

Supplementary Information:

Weathering the Ride: How Heat, Smoke, Rain, and Ozone Shape Bus Ridership in Colorado

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S1 Figures

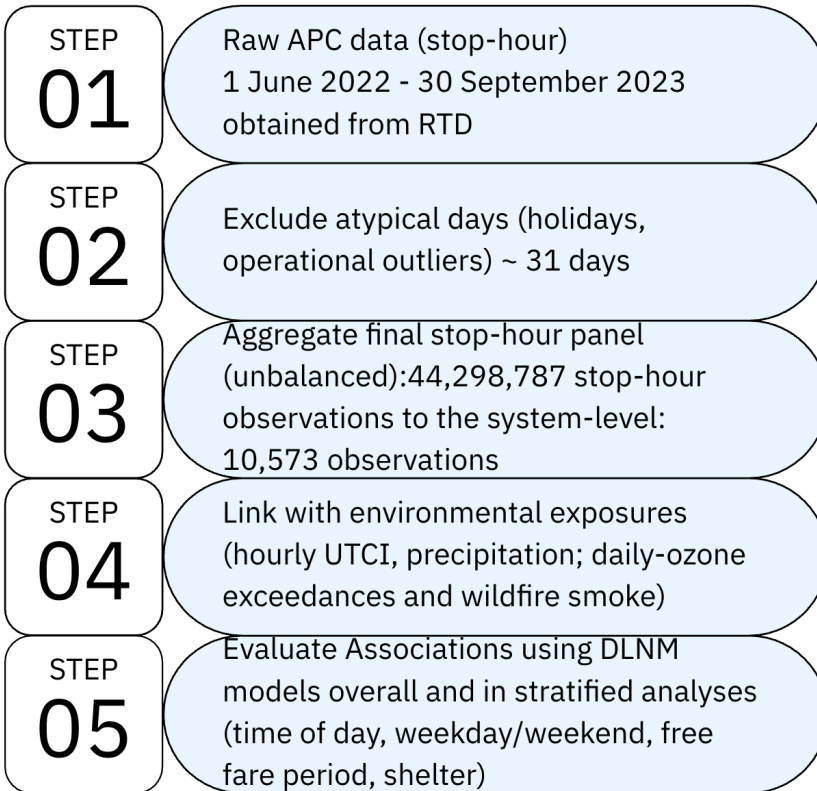


Figure S1: Flow diagram of data processing and analytic sample construction. Raw Automatic Passenger Counter (APC) data were filtered to remove atypical and disrupted days, linked to environmental exposures, and aggregated to a system-level hourly time series. Stratified analyses were conducted by time period, season, fare policy, and shelter availability.

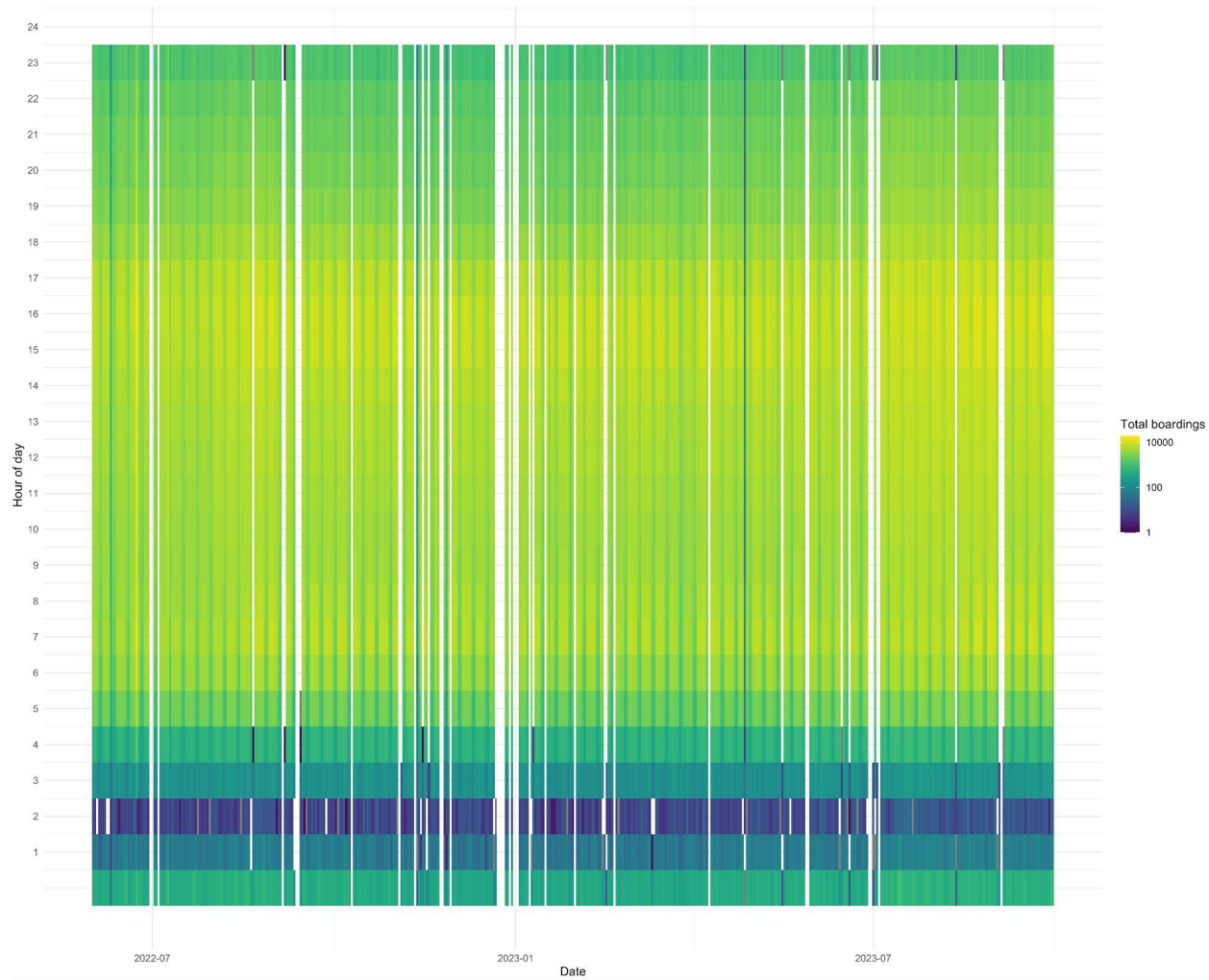


Figure S2: Heat map of total ridership over all stops by hour across the study time period.

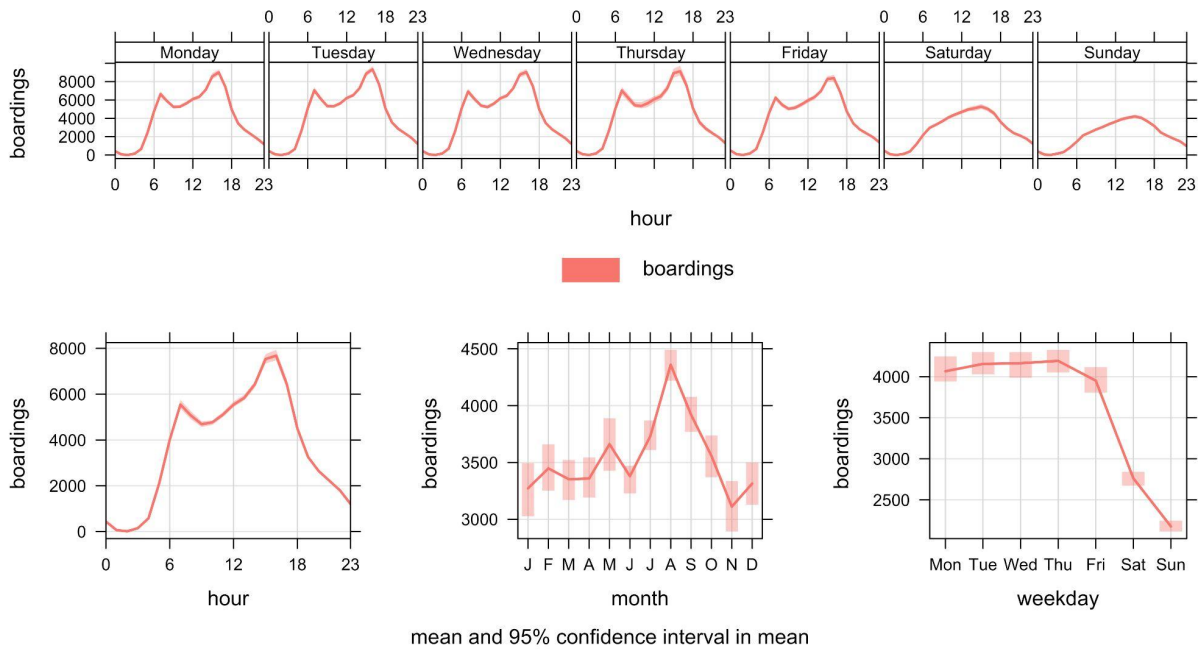


Figure S3: Time variation of total hourly boardings across all bus stops for an average week, day, season, weekday/weekend.

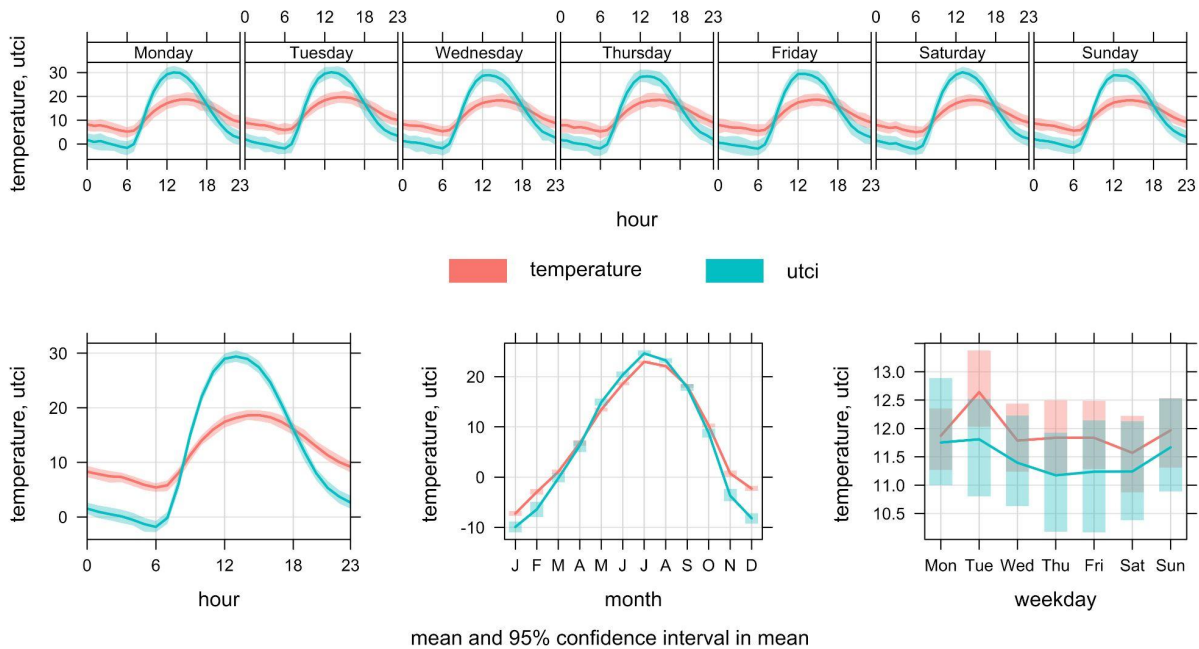


Figure S4: Time variation of mean ERA5-Land temperature (°C) and UTCI (°C) at bus stops over an average week, day, season, weekday/weekend.

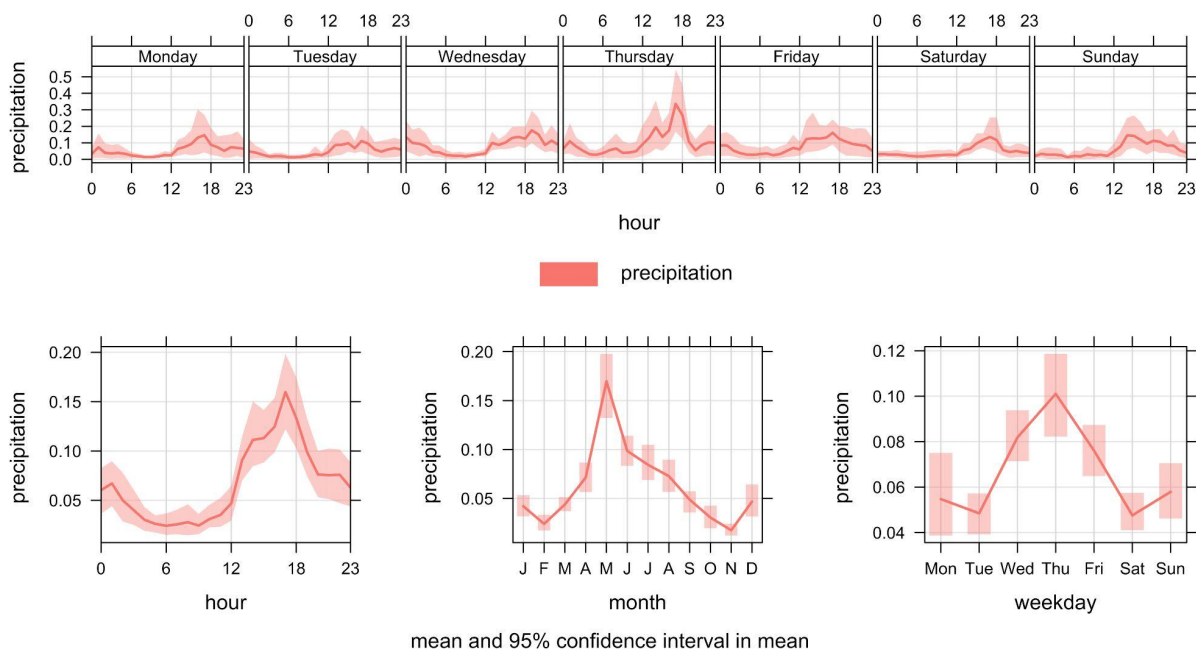


Figure S5: Time variation of mean ERA5-Land precipitation (mm) at bus stops over an average week, day, season, weekday/weekend.

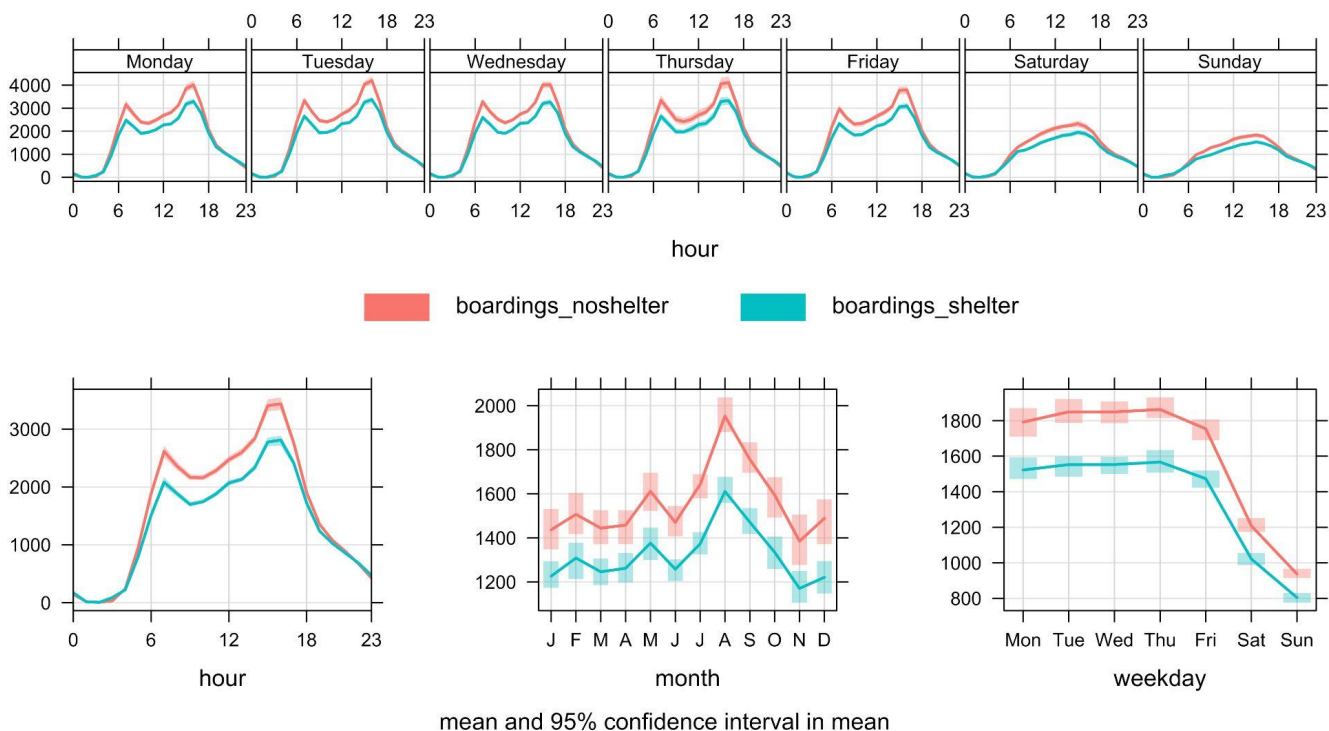


Figure S6: Time variation of total hourly boardings across all bus stops, disaggregated by shelter presence, for an average week, day, season, and weekday/weekend.

S2 Tables

Table S1: Associations between wildfire smoke, ozone exceedance, and hourly bus ridership. Relative risks (RRs) and percent changes in expected system-wide hourly boardings are estimated using fixed-effects negative binomial models, adjusted for distributed-lag nonlinear terms for thermal stress (UTCI) and precipitation (lags 0-24 hours), along with fixed effects for hour of day, day of week, and month-year. Wildfire smoke is modeled as a categorical variable (light, medium, heavy) relative to no-smoke conditions, based on NOAA HMS plume classifications. Ozone exceedance is defined as days on which the maximum 8-hour average ozone concentration exceeded 0.070 ppm at any Front Range regulatory monitor. Percent changes are derived from exponentiated coefficients ($100 \times [RR - 1]$). Standard errors are clustered at the day level.

Exposure	Contrast	RR (95% CI)	% change (95% CI)	p-value
Wildfire Smoke	Light Smoke	1.027 (0.988, 1.068)	2.7% (-1.2%, 6.8%)	0.173
Wildfire Smoke	Medium Smoke	0.985 (0.940, 1.031)	-1.5% (-6.0%, 3.1%)	0.515
Wildfire Smoke	Heavy Smoke	0.997 (0.951, 1.045)	-0.3% (-4.9%, 4.5%)	0.889
Ozone exceedance	Ozone Exceedance Day	0.991 (0.943, 1.041)	-0.9% (-5.7%, 4.1%)	0.714

Table S2: Percent changes in expected boardings (95% confidence intervals) comparing cold (10th percentile) and hot (90th percentile) Universal Thermal Climate Index (UTCI) values and wet (90th percentile) hourly precipitation with median conditions, estimated from system-wide fixed-effects negative binomial distributed lag nonlinear models stratified by period (AM weekday, Midday weekday (MD), PM weekday, Early/Late weekday (EL), and Weekend), season (Spring, Summer, Fall, Winter), and free-fare periods (free fare versus fare-required). Cumulative effects are shown over 0-3, 0-6, 0-12, and 0-24 hour lag windows. Models adjust for hour-of-day, day-of-week, and calendar-month fixed effects, with standard errors clustered by day. N hours and N days denote the number of hourly observations and unique days contributing to each period-specific model. Significant associations are **bolded**

Stratum	Exposure	Contrast	Lag window	Percent change in boardings (95% CI)	N hours	N days
Period						
AM weekday	Precipitation	Wet (p90) vs median	0-3 hr	4.2% (-5.2%, 14.6%)	906	302
AM weekday	Precipitation	Wet (p90) vs median	0-6 hr	5.6% (-5.2%, 17.7%)	906	302

AM weekday	Precipitation	Wet (p90) vs median	0-12 hr	5.3% (-10.3%, 23.7%)	906	302
AM weekday	Precipitation	Wet (p90) vs median	0-24 hr	8.1% (-18.0%, 42.5%)	906	302
AM weekday	UTCI	Cold (p10) vs median	0-3 hr	-0.0% (-15.3%, 17.9%)	906	302
AM weekday	UTCI	Cold (p10) vs median	0-6 hr	14.4% (-30.7%, 88.8%)	906	302
AM weekday	UTCI	Cold (p10) vs median	0-12 hr	8.4% (-32.6%, 74.5%)	906	302
AM weekday	UTCI	Cold (p10) vs median	0-24 hr	31.5% (-12.2%, 96.9%)	906	302
AM weekday	UTCI	Hot (p90) vs median	0-3 hr	-15.5% (-26.9%, -2.3%)	906	302
AM weekday	UTCI	Hot (p90) vs median	0-6 hr	-21.3% (-34.8%, -5.0%)	906	302
AM weekday	UTCI	Hot (p90) vs median	0-12 hr	-27.9% (-40.7%, -12.3%)	906	302
AM weekday	UTCI	Hot (p90) vs median	0-24 hr	-32.9% (-45.3%, -17.6%)	906	302
Early/Late weekday	Precipitation	Wet (p90) vs median	0-3 hr	-13.0% (-19.1%, -6.4%)	3435	394
Early/Late weekday	Precipitation	Wet (p90) vs median	0-6 hr	-13.2% (-20.7%, -5.0%)	3435	394
Early/Late weekday	Precipitation	Wet (p90) vs median	0-12 hr	-3.8% (-15.7%, 9.7%)	3435	394
Early/Late weekday	Precipitation	Wet (p90) vs median	0-24 hr	-0.1% (-15.9%, 18.5%)	3435	394
Early/Late weekday	UTCI	Cold (p10) vs median	0-3 hr	-17.3% (-26.7%, -6.7%)	3435	394
Early/Late weekday	UTCI	Cold (p10) vs median	0-6 hr	-19.7% (-32.0%, -5.3%)	3435	394
Early/Late weekday	UTCI	Cold (p10) vs median	0-12 hr	-6.5% (-17.7%, 6.3%)	3435	394
Early/Late weekday	UTCI	Cold (p10) vs median	0-24 hr	6.8% (-8.4%, 24.4%)	3435	394
Early/Late weekday	UTCI	Hot (p90) vs median	0-3 hr	14.4% (5.8%, 23.6%)	3435	394
Early/Late weekday	UTCI	Hot (p90) vs median	0-6 hr	5.1% (-5.3%, 16.7%)	3435	394
Early/Late weekday	UTCI	Hot (p90) vs median	0-12 hr	-3.9% (-17.9%, 12.6%)	3435	394
Early/Late weekday	UTCI	Hot (p90) vs median	0-24 hr	1.0% (-7.6%, 10.3%)	3435	394
Midday weekday	Precipitation	Wet (p90) vs median	0-3 hr	-9.4% (-14.3%, -4.2%)	1836	306
Midday weekday	Precipitation	Wet (p90) vs median	0-6 hr	-16.9% (-24.8%, -8.3%)	1836	306
Midday weekday	Precipitation	Wet (p90) vs median	0-12 hr	-29.4% (-42.4%, -13.4%)	1836	306
Midday weekday	Precipitation	Wet (p90) vs median	0-24 hr	-35.0% (-46.6%, -20.9%)	1836	306
Midday weekday	UTCI	Cold (p10) vs median	0-3 hr	-3.1% (-16.9%, 13.1%)	1836	306
Midday weekday	UTCI	Cold (p10) vs median	0-6 hr	0.3% (-16.9%, 21.1%)	1836	306
Midday weekday	UTCI	Cold (p10) vs median	0-12 hr	7.0% (-16.5%, 37.3%)	1836	306

Midday weekday	UTCI	Cold (p10) vs median	0-24 hr	20.6% (-27.3%, 99.8%)	1836	306
Midday weekday	UTCI	Hot (p90) vs median	0-3 hr	-6.4% (-13.7%, 1.5%)	1836	306
Midday weekday	UTCI	Hot (p90) vs median	0-6 hr	-12.6% (-20.2%, -4.3%)	1836	306
Midday weekday	UTCI	Hot (p90) vs median	0-12 hr	-20.4% (-36.5%, -0.3%)	1836	306
Midday weekday	UTCI	Hot (p90) vs median	0-24 hr	-16.8% (-30.9%, 0.2%)	1836	306
PM weekday	Precipitation	Wet (p90) vs median	0-3 hr	-2.6% (-14.4%, 10.9%)	1216	381
PM weekday	Precipitation	Wet (p90) vs median	0-6 hr	-6.0% (-19.1%, 9.3%)	1216	381
PM weekday	Precipitation	Wet (p90) vs median	0-12 hr	-11.6% (-25.9%, 5.5%)	1216	381
PM weekday	Precipitation	Wet (p90) vs median	0-24 hr	-11.9% (-35.0%, 19.3%)	1216	381
PM weekday	UTCI	Cold (p10) vs median	0-3 hr	-9.8% (-18.9%, 0.3%)	1216	381
PM weekday	UTCI	Cold (p10) vs median	0-6 hr	-2.3% (-13.8%, 10.8%)	1216	381
PM weekday	UTCI	Cold (p10) vs median	0-12 hr	3.3% (-16.0%, 27.1%)	1216	381
PM weekday	UTCI	Cold (p10) vs median	0-24 hr	1.8% (-13.9%, 20.4%)	1216	381
PM weekday	UTCI	Hot (p90) vs median	0-3 hr	2.6% (-6.8%, 13.0%)	1216	381
PM weekday	UTCI	Hot (p90) vs median	0-6 hr	-5.9% (-15.4%, 4.6%)	1216	381
PM weekday	UTCI	Hot (p90) vs median	0-12 hr	-10.7% (-23.4%, 4.1%)	1216	381
PM weekday	UTCI	Hot (p90) vs median	0-24 hr	14.3% (-5.3%, 38.0%)	1216	381
Weekend	Precipitation	Wet (p90) vs median	0-3 hr	-0.5% (-14.5%, 15.9%)	3059	198
Weekend	Precipitation	Wet (p90) vs median	0-6 hr	7.4% (-16.4%, 38.0%)	3059	198
Weekend	Precipitation	Wet (p90) vs median	0-12 hr	33.8% (-14.9%, 110.3%)	3059	198
Weekend	Precipitation	Wet (p90) vs median	0-24 hr	63.0% (-13.6%, 207.6%)	3059	198
Weekend	UTCI	Cold (p10) vs median	0-3 hr	-19.5% (-30.1%, -7.3%)	3059	198
Weekend	UTCI	Cold (p10) vs median	0-6 hr	-19.5% (-31.9%, -4.7%)	3059	198
Weekend	UTCI	Cold (p10) vs median	0-12 hr	-10.1% (-27.4%, 11.3%)	3059	198
Weekend	UTCI	Cold (p10) vs median	0-24 hr	-9.0% (-34.8%, 27.0%)	3059	198
Weekend	UTCI	Hot (p90) vs median	0-3 hr	-1.7% (-10.1%, 7.5%)	3059	198
Weekend	UTCI	Hot (p90) vs median	0-6 hr	-3.6% (-16.4%, 11.1%)	3059	198
Weekend	UTCI	Hot (p90) vs median	0-12 hr	-10.5% (-28.6%, 12.2%)	3059	198
Weekend	UTCI	Hot (p90) vs median	0-24 hr	-26.8% (-46.4%, -0.0%)	3059	198

AM weekday	Ozone exceedance	-	-	7.3% (1.2%, 13.7%)	906	302
Early/Late weekday	Ozone exceedance	-	-	3.3% (-1.8%, 8.7%)	3435	394
Midday weekday	Ozone exceedance	-	-	-0.6% (-5.6%, 4.6%)	1836	306
PM weekday	Ozone exceedance	-	-	0.5% (-3.5%, 4.6%)	1216	381
Weekend	Ozone exceedance	-	-	0.5% (-5.3%, 6.7%)	3059	198
AM weekday	Heavy smoke	-	-	-16.6% (-30.2%, -0.3%)	906	302
AM weekday	Light smoke	-	-	2.7% (-1.3%, 6.8%)	906	302
AM weekday	Medium smoke	-	-	-6.8% (-13.0%, -0.1%)	906	302
Early/Late weekday	Heavy smoke	-	-	-3.5% (-15.8%, 10.5%)	3435	394
Early/Late weekday	Light smoke	-	-	5.0% (0.8%, 9.3%)	3435	394
Early/Late weekday	Medium smoke	-	-	-5.7% (-13.0%, 2.3%)	3435	394
Midday weekday	Heavy smoke	-	-	4.7% (-6.1%, 16.6%)	1836	306
Midday weekday	Light smoke	-	-	4.6% (-0.4%, 9.8%)	1836	306
Midday weekday	Medium smoke	-	-	3.4% (-2.0%, 9.1%)	1836	306
PM weekday	Heavy smoke	-	-	6.3% (-2.4%, 15.8%)	1216	381
PM weekday	Light smoke	-	-	1.4% (-2.7%, 5.8%)	1216	381
PM weekday	Medium smoke	-	-	-0.8% (-7.5%, 6.3%)	1216	381
Weekend	Heavy smoke	-	-	-15.1% (-30.4%, 3.5%)	3059	198
Weekend	Light smoke	-	-	-3.6% (-10.6%, 3.9%)	3059	198
Weekend	Medium smoke	-	-	-1.6% (-9.0%, 6.4%)	3059	198
Season						
Fall	Precipitation	Wet (p90) vs median	0-3hr	-10.4% (-18.8%, -1.0%)	2500	119
Fall	Precipitation	Wet (p90) vs median	0-6hr	-13.9% (-24.8%, -1.4%)	2500	119
Fall	Precipitation	Wet (p90) vs median	0-12hr	-20.1% (-35.7%, -0.6%)	2500	119
Fall	Precipitation	Wet (p90) vs median	0-24hr	-33.4% (-48.9%, -13.2%)	2500	119
Fall	UTCI	Cold (p10) vs median	0-3hr	-7.0% (-18.4%, 5.9%)	2500	119
Fall	UTCI	Cold (p10) vs median	0-6hr	-2.5% (-15.4%, 12.5%)	2500	119

Fall	UTCI	Cold (p10) vs median	0-12hr	-0.3% (-13.5%, 14.9%)	2500	119
Fall	UTCI	Cold (p10) vs median	0-24hr	-25.3% (-41.8%, -4.3%)	2500	119
Fall	UTCI	Hot (p90) vs median	0-3hr	-3.3% (-14.1%, 8.9%)	2500	119
Fall	UTCI	Hot (p90) vs median	0-6hr	-3.9% (-19.6%, 14.9%)	2500	119
Fall	UTCI	Hot (p90) vs median	0-12hr	-2.6% (-24.1%, 24.9%)	2500	119
Fall	UTCI	Hot (p90) vs median	0-24hr	-15.4% (-39.5%, 18.3%)	2500	119
Spring	Precipitation	Wet (p90) vs median	0-3hr	-7.7% (-15.2%, 0.3%)	2087	91
Spring	Precipitation	Wet (p90) vs median	0-6hr	-9.6% (-18.6%, 0.4%)	2087	91
Spring	Precipitation	Wet (p90) vs median	0-12hr	-11.9% (-25.6%, 4.2%)	2087	91
Spring	Precipitation	Wet (p90) vs median	0-24hr	-22.7% (-53.2%, 27.5%)	2087	91
Spring	UTCI	Cold (p10) vs median	0-3hr	-13.3% (-23.8%, -1.4%)	2087	91
Spring	UTCI	Cold (p10) vs median	0-6hr	-11.9% (-22.9%, 0.7%)	2087	91
Spring	UTCI	Cold (p10) vs median	0-12hr	-2.2% (-16.0%, 13.9%)	2087	91
Spring	UTCI	Cold (p10) vs median	0-24hr	10.7% (-17.5%, 48.5%)	2087	91
Spring	UTCI	Hot (p90) vs median	0-3hr	8.0% (-3.3%, 20.5%)	2087	91
Spring	UTCI	Hot (p90) vs median	0-6hr	10.2% (-3.1%, 25.4%)	2087	91
Spring	UTCI	Hot (p90) vs median	0-12hr	1.9% (-20.4%, 30.6%)	2087	91
Spring	UTCI	Hot (p90) vs median	0-24hr	7.8% (-24.7%, 54.4%)	2087	91
Summer	Precipitation	Wet (p90) vs median	0-3hr	8.3% (-2.9%, 20.7%)	4126	183
Summer	Precipitation	Wet (p90) vs median	0-6hr	13.5% (-2.0%, 31.4%)	4126	183
Summer	Precipitation	Wet (p90) vs median	0-12hr	12.6% (-6.4%, 35.5%)	4126	183
Summer	Precipitation	Wet (p90) vs median	0-24hr	-12.8% (-41.5%, 30.0%)	4126	183
Summer	UTCI	Cold (p10) vs median	0-3hr	2.0% (-8.1%, 13.1%)	4126	183
Summer	UTCI	Cold (p10) vs median	0-6hr	2.9% (-8.8%, 16.2%)	4126	183
Summer	UTCI	Cold (p10) vs median	0-12hr	-0.2% (-16.2%, 18.7%)	4126	183
Summer	UTCI	Cold (p10) vs median	0-24hr	13.7% (-6.9%, 38.9%)	4126	183
Summer	UTCI	Hot (p90) vs median	0-3hr	2.0% (-6.4%, 11.1%)	4126	183
Summer	UTCI	Hot (p90) vs median	0-6hr	2.8% (-7.2%, 13.7%)	4126	183
Summer	UTCI	Hot (p90) vs median	0-12hr	-7.6% (-24.0%, 12.3%)	4126	183

Summer	UTCI	Hot (p90) vs median	0-24hr	-21.5% (-42.4%, 7.0%)	4126	183
Winter	Precipitation	Wet (p90) vs median	0-3hr	-8.9% (-16.5%, -0.6%)	1763	84
Winter	Precipitation	Wet (p90) vs median	0-6hr	-9.9% (-19.6%, 1.0%)	1763	84
Winter	Precipitation	Wet (p90) vs median	0-12hr	-10.8% (-24.5%, 5.4%)	1763	84
Winter	Precipitation	Wet (p90) vs median	0-24hr	-15.8% (-34.8%, 8.8%)	1763	84
Winter	UTCI	Cold (p10) vs median	0-3hr	-7.4% (-14.4%, 0.1%)	1763	84
Winter	UTCI	Cold (p10) vs median	0-6hr	-4.5% (-11.9%, 3.5%)	1763	84
Winter	UTCI	Cold (p10) vs median	0-12hr	-6.3% (-15.8%, 4.2%)	1763	84
Winter	UTCI	Cold (p10) vs median	0-24hr	-6.2% (-18.0%, 7.2%)	1763	84
Free-Fare						
Free fare	Precipitation	Wet (p90) vs median	0-3hr	8.4% (%-4.3, %22.8)	2106	94
Free fare	Precipitation	Wet (p90) vs median	0-6hr	11.5% (-5.6%, 31.8%)	2106	94
Free fare	Precipitation	Wet (p90) vs median	0-12hr	12.7% (-14.1, 48.0)	2106	94
Free fare	Precipitation	Wet (p90) vs median	0-24hr	41.1% (-6.5, 113.0)	2106	94
Free fare	UTCI	Cold (p10) vs median	0-3hr	8.7% (-5.2, 24.7)	2106	94
Free fare	UTCI	Cold (p10) vs median	0-6hr	12.0% (-5.3, 32.5)	2106	94
Free fare	UTCI	Cold (p10) vs median	0-12hr	7.1% (-13.7, 32.7)	2106	94
Free fare	UTCI	Cold (p10) vs median	0-24hr	16.0% (-8.7, 47.2)	2106	94
Free fare	UTCI	Hot (p90) vs median	0-3hr	9.0% (-3.9, 23.7)	2106	94
Free fare	UTCI	Hot (p90) vs median	0-6hr	23.3% (2.1, 48.9)	2106	94
Free fare	UTCI	Hot (p90) vs median	0-12hr	25.0% (-1.5, 58.6)	2106	94
Free fare	UTCI	Hot (p90) vs median	0-24hr	9.9% (-18.0, 47.3)	2106	94
Not free fare	Precipitation	Wet (p90) vs median	0-3hr	-8.4% (-14.4, -1.9)	6398	294
Not free fare	Precipitation	Wet (p90) vs median	0-6hr	-8.6% (-16.1, -0.4)	6398	294
Not free fare	Precipitation	Wet (p90) vs median	0-12hr	-4.9% (-15.9, 7.5)	6398	294
Not free fare	Precipitation	Wet (p90) vs median	0-24hr	1.5% (-26.4, 40.0)	6398	294
Not free fare	UTCI	Cold (p10) vs median	0-3hr	-10.5% (-16.3, -4.3)	6398	294
Not free fare	UTCI	Cold (p10) vs median	0-6hr	-10.8% (-18.1, -2.8)	6398	294
Not free fare	UTCI	Cold (p10) vs median	0-12hr	-9.8% (-20.0, 1.6)	6398	294

Not free fare	UTCI	Cold (p10) vs median	0-24hr	-8.9% (-21.7, 6.0)	6398	294
Not free fare	UTCI	Hot (p90) vs median	0-3hr	2.1% (-3.7, 8.3)	6398	294
Not free fare	UTCI	Hot (p90) vs median	0-6hr	3.9% (-3.6, 12.0)	6398	294
Not free fare	UTCI	Hot (p90) vs median	0-12hr	8.6% (-4.0, 22.9)	6398	294
Not free fare	UTCI	Hot (p90) vs median	0-24hr	-1.3% (-19.1, 20.3)	6398	294
Not free fare Summer	Precipitation	Wet (p90) vs median	0-3hr	17.5% (-4.2, 44.1)	1996	89
Not free fare Summer	Precipitation	Wet (p90) vs median	0-6hr	28.8% (-3.6, 72.0)	1996	89
Not free fare Summer	Precipitation	Wet (p90) vs median	0-12hr	30.3% (-11.0, 90.8)	1996	89
Not free fare Summer	Precipitation	Wet (p90) vs median	0-24hr	-24.1% (-54.6, 26.9)	1996	89
Not free fare Summer	UTCI	Cold (p10) vs median	0-3hr	0.9% (-14.4, 18.9)	1996	89
Not free fare Summer	UTCI	Cold (p10) vs median	0-6hr	9.1% (-11.0, 33.7)	1996	89
Not free fare Summer	UTCI	Cold (p10) vs median	0-12hr	22.2% (-10.1, 66.2)	1996	89
Not free fare Summer	UTCI	Cold (p10) vs median	0-24hr	59.4% (2.2, 148.8)	1996	89
Not free fare Summer	UTCI	Hot (p90) vs median	0-3hr	7.2% (-6.8, 23.2)	1996	89
Not free fare Summer	UTCI	Hot (p90) vs median	0-6hr	3.1% (-11.1, 19.6)	1996	89
Not free fare Summer	UTCI	Hot (p90) vs median	0-12hr	-6.8% (-29.3, 23.0)	1996	89
Not free fare Summer	UTCI	Hot (p90) vs median	0-24hr	-19.5% (-48.9, 26.8)	1996	89
Free fare	Ozone exceedance	-	-	0.3% (-2.3, 3.0)	2106	94
Not free fare	Ozone exceedance	-	-	3.4% (-5.4, 13.1)	6398	294
Not free fare Summer	Ozone exceedance	-	-	0.6% (-7.6, 9.6)	1996	89
Free fare	Light smoke	-	-	2.7% (-2.5, 8.1)	2106	94
Free fare	Medium smoke	-	-	-1.7% (-10.1, 7.6)	2106	94

Not free fare	Heavy smoke	-	-	-8.6% (-19.3, 3.5)	6398	294
Not free fare	Light smoke	-	-	0.6% (-1.9, 3.2)	6398	294
Not free fare	Medium smoke	-	-	-3.8% (-10.1, 2.9)	6398	294
Not free fare Summer	Heavy smoke	-	-	4.6% (-11.8, 23.9)	1996	89
Not free fare Summer	Light smoke	-	-	5.3% (-5.9, 17.7)	1996	89
Not free fare Summer	Medium smoke	-	-	5.1% (-9.4, 22.0)	1996	89

Table S3: Cumulative percent change in expected boardings (95% CI) comparing extreme precipitation (wet, p90 vs median) and thermal stress (UTCI cold p10 vs median; hot p90 vs median) across cumulative windows (0-3, 0-6, 0-12, and 0-24 hours) under alternative maximum lag specifications (12, 24, 36, 48, and 72 hours). Estimates are from system-wide fixed-effects negative binomial distributed lag nonlinear models controlling for hour of day, day of week, month, wildfire smoke, and ozone, with standard errors clustered by day.

Exposure	Contrast	Lag window	12hr DLNM model	24hr DLNM model	36hr DLNM model	48hr DLNM model	72hr DLNM model
Precipitation	Wet (p90) vs median	0-3hr	-9.9% (-14.6, -5.0)	-8.4% (-13.2, -3.4)	-6.2% (-10.8, -1.4)	-4.5% (-9.2, 0.4)	-5.2% (-9.0, -1.2)
Precipitation	Wet (p90) vs median	0-6hr	-9.3% (-15.3, -2.9)	-9.8% (-15.6, -3.5)	-8.3% (-14.4, -1.7)	-6.4% (-12.7, 0.3)	-7.3% (-12.8, -1.5)
Precipitation	Wet (p90) vs median	0-12hr	-10.3% (-18.0, -1.8)	-7.3% (-15.5, 1.6)	-7.5% (-15.3, 1.1)	-6.7% (-15.1, 2.6)	-7.9% (-16.2, 1.3)
Precipitation	Wet (p90) vs median	0-24hr	-	0.3% (-22.0, 29.1)	2.8% (-19.0, 30.4)	4.5% (-18.4, 33.8)	3.1% (-18.8, 30.9)
UTCI	Cold (p10) vs median	0-3hr	-9.4% (-14.2, -4.4)	-9.2% (-14.4, -3.7)	-11.4% (-16.4, -6.1)	-6.6% (-11.3, -1.6)	-8.3% (-12.5, -4.0)
UTCI	Cold (p10) vs median	0-6hr	-8.9% (-14.5, -3.0)	-10.9% (-17.0, -4.2)	-13.8% (-20.5, -6.5)	-8.9% (-16.0, -1.3)	-11.6% (-17.8, -4.9)
UTCI	Cold (p10) vs median	0-12hr	-6.4% (-14.3, 2.3)	-10.5% (-18.3, -1.8)	-12.1% (-22.4, -0.5)	-8.9% (-19.8, 3.5)	-12.3% (-21.9, -1.6)
UTCI	Cold (p10) vs median	0-24hr	-	-15.7% (-26.0, -4.0)	-16.4% (-27.7, -3.4)	-5.1% (-19.7, 12.3)	-5.3% (-20.7, 13.2)
UTCI	Hot (p90) vs median	0-3hr	3.6% (-1.0, 8.4)	2.1% (-2.7, 7.2)	5.0% (0.3, 9.9)	8.2% (3.6, 12.9)	6.0% (1.7, 10.4)
UTCI	Hot (p90) vs median	0-6hr	5.6% (-0.4, 11.9)	5.6% (-0.4, 11.9)	7.7% (1.4, 14.4)	10.4% (3.6, 17.7)	8.3% (1.7, 15.4)
UTCI	Hot (p90) vs median	0-12hr	7.1% (-1.3, 16.2)	5.4% (-3.2, 14.7)	7.1% (-1.9, 17.0)	6.6% (-3.2, 17.5)	7.8% (-2.3, 18.9)

UTCI	Hot (p90) vs median	0-24hr	-	-11.9% (-21.7, -0.7)	-11.3% (-22.7, 1.9)	-8.3% (-21.3, 6.8)	-5.3% (-19.4, 11.4)
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Table S4: Cumulative percent change in expected boardings (95% CI) comparing cold (p10) and hot (p90) conditions to the median, from distributed lag nonlinear models with lags 0-24 h. Both models additionally include a precipitation DLNM, smoke, ozone exceedance, and time fixed effects.

Contrast	Lag window	UTCI DLNM (% change, 95% CI)	Air Temperature DLNM (% change, 95% CI)
Cold (p10 vs median)	0-3 h	-9.4% (-14.2%, -4.4%)	-7.8% (-12.6%, -2.7%)
	0-6 h	-8.9% (-14.5%, -3.0%)	-8.1% (-14.2%, -1.6%)
	0-12 h	-6.4% (-14.3%, 2.3%)	-5.9% (-14.9%, 4.4%)
	0-24 h	-15.7% (-26.0%, -4.0%)	-10.8% (-25.2%, 6.1%)
Hot (p90 vs median)	0-3 h	3.6% (-1.0%, 8.4%)	2.9% (-1.8%, 7.8%)
	0-6 h	5.6% (-0.4%, 11.9%)	5.1% (-1.1%, 11.8%)
	0-12 h	7.1% (-1.3%, 16.2%)	6.3% (-2.6%, 16.3%)
	0-24 h	-11.9% (-21.7%, -0.7%)	-8.7% (-22.4%, 7.4%)

S3 Evaluating Disparities in Bus-Stop Level Amenities

S3.1 Methods

We assessed socioeconomic disparities in the distribution of bus stop amenities using a stop-level dataset that linked RTD stop inventories with Colorado EnviroScreen 2.0 data. Stops were classified as ‘screening-priority’ (SP) stops if they met any of the following criteria: Justice40 designation, placement in a Colorado EnviroScreen block group above the 80th percentile, or classification as a “Cumulatively Impacted Community” by the Colorado Air Quality Control Commission. This classification provides a reproducible indicator of stops located in areas identified by existing socio-economic screening tools.

Amenity availability was harmonized into binary indicators for shelter, bench, lighting, bike rack, sidewalk connection, digital display, ticket vending machine, and public art. For each amenity, we estimated unweighted prevalence separately for SP and non-SP stops. Primary disparities were summarized using absolute differences in prevalence (percentage-point differences)

between SP and non-SP stops, with approximate 95% confidence intervals computed using normal approximations for differences in proportions. This metric directly quantifies inequities in amenity access and is more interpretable for policy and equity applications than relative measures.

To reflect passenger exposure, we conducted ridership-weighted analyses, estimating the share of total boardings served by amenitized stops in SP versus non-SP areas. Weighted prevalence differences represent the proportion of riders in each group with access to amenities. As a secondary analysis, we estimated adjusted associations between SP status and each amenity using logistic regression models with amenity presence as the outcome and SP status as the primary predictor. Models adjusted for stop type, headway, ridership volume, jurisdiction (city, county), and Title VI status. Adjusted odds ratios with 95% confidence intervals were used to assess whether disparities persisted after accounting for service characteristics and location.

S3.2 Results

Several amenities were less prevalent at SP stops than at non-SP stops (**Table S3.1**). The largest unweighted disparity was observed for bike racks, which were present at 3.0% of SP stops compared with 5.6% of non-SO stops (difference -2.6 percentage points; 95% CI: -3.8, -1.4). Bench availability was similar across groups (41.8% vs 43.5%; difference -1.7 percentage points (95% CI: -3.4, 0.0)). Lighting, digital displays, and public art exhibited small or statistically imprecise differences.

Ridership-weighted analyses revealed substantially larger inequities in passenger exposure (**Table S3.2**). Only 5.8% of SP boardings occurred at stops with bike racks compared with 13.7% of non-SP boardings, corresponding to a -7.9 percentage-point disparity. Lighting was present for 50.5% of SP boardings versus 65.0% of non-SP boardings (difference -14.4 percentage points). Bench availability was also lower among SP riders (64.9% vs 71.6%; difference -6.6 percentage points). These results indicate that riders in disadvantaged communities experience substantially lower access to key amenities than suggested by stop counts alone, particularly for lighting, bike infrastructure, and seating.

After adjustment for ridership, headway, stop type, and jurisdiction, SP status remained strongly associated with lower odds of several amenities (**Table S3.3**). SP stops had significantly lower odds of shelter availability (OR 0.75, 95% CI: 0.63-0.90) and sidewalk connections (OR 0.60, 95% CI: 0.44-0.84). Bench availability was modestly lower (OR 0.88, 95% CI: 0.77-1.00), while lighting showed borderline evidence of disparity. These findings indicate that observed prevalence differences are not fully explained by service levels or stop characteristics.

Table S3.1. *Unweighted amenity prevalence and absolute percentage-point (pp) disparities by Screening Priority (SP) status*

Amenity	Prevalence (Non-SP vs SP)	Absolute Difference (pp, 95% CI)	Non-S PJ (n)	SP (n)
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Bench	43.5% vs 41.8%	-1.7 pp (-4.0, 0.6)	4612	2895
Bike rack	5.6% vs 3.0%	-2.6 pp (-3.5, -1.7)	4599	2877
Digital display	0.8% vs 0.5%	-0.3 pp (-0.7, 0.0)	4599	2877
Lighting	36.0% vs 35.5%	-0.5 pp (-2.7, 1.7)	4607	2892
Public art	2.5% vs 2.5%	0.0 pp (-0.8, 0.7)	4599	2877
Shelter	18.7% vs 14.8%	-3.9 pp (-5.6, -2.2)	4614	2895
Sidewalk connection	94.4% vs 94.5%	0.1 pp (-1.0, 1.2)	4568	2858
Ticket vending	1.7% vs 1.3%	-0.5 pp (-1.0, 0.1)	4599	2877

Table S3.2: Ridership-weighted prevalence of amenities and absolute differences (pp)

Amenity	Weighted Prevalence (Non-SP vs SP)	Weighted Difference (pp)
Bench	71.6% vs 65.0%	-6.6 pp
Bike rack	13.7% vs 5.8%	-7.9 pp
Digital display	8.2% vs 2.0%	-6.2 pp
Lighting	65.0% vs 50.5%	-14.4 pp
Public art	9.9% vs 9.5%	-0.4 pp
Shelter	50.0% vs 41.7%	-8.3 pp
Sidewalk connection	99.4% vs 98.6%	-0.8 pp
Ticket vending	13.9% vs 5.5%	-8.5 pp

Table S3.3: Adjusted odds of amenity presence at Screening Priority stops derived from logistic regression models adjusted for ridership, headway, stop type, and location

Amenity	Adjusted OR (95% CI)	p-value	n
Shelter	0.75 (0.63, 0.90)	0.002	6647
Sidewalk connection	0.60 (0.44, 0.84)	0.003	6572
Bench	0.88 (0.77, 1.00)	0.046	6645
Lighting	0.88 (0.77, 1.00)	0.051	6637
Digital display	0.43 (0.13, 1.43)	0.169	6619
Ticket vending	0.62 (0.30, 1.28)	0.197	6619
Public art	1.10 (0.74, 1.64)	0.636	6619
Bike rack	0.97 (0.69, 1.37)	0.869	6619

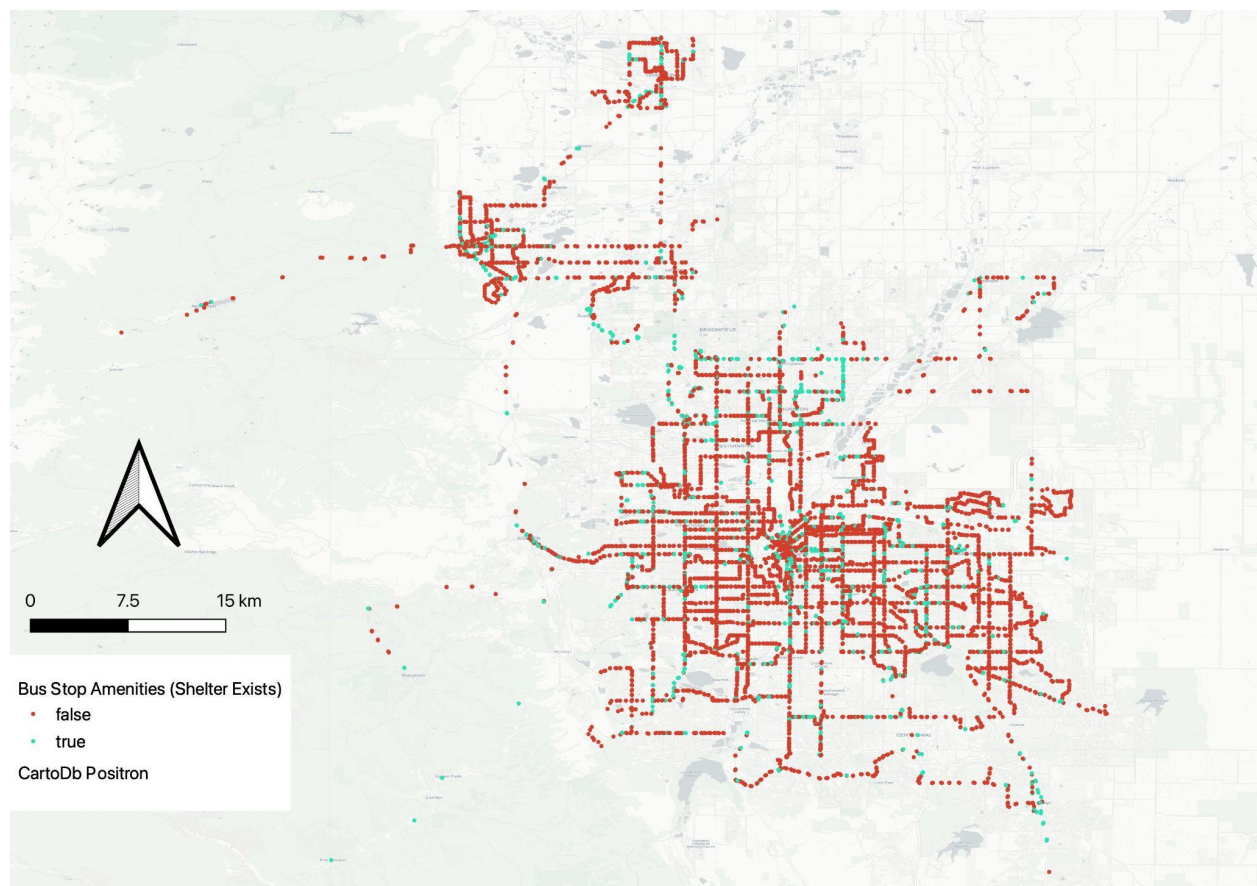


Figure S3.1: Map of shelters across RTD bus stops