RSS 2022
8th Road Safety & Simulation International Conference
Road Safety and Digitalization
08-10 June 2022 • Athens, Greece

Association of Crash Potential of Powered Two-Wheelers (PTWs) with the State of Traffic Stream

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Introduction

- PTWs are more susceptible to instability and fatal crashes compared to cars
- PTWs has Significantly different driving behavior compared to other vehicle types
- Previous research on PTW safety has primarily relied on historical crash data
- Historical crash reports are known for their shortcomings:
  - lengthy data collection period
  - inconsistent and limited availability of crash data
  - Lack of secondary data
- Traditional road safety evaluation using historical crash data is a passive approach
- Surrogate Safety Measures (SSMs) are a viable proactive technique for determining crash contributing components

Objectives

- To perform a proactive safety assessment of PTWs
- To capture the conflict types and overall crash risk associated with the mixed traffic conditions existing on the urban arterial
- To investigate the impact of state of traffic stream on PTW crash likelihood, exposure, and severity for different conflict types

Literature Review

- Several researchers found that the conflict frequency is positively related to the crash frequency (Jiang et al., 2020; Zheng et al., 2019)
- The well-known SSMs like Time to Collision (TTC), Post-Encroachment Time (PET), and others have been criticized for being limited to homogeneous traffic circumstances and specific conflict types like rear-end or angled
- Many have questioned the applicability of these SSMs to vulnerable road users (VRUs) like PTWs (Guo et al., 2019, 2018; Venthuruthiyil and Chunchu, 2022). They found that, compared to time-based SSMs, evasive action-based indicators are more meaningful.
- Based on crash data, the most frequent collision types of PTWs were side-swipe collisions (Carmai et al., 2018), which cannot be captured by the existing conflict indicators widely used for safety assessment.
- Conventional SSMs are not capturing several conflict types found in the traffic stream.

Methodology

Traffic Flow Characteristics

- This study uses Area-Density (AD), Area Flow (AF), and Road-space-Freeing-Rate (RFR), which consider the lateral dimensions of both vehicles and road space to capture the heterogeneity & weak-lane disciplined driving behavior (Suvin and Mallikarjuna 2018).

Surrogate Safety Measure (SSM)

- The crash risk for the traffic was evaluated using Anticipated Collision Time (ACT), and its derivatives Time-of-Evasive-Action (TEA), Time-Exposed ACT (TEACT), and Time-Integrated ACT (TIACT) proposed by Suvin and Mallikarjuna (2022).

- ACT captures all dimensions of crash risk, including crash likelihood, crash exposure, crash severity, and evasive actions.

- The inputs for *ACT* estimation are the vehicles position, speed and acceleration in the longitudinal and lateral direction, heading angle, and yaw rate.

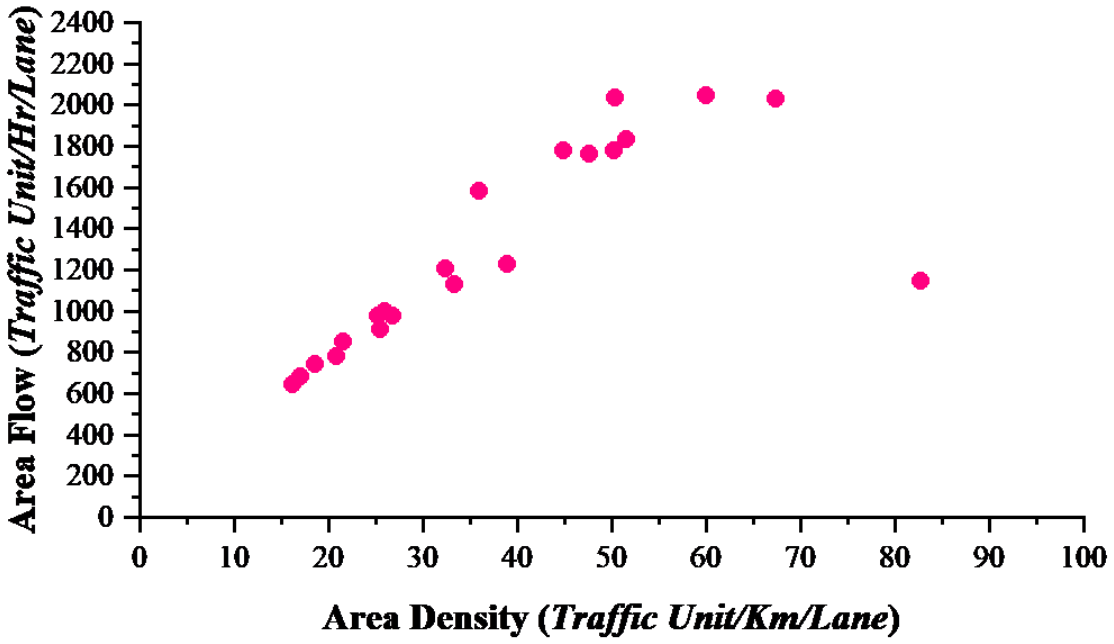
Data Collection

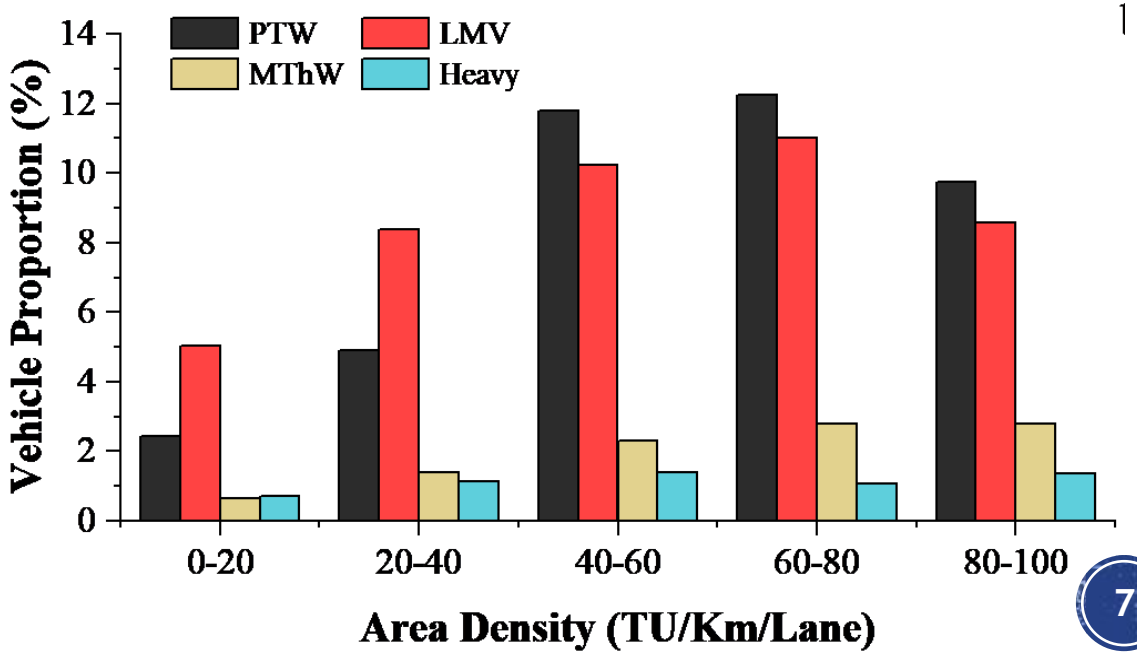
- Traffic video data collected from a 4-lane, divided, urban mid-block road located in Dispur, Guwahati, India.
- Length of road stretch monitored was 60m and Duration is 2 hours.
- The location is more than 150 meters from near by intersection on both sides.
- Trajectory Extraction: using SAVETRAX tool
- Trajectory Smoothing Technique: Recursively Ensembled Low-Pass Filter (RELP) & Adaptive Tri-Cubic Kernel Smoother (Suvin and Mallikarjuna, 2022)
- Tracked 4723 vehicles (PTW-37.95%, MThW-9.15%, LMV-46.57%, HMV-6.33%)
- The traffic flow variables were determined for each 5 min interval from the extracted trajectory data.

Traffic Flow Characteristics

- The traffic states where AD ranges from 40-80 indicate near capacity and capacity conditions, and 80-100 indicate the congested condition.

- When AD is below 40 TU/km/lane, PTW proportion was lower than LMVs, whereas it was the opposite when AD was above 40 TU/km/lane.

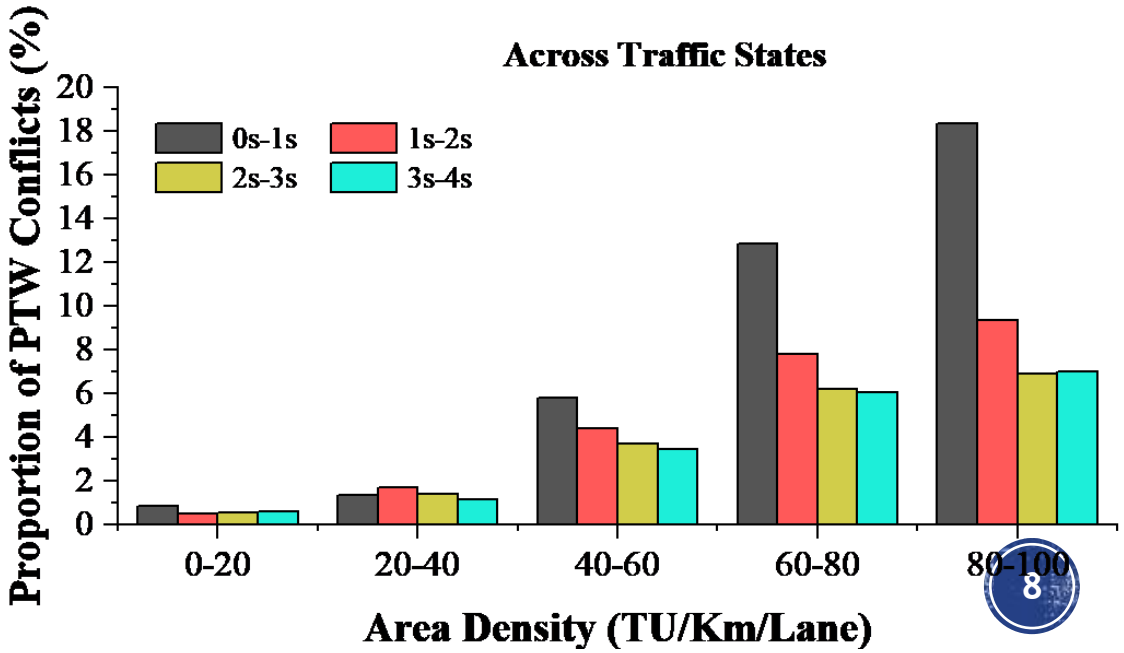




Results and Discussions

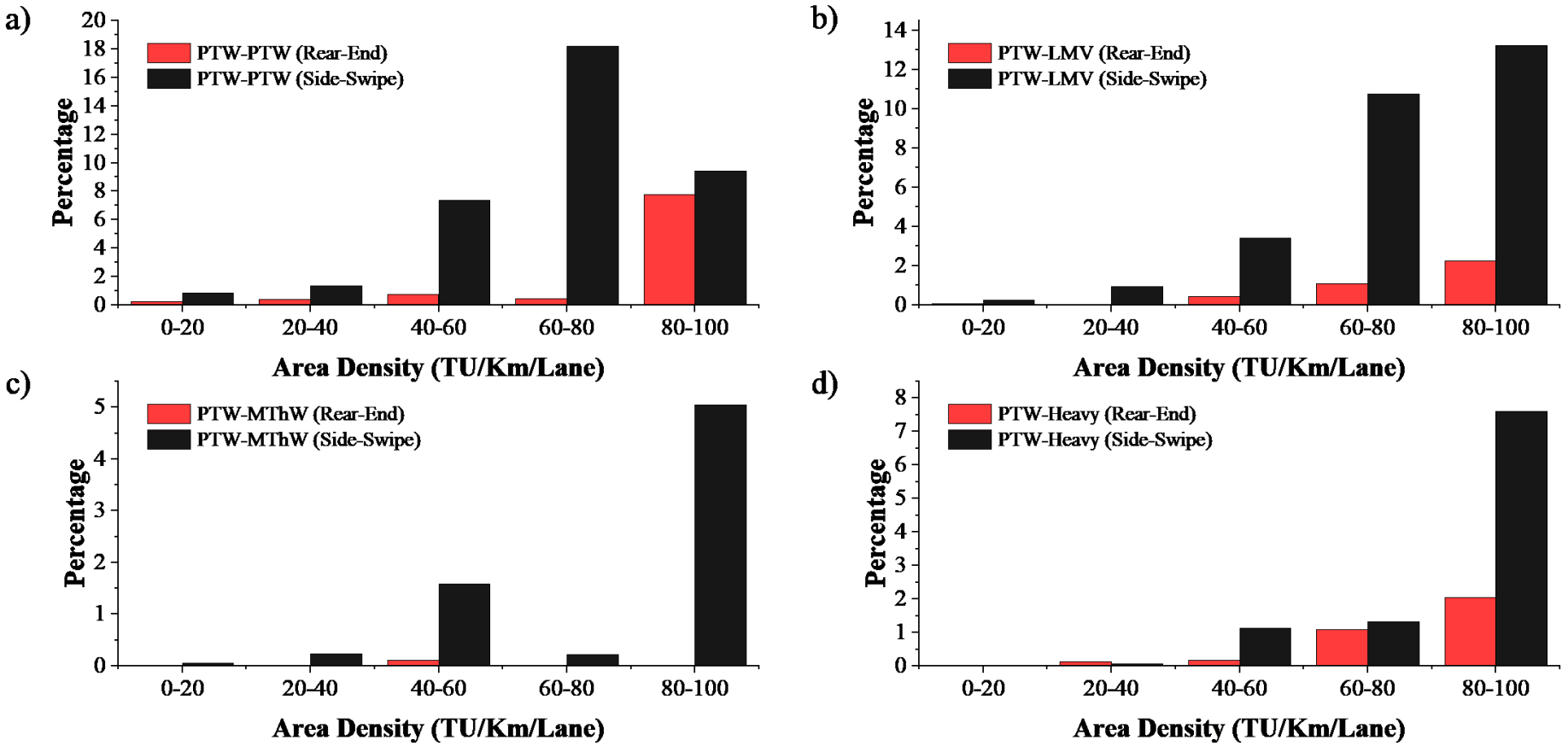
Variation of Conflict Frequency with AD

- Higher severity conflicts are more prevalent after capacity conditions, and the severity increases with the AD
- Average PTW proportion above 80 TU/km/lane is 23.7%, with a conflicts of 41.63%
- The increased crash likelihood at higher AD ranges could be attributed to the PTW rider's close moving attitude and higher relative speed in those conditions
- When AD is between 40&80 TU/km/lane, the observed PTW proportion is 58.44%, results in 50.24% of the conflicts and when AD is below 40 TU/km/lane, only 8.13% of PTW conflicts caused by 17.86% of PTWs



Distribution of conflict types between different vehicle types

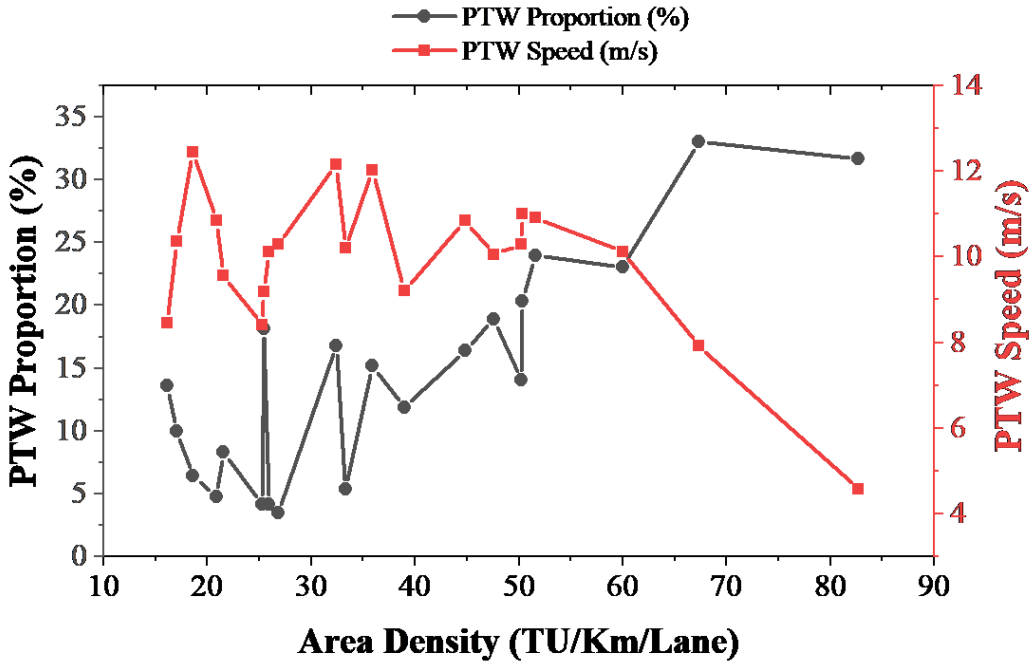
- Side-swipe and rear-end conflicts account for 83% and 17% of all PTW conflicts
- PTW-PTW conflicts (46.78%) are higher compared to other vehicle classes, where share of PTW conflict with LMV, MThW, and HMV conflicts are 32.43%, 7.25%, & 13.54%.

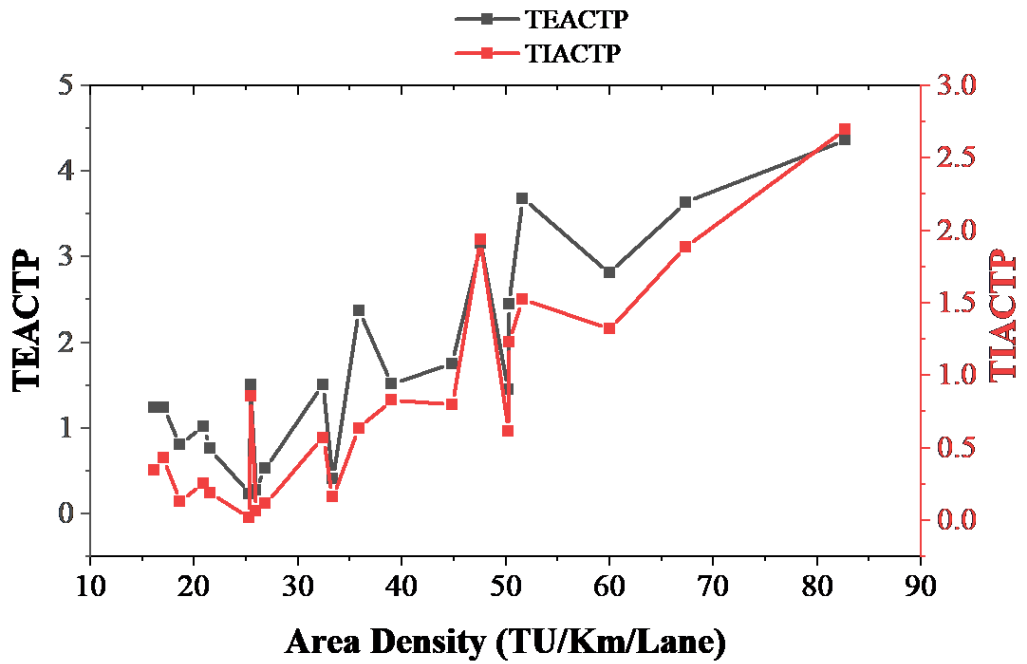


Relationship of percentage of PTWs exposed to crash risk, conflict exposure and severity with AD

- One-way ANOVA [F(4,16) = 11.25, p-value < 0.05] results show that AD substantially impacts the percentage of PTWs exposed to crash risk
- One-way ANOVA shows that AD has significant impact on conflict exposure [F(4,16) = 50.68, p-value < 0.05] & conflict severity [F(4,16) = 15.83, p-value < 0.05].

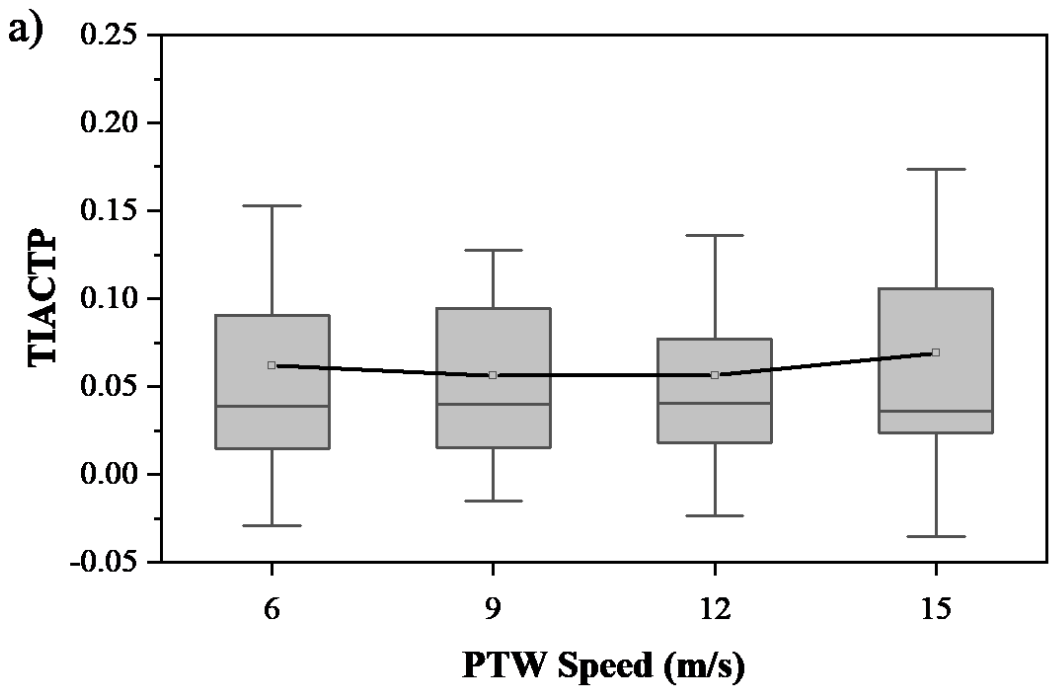
Variables	Pearson cc	p-value	Spearman cc	p-value
AD, $TEACT_P$	0.85	0.00	0.77	0.00
AD, $TIACT_P$	0.88	0.00	0.76	0.00
AD, Percent of PTWs exposed to crash risk	0.84	0.00	0.74	0.00

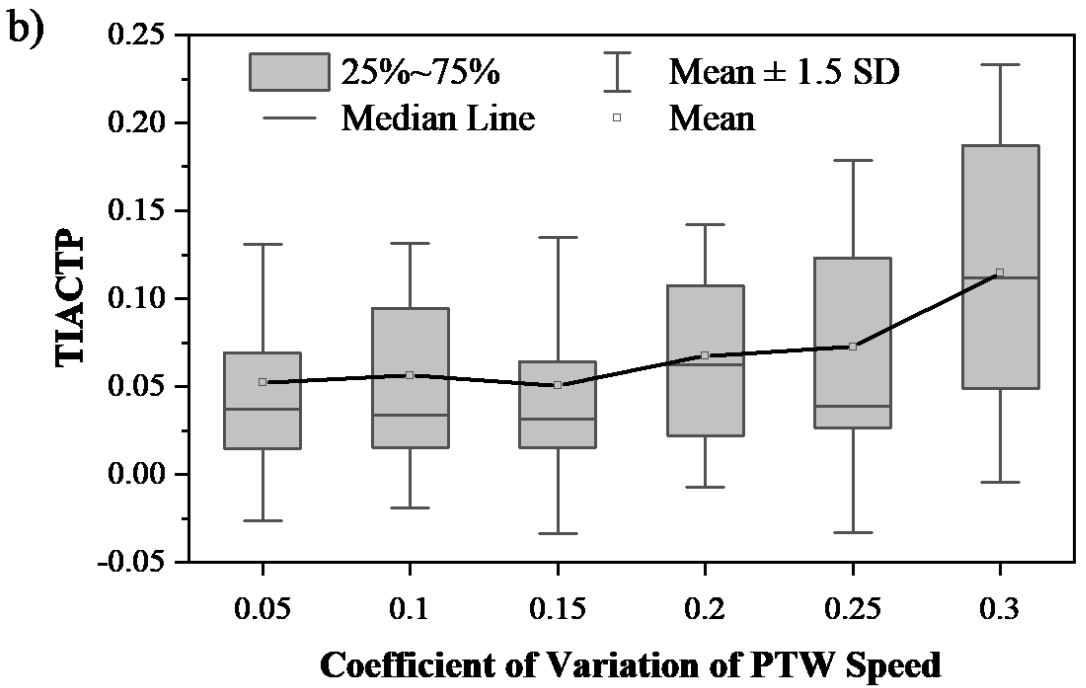




Effect of PTW Speed on Conflict Severity

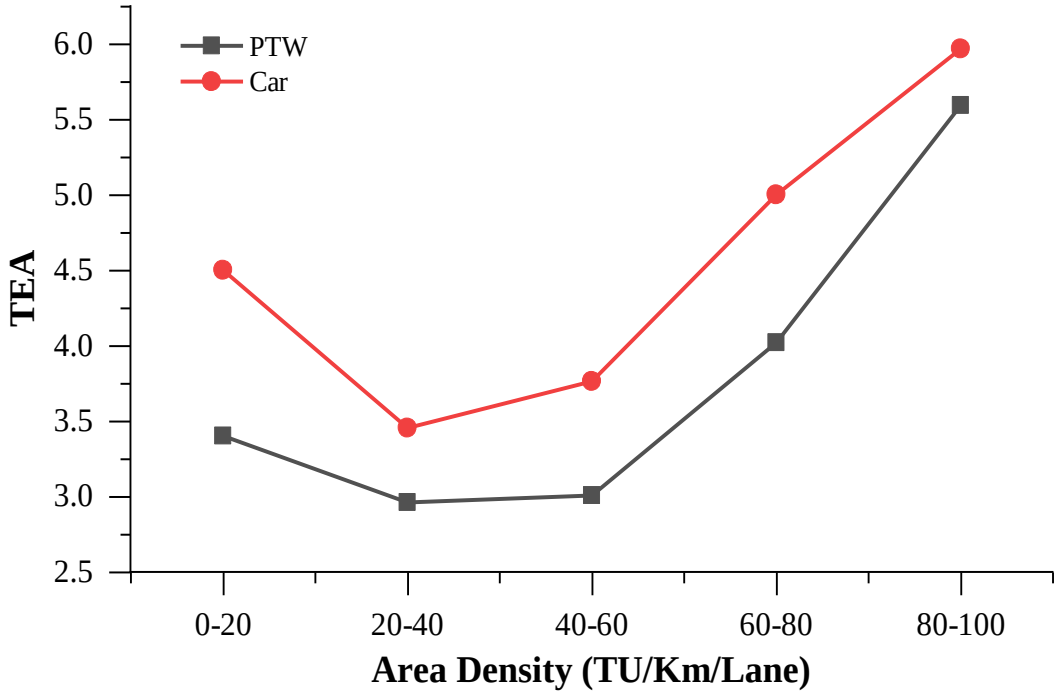
- Total PTWs was 1805, where 298 PTWs were exposed to unsafe situation (ACT < 1s).
- Average speed of PTW has no significant impact on PTW conflict severity [F(3, 295) = 0.71, p-value > 0.05].
- However, the CV of PTW speed has a significant impact on conflict severity [F(5, 295) = 2.95, p-value < 0.05]





Response Time of Drivers to Unsafe Situation

- Higher TEA indicates early response of drivers to unsafe situation.
- The mean TEA of PTW riders (3.8 s) is lower than cars (4.5 s). However, they are not statistically insignificant by a two-sample t-test (p-value > 0.05).
- AD has statistically significant impact on the TEA of PTW riders [$F(4, 100) = 3.43$, p-value < 0.05], whereas for car drivers, it is not [$F(4, 43) = 0.96$, p-value > 0.05]
- However, the pairwise comparison shows that only TEA of PTW riders under AD range (80-100 TU/km/lane) is statistically different from AD ranges (40-60 TU/km/lane and 60-80 TU/km/lane) (p-value < 0.1).



Conclusions

- The results indicate that the frequency, exposure, severity of PTW conflicts, and proportion of PTW exposed to crash risk are positively correlated with AD.
- The CV of PTW speed was found to be significantly impacting the conflict severity. However, the average PTW speed doesn't explain the conflict severity
- The response times at higher AD levels were found to be higher compared to the lower AD levels indicating that drivers are more cautious during congestion than free-flow
- The involvement of PTWs in side-swipe collisions was more. The main reasons for this is improper filtering and overtaking
- Therefore, it is advised to make PTW riders aware of these safety issues while conducting road safety campaigns.
- It is essential to communicate with the PTW riders and other vehicle drivers about the crash risk in the traffic stream with a high proportion of PTWs

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