

TRANSPORT FINDINGS

Residential Context and Ethnic Stratification in Urban Travel Behaviour

Diana Saadi, Ph.D.¹, Karel Martens, Professor¹¹ Architecture and Town Planning, Technion – Israel Institute of Technology

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Findings

Mobility inequalities are commonly attributed to individual or cultural differences, yet they are often produced through long-standing spatial and infrastructural conditions. This study examines how residential context and ethnic stratification are associated with daily travel behaviour in the Tel Aviv metropolitan area. Using GPS-based data from the 2016–2017 Household Travel Survey (N = 13,503), we compare Jews living in Jewish towns (JJ), Arabs living in Jewish towns (AJ), and Arabs living in Arab towns (AA).

Weighted ANCOVA and interaction regression models show that AJ and JJ display highly similar travel distances, times, and speeds, while AA consistently experiences longer, slower, and more time-intensive travel. These disparities are substantially reduced under higher household vehicle availability and greater neighbourhood density.

Rather than reflecting intrinsic ethnic differences, the observed mobility gaps are consistent with ethnic stratification operating through residential context and access to transport resources. The findings contribute empirical evidence on the spatial structuring of mobility outcomes within a single metropolitan region.

1. Questions

Spatial differences in the built environment and transport accessibility are known to shape daily travel behaviour and mobility outcomes. In the Israeli context, these differences are closely linked to long-standing patterns of residential segregation and uneven infrastructural investment, particularly between Jewish and Arab towns.

Ethnic identity is therefore not expected to influence travel behaviour directly. Rather, it reflects historically produced spatial conditions—such as land-use structure, transport provision, and access to urban opportunities—that systematically shape everyday mobility. From this perspective, ethnicity functions as a proxy for structural and spatial disadvantage rather than an independent causal factor.

The presence of Arab residents living in Jewish towns provides a rare empirical opportunity to examine how residential context is associated with mobility outcomes within the same metropolitan region. The analysis compares Jews living in Jewish towns (JJ), Arabs living in Jewish towns (AJ),

and Arabs living in Arab towns (AA). Mixed cities are excluded due to their internal spatial heterogeneity, which limits the ability to assign a consistent residential context at the town level.

The study addresses two research questions:

1. Do Arabs living in Jewish towns exhibit travel behaviour patterns similar to Jews living in Jewish towns or to Arabs living in Arab towns?
2. To what extent do contextual factors—specifically household vehicle availability and neighbourhood density—attenuate observed mobility gaps between these groups?

2. Methods

Data Source

The analysis uses data from the 2016–2017 Tel Aviv Household Travel Survey, commissioned by Ayalon Highways and publicly available via OData Israel. The survey combines passive GPS tracking with detailed household and individual questionnaires, allowing precise measurement of daily travel behaviour. Household-level attributes are linked to individual respondents. Detailed documentation of data processing and weighting procedures is provided in the Supplementary Information (Section S1).

Sample and Group Definition

The final analytic sample includes 13,503 respondents residing in the Tel Aviv metropolitan area. Individuals are classified into three resident groups based on ethnic identity and town of residence: Jews living in Jewish towns (JJ), Arabs living in Jewish towns (AJ), and Arabs living in Arab towns (AA). Towns are classified according to official Central Bureau of Statistics designations. Mixed cities are excluded because their internal spatial heterogeneity makes it difficult to assign a consistent residential context at the town level. Jews residing in Arab towns are not analysed due to their very small representation in the dataset, which limits statistical reliability.

Outcomes and Predictors

Six travel outcomes are examined: total daily distance, commute distance, total daily travel time, commute time, mean travel speed, and the number of travel companions. Residential group indicators constitute the primary explanatory variables. Contextual factors include household vehicle availability and neighbourhood population density, both standardised as z-scores. All models control for age, gender, household size, and fuel-expense coverage. Full variable definitions are reported in the Supplementary Information (Section S3).

Analytical Strategy

The analysis follows a quasi-experimental, associational design. First, weighted analyses of covariance (ANCOVA) are used to estimate adjusted group differences in travel outcomes, reported as estimated marginal means (EMMs) with 95% confidence intervals. These estimates describe differences across resident groups after accounting for observed covariates.

Second, multiple regression models are estimated to examine whether contextual factors moderate observed group differences. Interaction terms between resident group and household vehicle availability, as well as between resident group and neighbourhood density, are included to assess how mobility gaps vary under different contextual conditions. All models apply survey weights and cluster standard errors at the household level. Complete model specifications and robustness checks are reported in the Supplementary Information (Sections S4–S6).

3. Findings

3.1. Group Differences in Travel Outcomes (Adjusted Means)

Adjusted group differences in travel behaviour are estimated using weighted analyses of covariance (ANCOVA). [Figure 1a](#) displays estimated marginal means (EMMs) with 95% confidence intervals for travel distance and time across the three resident groups: Jews living in Jewish towns (JJ), Arabs living in Jewish towns (AJ), and Arabs living in Arab towns (AA). [Figure 1b](#) presents corresponding adjusted means for travel speed and the number of travel companions.

Across all outcomes, AJ and JJ display closely aligned travel patterns, while AA differs substantially from both groups. For commute distance, JJ averages 2.30 km (95% CI: 2.22–2.38) and AJ averages 2.10 km (95% CI: 1.98–2.22), compared with 4.50 km for AA (95% CI: 4.12–4.88). Similar patterns are observed for total daily distance and total daily travel time: residents of Arab towns travel farther and spend more time traveling, while Arabs living in Jewish towns exhibit outcomes close to those of Jewish residents. Mean travel speed is lower in Arab towns than in Jewish towns, whereas the number of travel companions is higher among AA and AJ than among JJ. Full adjusted means for all six outcomes are reported in Supplementary Table S3.

3.2. Interaction Effects: Contextual Moderation

To examine whether contextual factors moderate observed group differences, interaction regression models are estimated including household vehicle availability and neighbourhood density. [Table 1](#) reports coefficients from the primary interaction model for commute distance, while full models for additional outcomes are reported in Supplementary Tables S5–S6.

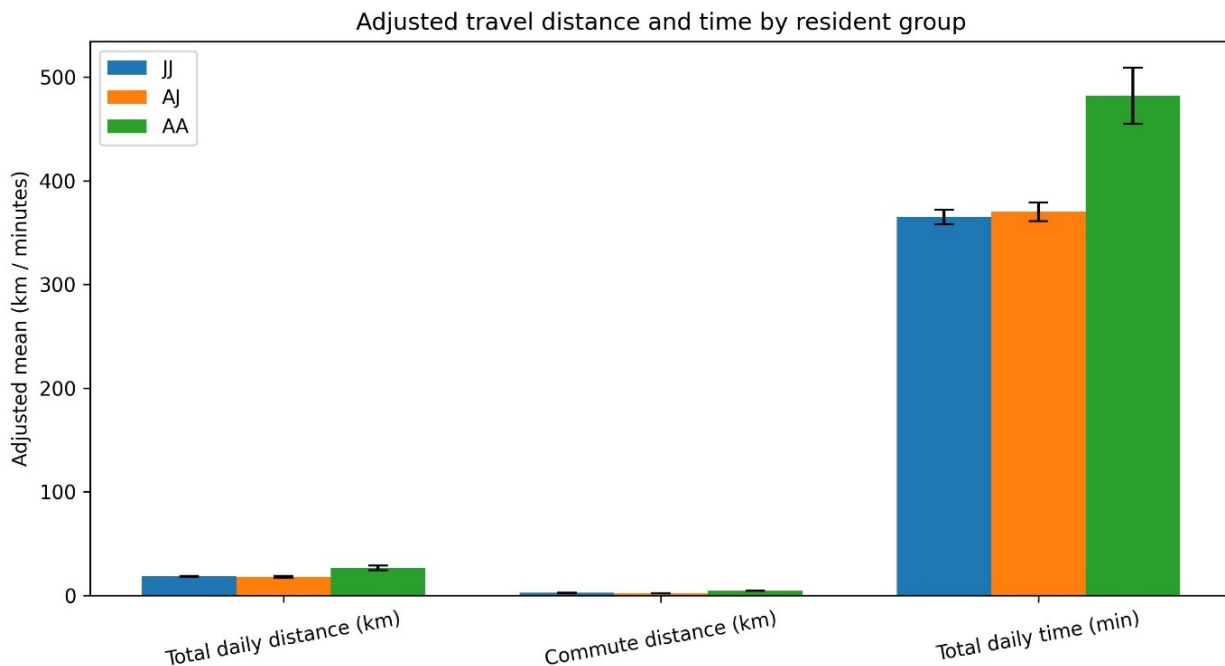


Figure 1a. Adjusted travel distance and time by resident group (JJ, AJ, AA).

Bars represent estimated marginal means with 95% confidence intervals from weighted ANCOVA models, adjusted for demographic and household characteristics. Distances are measured in kilometres and time in minutes.

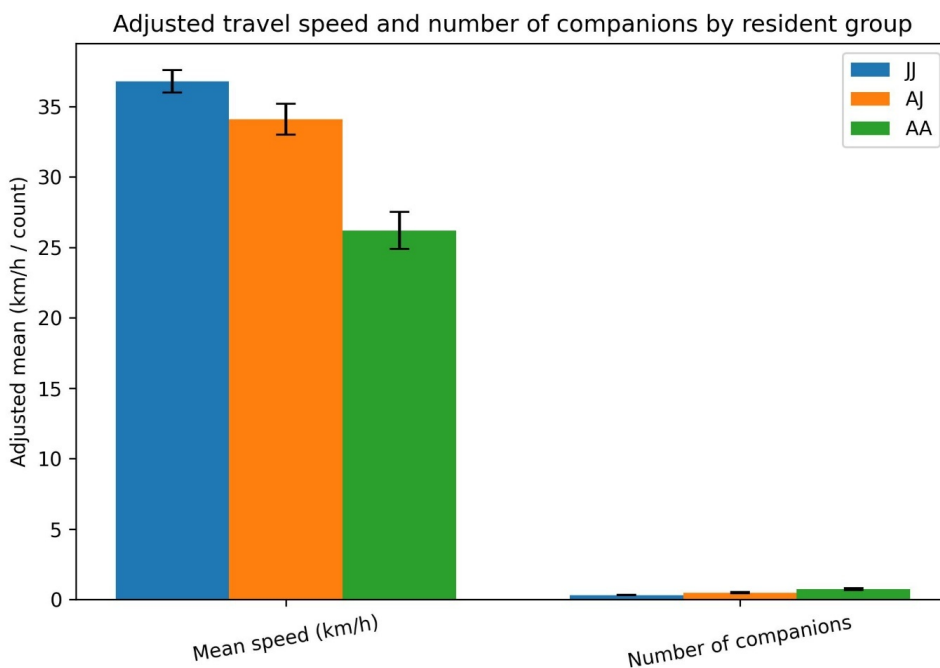


Figure 1b. Adjusted travel speed and number of companions by resident group (JJ, AJ, AA).

Bars represent estimated marginal means with 95% confidence intervals from weighted ANCOVA models. Mean speed is measured in kilometres per hour, and number of companions reflects the average count per trip.

Results indicate that household vehicle availability and neighbourhood density are both significantly associated with commute distance. Higher vehicle availability is associated with longer commute distances overall;

Table 1. Interaction effects on commute distance (weighted regression model).

Predictor	B	SE	p
AJ (vs JJ)	-0.18	0.06	.003
AA (vs JJ)	1.95	0.21	<.001
Vehicles (z)	0.42	0.05	<.001
Density (z)	-0.25	0.04	<.001
AA × Vehicles	-0.28	0.09	.002
AA × Density	-0.22	0.07	.002

however, the interaction term indicates that greater vehicle availability attenuates the commute distance gap between residents of Arab towns and the JJ reference group. Similarly, higher neighbourhood density is associated with shorter commute distances and reduces the magnitude of the AA–JJ difference. In contrast, coefficients for the AJ group are small and mostly statistically non-significant, indicating limited evidence of contextual moderation for Arabs residing in Jewish towns.

3.3. Summary of Empirical Patterns

Taken together, the results document a consistent empirical pattern across multiple mobility indicators. Residents of Arab towns experience systematically longer and slower travel than residents of Jewish towns, while Arabs residing in Jewish towns exhibit mobility outcomes similar to those of Jewish residents. Differences between residents of Arab and Jewish towns are partially mitigated under conditions of higher household vehicle availability and greater neighbourhood density, but they are not fully eliminated.

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SUPPLEMENTAL INFORMATION

Includes:

- **S1:** Data source, GPS processing, weighting
- **S2:** Spatial variables (CBS link)
- **S3:** Variable definitions
- **S4:** Full EMMs of all six outcomes
- **S5:** Full regression models
- **S6:** Robustness checks

S1. Data Sources and Processing

SI.1. PRIMARY DATASET: TEL AVIV HOUSEHOLD TRAVEL SURVEY (2016–2017)

Data come from the **Tel Aviv Household Travel Survey (2016–2017)**, commissioned by *Ayalon Highways Ltd.* and publicly available via OData Israel: <https://www.odata.org.il/dataset/b837a15c-2cda-4597-b04b-f9b6a7e462b5>

The survey integrates passive **GPS traces** with household and person-level survey responses.

SI.2. SPATIAL INDICATORS

Neighbourhood population density (persons/km²) was obtained from the **Israel Central Bureau of Statistics (CBS)**, 2016 data: <https://www.cbs.gov.il>

SI.3. PROCESSING STEPS

- Trip extraction used GPS-derived trajectories cleaned for signal loss.
- Trips <80 m or <45 seconds were removed (standard rule).
- Implausible speeds (>160 km/h) were flagged and corrected.
- Household variables were attached to individuals.
- Calibration weights were aligned to ICBS marginals (age × gender × region).
- Standard errors were clustered at the household level.

CAPTION (S1)

S1 provides complete documentation of data sources, GPS processing, spatial data, and weighting procedures used to construct the analytic file.

S2. Weighted Sample Composition and Demographics

Table S1. Weighted sample composition and demographics by group

Variable	JJ (weighted)	AJ (weighted)	AA (weighted)
N (% of sample)	12,063 (89.3%)	1,107 (8.2%)	333 (2.5%)
Age (years), mean (SD)	47.9 (17.8)	44.1 (19.1)	29.5 (19.0)
Household size	2.92 (1.77)	2.31 (1.61)	3.75 (1.46)
Vehicles per household	1.14 (0.84)	0.81 (0.75)	1.30 (0.68)
Neighbourhood density (persons/km ²)	6,800 (3,100)	7,100 (3,200)	3,200 (1,400)
Male (%)	49.5%	48.3%	58.3%
Female (%)	50.5%	51.7%	41.7%

Table S1 reports weighted demographic and structural characteristics for each resident group. These variables are used as covariates and contextual indicators in all models.

S3. Variable Definitions

Table S2. Variables and measures used in the study

Construct	Variable	Definition / Unit	Source
Travel outcome	Total daily distance	Sum of all trip distances per person (km)	GPS + survey
Travel outcome	Commute distance	Home→work distance (km)	GPS + survey
Travel outcome	Total daily time	Sum of trip durations per day (minutes)	GPS + survey
Travel outcome	Commute time	Home→work duration (minutes)	GPS + survey
Travel outcome	Mean speed	Total distance / total time (km/h)	Derived
Travel outcome	Travel companions	Number of persons accompanying (count)	Survey
Resource	Household vehicles	0/1/2+ vehicles	Survey
HH composition	Household size	Persons per household	Survey
Neighbourhood	Population density	Residents per km ²	CBS
Temporal	Time-of-day	Start / Mid / End	Derived
Group	JJ / AJ / AA	Resident group	Registry + survey
Weighting	Survey weight	Calibration weights	Provider; ICBS

Table S2 defines all outcome and predictor variables used in the main text and robustness analyses.

S4. ANCOVA Estimated Marginal Means

These EMMs correspond to the values shown in [Figure 1](#) in the main article.

Table S3. Estimated Marginal Means (EMMs) \pm 95% CI

Outcome	JJ	AJ	AA
Commute distance (km)	2.30 (2.22–2.38)	2.10 (1.98–2.22)	4.50 (4.12–4.88)
Total daily distance (km)	18.4 (17.8–19.0)	17.9 (16.8–19.0)	26.5 (24.1–28.8)
Total daily time (min)	365 (358–372)	370 (361–379)	482 (455–509)
Commute time (min)	18.5 (17.9–19.2)	17.8 (17.0–18.7)	27.9 (25.5–30.3)
Mean speed (km/h)	36.8 (36.0–37.6)	34.1 (33.0–35.2)	26.2 (24.9–27.5)
Travel companions (count)	0.31 (0.29–0.33)	0.48 (0.44–0.52)	0.72 (0.65–0.79)

Table S3 summarizes adjusted mean differences across groups. AJ aligns closely with JJ, while AA shows consistently higher distances and times and lower speeds.

S5. Full Regression Models (Six Outcomes)

Below are the key models beyond the one displayed in the main article.

Table S4. Regression: Total Daily Distance

Predictor	B	SE	p
AJ	-0.55	0.28	.046
AA	6.98	0.73	<.001
Vehicles	1.28	0.14	<.001
Density	-0.42	0.09	<.001
AA \times Vehicles	-1.05	0.33	.002
AA \times Density	-0.78	0.25	.003

The model shows that AA travels substantially farther per day than JJ/AJ; contextual variables reduce this gap.

Table S5. Regression: Total Daily Time

Predictor	B	SE	p
AJ	3.4	4.1	.41
AA	112.5	18.3	<.001
Vehicles	-15.2	2.3	<.001
Density	-8.9	2.1	<.001
AA \times Vehicles	-12.5	4.8	.008
AA \times Density	-10.8	4.1	.01

AA spends substantially more time traveling; vehicles and density reduce the disadvantage.

Table S6. Regression: Mean Speed

Predictor	B	SE	p
AJ	-1.2	0.9	.19
AA	-8.7	1.7	<.001
Vehicles	1.9	0.3	<.001
Density	-0.8	0.3	.01
AA \times Vehicles	1.3	0.5	.011
AA \times Density	1.0	0.4	.016

AA travels more slowly; improved resources mitigate this.

S6. Sensitivity Checks

Table S7. Alternative Specifications

Outcome	Changes	Effect
Commute distance	Without weights	Same sign/size
Total daily distance	Robust to trimming the top 1%	Stable
Mean speed	Excluding extreme outliers	Stable
Travel companions	Poisson vs OLS models	No change in significance

All outcomes are robust to alternative modelling specifications.