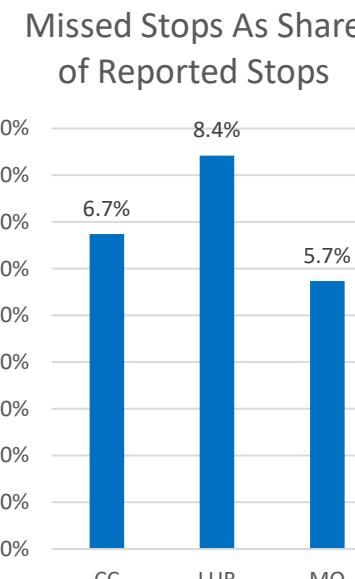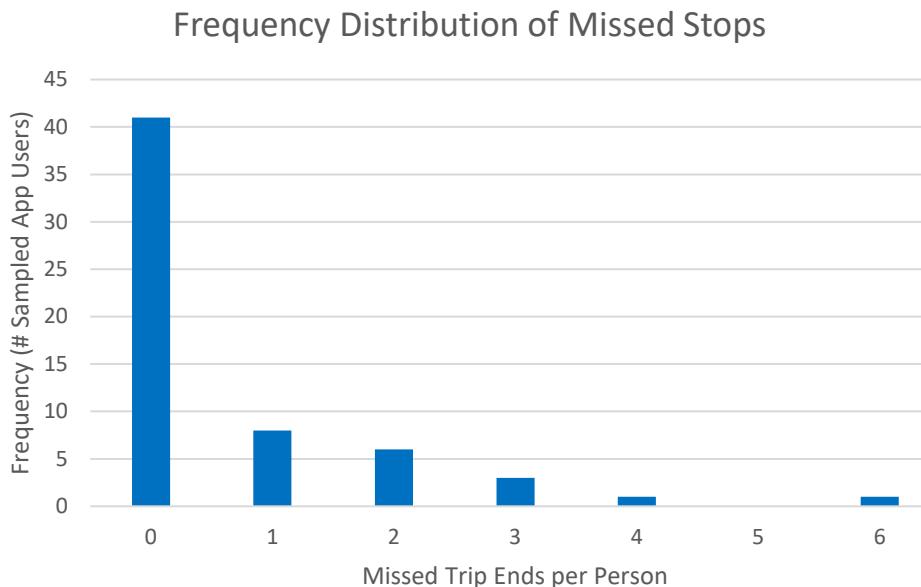
Trip Rates for App Users vs Non-App Users and Impact on Model Inputs

- Higher trip makers may gravitate to App to facilitate capture/reporting of numerous stops
- App users employed at higher rates, often engaged in commercial activities (longer tail in chart at right)
- Zero trip-makers concentrated among Non-App users

Frequency Distribution of Daily Person Trips for Non-App Users

Frequency Distribution of Daily Person Trips for App Users
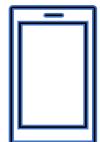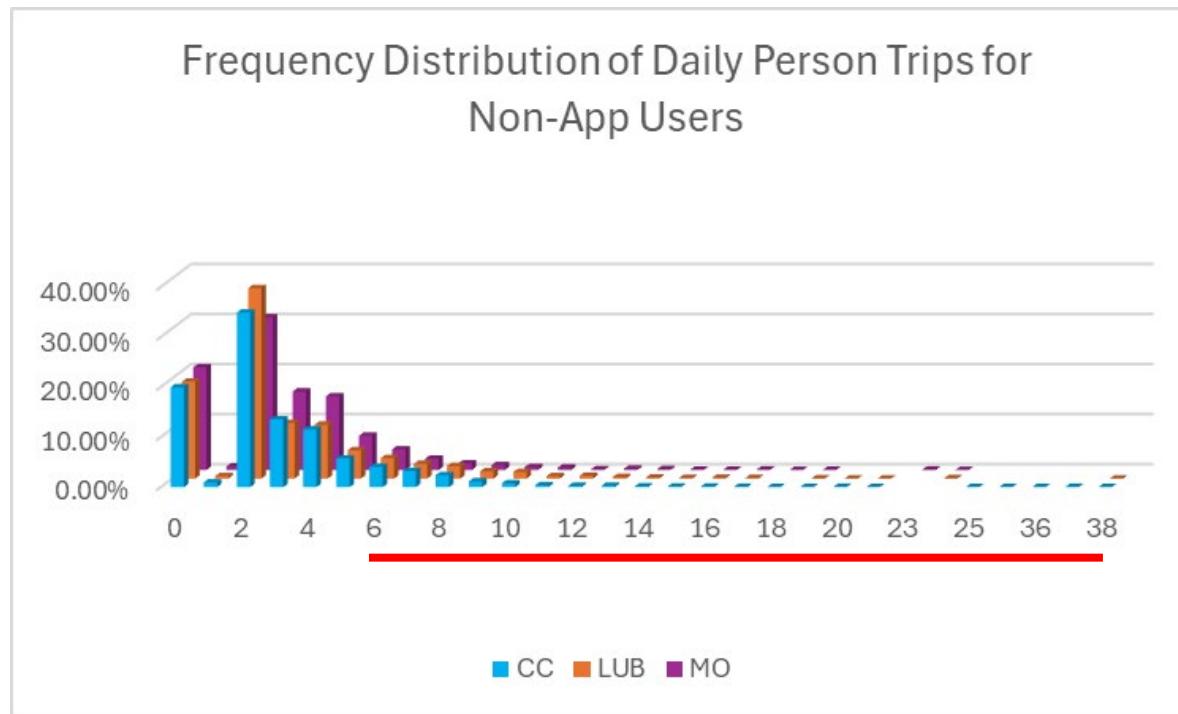
More Missed Tripends detected for Apple users (0.88) than for Android (0.49)
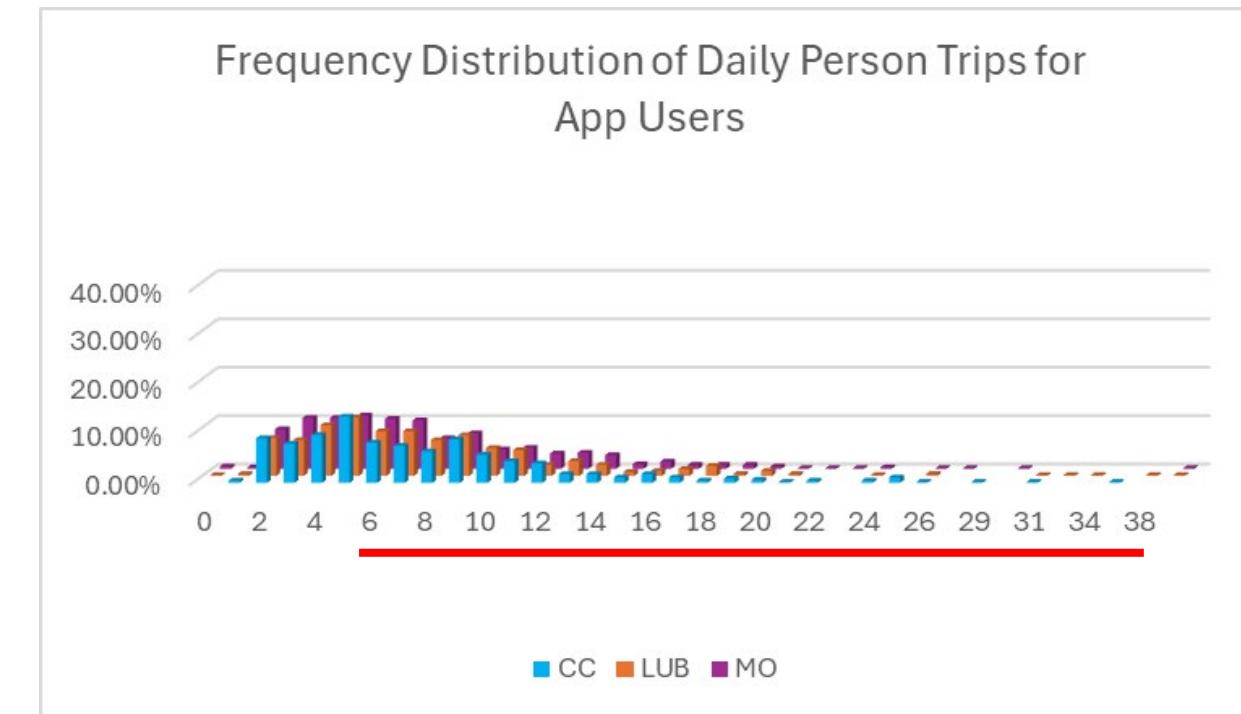
Average App use time burden estimated at approximately 9 minutes per person

App Trip Underreporting Mitigation and Future Research

- Opportunities identified in case study analysis:

  - Better estimates of regional VMT
  - Algorithm development and refinement,
  - Clearer/re-emphasized participant instructions
  - More user-friendly or intuitive App interfaces to facilitate trip editing/insertion
  - Stricter enforcement of accurate trip reporting
  - Incentives commensurate with reporting expectations,
  - TxDOT has not mandated App use thus far (due to potential bias, impact on response rates...but could be considered in the future)
  - Potential Austin or San Antonio Pilot: assigned participation mode to better assess impact of survey mode on travel reporting and trip rates
  - Possible implementation of trip rate correction factors
  - Future extraction of survey burden (time) for editing activities from vendor backend data

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Thank You!

Questions?