Analysis of Road Traffic Accidents on NH45, Kanchipuram District (Tamil Nadu, India)

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ABSTRACT

With the support and cooperation of the Kanchipuram district police and Tamil Nadu police, researchers conducted detailed investigations of accidents occurring on the National Highway 45 over a 60 km stretch. The primary objective was to collect and analyze India-based traffic crash data to begin to create a sound basis for decision making for improving safety on India's roadways. A secondary objective was to establish a standardized methodology for collecting and analyzing crash data, specific to Indian roads. For the 45 day study period, an accident intimation network was established between researchers and all police stations/highway patrols in the study area. On occurrence of an accident, police called a 24-hour contact number and researchers responded to the scene. On site, researchers used standardized reporting forms, methodologies, and equipment to perform accident scene examinations, accident vehicle examination, and AIS injury coding. The collected accident data was categorized first by single- or multiple-vehicle crash and next by accident type based on the first accident event. The data was then analyzed to identify accident (crash type, location time), vehicle (vehicle type, pre-crash condition), occupant (restraint use, gender, age) and other contributing factors, and environmental factors associated with injury severity. Findings show that front-to-rear collisions, mainly involving heavy trucks and buses, caused due to slowing down, stopping, breaking down or overtaking account for 59% of the accidents. This paper presents the methodology adopted, data analysis, results, conclusions and recommendations to mitigate road accidents and injuries on NH45 and other similar highways.

INTRODUCTION

In August 2008, the Tamil Nadu (State) Police gave researchers permission to carry out a traffic accident research project on a section of National Highway 45 (NH45) between Otteri and Acharapakkam in Kanchipuram District, with the help of the Kanchipuram District Police. The project involved collecting in-depth accident data on accidents occurring in the period starting from 1 September 2008 to 15 October 2008.

THE AREA OF STUDY - A 60 km stretch of the NH45 between Otteri and Acharapakkam in Kanchipuram district was selected for the study. Some features of this highway are given below:

- The entire stretch is a 4 lane divided highway.
- Road surface is asphalt.
- The divider is about 5 m in width and is usually planted with large bushes and plants, except at U-turns, intersections and bridges.
- No potholes were observed all along the main highway.
- Speed Limit at some sections is 60 kmph and at other sections is 80 kmph.

- Lighting is provided only at intersections/junctions and some areas such as truck lay bys. Otherwise a good part of the highway is not lit.
- The highway infrastructure also includes:
  a. 1 Toll booth.
  b. 3 Truck Lay-Bys.
  c. 60 bus stops (counting both directions).
  d. 19 petrol pumps.
- Number of police stations: 9
- Number of highway police patrol cars: 3
- EMS is provided by an Emergency Accident Relief Centre (a small station with an ambulance) operated by Parvathy Hospital (private), which is located outside the study area, and Chengalpattu Medical College and Hospital (government) located inside Chengalpattu Town.

The objectives for this real time accident investigation and data collection project were:

1. To initiate in-depth traffic accident data collection with the support of the police.
2. To establish a methodology and develop a framework for a comprehensive accident database for road accidents in India.
3. To understand the nature of accidents and identify causes/problems along NH45.
4. To provide recommendations based on this study for reducing accidents on NH45.

ACCIDENT INVESTIGATION METHODOLOGY

ACCIDENT INTIMATION - For the 45-day period of this study, an accident intimation network was established between researchers and all the police stations and highway patrols located in the study area. On occurrence of an accident, the police called a dedicated contact number that was manned 24 hours a day by researchers during the entire project period. As soon as a call was received and details of the accident noted down, researchers travelled to the accident scene from their base camp in Chengalpattu town, which is located midway of the study area. After visiting the accident scene, the researchers collected accident details (police reports, vehicle and driver documents and injury details) from the police station in whose jurisdiction the accident took place. The study being purely scientific, no proprietary information including names/addresses of accident victims was included in the research. Once researchers arrived at the scene, the accident was investigated by performing the following three activities described below.

SCENE EXAMINATION - Scene data is very important for understanding the cause of an accident.

Photographs of the point of impact (POI), vehicles, and surroundings are taken from all angles, especially covering the direction of vehicle approach and travel. The notion is to document the accident and all available evidence in photographs, which can be used for future references and analyses. Recording the GPS coordinates and the distance of the point of impact from other specific locations help in identifying the exact accident location for future study and identification of black spots. Scene measurements help identify the final resting positions of the crashed vehicles after a collision, the position of any object that may have been struck by a vehicle, and volatile evidence (such as skid marks, broken parts, etc.) with respect to the road infrastructure and surrounding environment. Infrastructure assessment involves recording the road infrastructure and surrounding environment details such as road type, surface condition, road quality, flow of traffic, presence of a divider or median, junction type, road construction

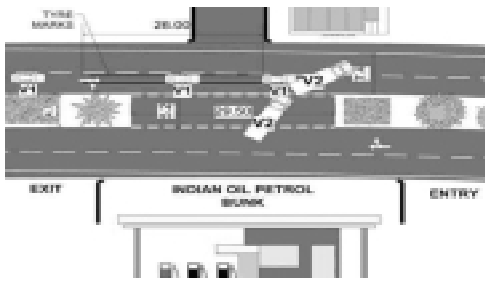


Figure 1A: Accident Scene Diagram

Figure 1B: Accident Spot and direction of approach material, weather, lighting, etc. On completion of the above activities and after developing an understanding of the accident events, the entire accident scene is diagrammatically represented to scale in order to give a simple and clear picture of the accident for future reference.

Figure 1C: Direction of Travel

Figure 1A shows the diagram of an accident scene. The truck V2, which had stopped at the petrol station on the other side for refueling, exited the petrol station to join back onto the other side of highway. The car V1, approaching the intersection, braked and skidded for a distance before hitting the rear left wheel of the truck V2. Photographs of the scene showing the direction of approach and travel are given in figures 1B and 1C.

VEHICLE EXAMINATION - Researchers examined crash vehicles on-scene and/or after it was towed to the side of the road. This examination involved:

- Recording direct and indirect damages.
- Determination of Collision Deformation Classification (CDC) and/or Truck Deformation Classification (TDC) [1 & 2].
- Measurement of interior intrusions.
- Occupant contact points with vehicle interiors.
- Determination of belt use/airbag deployment.

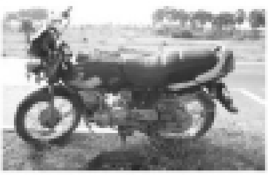
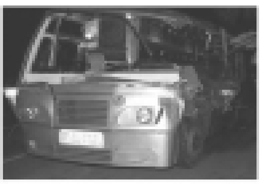
To scientifically describe impacts on a vehicle, researchers use the seven-character Collision Deformation Classification (CDC) code for cars and SUVs, and Truck Deformation Classification (TDC) code for trucks, as per standards J224 and J1301 of the Society of Automotive Engineers (SAE) [1 & 2]. This internationally accepted standard crosses language barriers and gives a 3-dimensional description and specified magnitude of the impact damage on a vehicle. In addition the CDC/TDC helps in describing, recording and communicating vehicle impact damage very easily in reports and analyses. CDC/TDC retains the damage information for reference should it be required at a future date, especially in the physical absence of the vehicle. An example of CDC is described below using a crashed car examined in our study.

Explanation of the CDC code:
01 = Principal Direction of Force (1 o'clock direction)
F = Type of Impact (Frontal)
Z = Location of Damage (Right and centre of frontal area)
E = Vertical Location (Below lower end of windshield)
W = Type of Damage Distribution (Wide)
3 = Maximum Extent of Crush from front bumper to lower windshield on a scale from 1 to 5

Figure 2: Frontal impact damage to a sedan. CDC coded is 0 1 F Z E W 3.

CDC is developed for passenger cars and SUVs, but researchers used the first four characters to apply CDC to motorcycles and buses as shown in table 1. Examples of TDC are also provided in Table 1.

Table 1: Case examples of CDC applied to two-wheelers and buses and TDC applied to trucks.

CDC (first 4 characters only)		TDC	
			
12FD	12FL	12FDHR7	12FRAW9

INJURY CODING AND CORRELATION - The Abbreviated Injury Scale (AIS) [3] developed by the Association for the Advancement of Automotive Medicine (AAAM) is used by researchers for injury coding. The code has seven digits in which the first digit represents the affected region of the body, the second digit the type of anatomical structure, the third and fourth the specific anatomical structure and the fifth and sixth the level of injury. Based on the values given to these six digits, the seventh digit is determined which gives the severity of the injury. The severity is indicated by a number ranging from 1 to 6 as shown in the table 2.

Table 2: Abbreviated Injury Scale

Scale	Severity	Example
1	Minor	Superficial laceration
2	Moderate	Fractured sternum
3	Serious	Open fracture of the humerus bone
4	Severe	Perforated trachea
5	Critical	Ruptured liver with tissue loss
6	Unsurvivable	Total severance of aorta

An example of injury coding and correlation is described below. Figures 3A, 3B and 3C show the exterior and interior parts of a car involved in a rollover accident examined under this study. Although the driver escaped uninjured, the front left occupant sustained injuries in the accident. The injury report for the front left occupant mentioned a head laceration. The AIS codes obtained for the injuries were as follows:

Injury	AIS code
Head Laceration	110600.1

The occupant contact points in the car interiors, shown in figures 3B and 3C, were examined and then correlated with the injuries of the occupant to determine the cause of each injury. As can be seen the blood marks on the roof indicate injury on the head. On closer inspection of the windshield, blood marks were found giving the indication that the occupant's head hit the windshield, which caused the injury. Hence the source of the head laceration was determined as windshield. This also indicates that the occupant was not wearing seatbelts, and the same was confirmed on checking the seatbelts as they too had no marks on them to indicate usage.

During the study, coding of injuries could not be an area of focus due to inaccessibility to hospital records. Hence, researchers had to perform AIS coding based on injuries mentioned in the police reports. In this analysis, the traditional classification of "Fatal", "Grievous", "Minor" or "No Injury" used by the police departments in their reports, has been followed.

Figure 3A: Rollover Accident. Roof Crush measured is 18 cm and occupant contact identified.

Figure 3B: Head contact with windshield.

Figure 3C: Occupant contact points.

Poster Presentations

ACCIDENT DATA ANALYSIS

Over the 45 days of this project, researchers investigated 32 accidents. The accident data parameters are provided in Appendix A. Figure 4 gives the distribution of accidents by level of injury noted at the time of accident.

Figure 5 shows the type and number of road users involved in the 32 accidents investigated. Trucks form the majority vehicle type (45.61%) followed by passenger cars (15.79%).

The distribution of accidents by time is show in figure 6. 21 of the 32 accidents (65.6%) took place between 00:00 and 09:00 hours. Maximum number of accidents recorded (10) was between 03:00 to 06:00 hours. These graphs broadly indicate that night time accidents, involving trucks, was an area for further research.

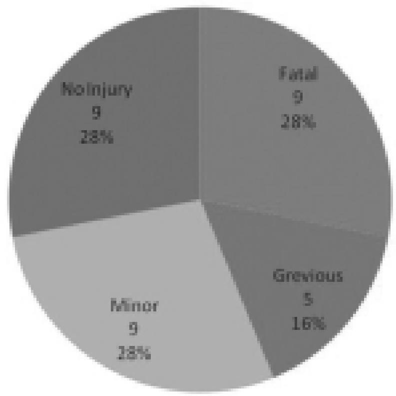


Figure 4: Distribution of accidents by injury level.

Figure 5: Accident Distribution by Road User Type.

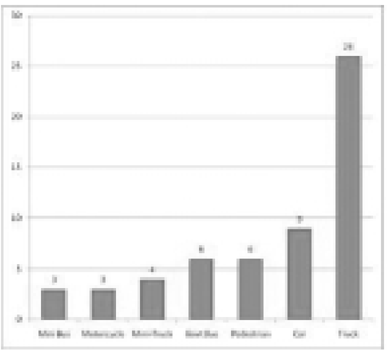
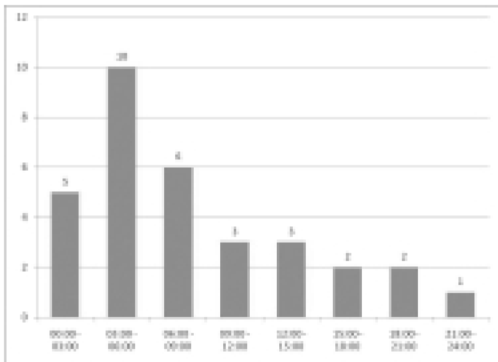


Figure 6: Accident Distribution by Time



To get a deeper insight into the accidents, the 32 accidents were categorized for analysis as shown in figure 7. The accidents are first divided into Multiple-Vehicle and Single-Vehicle Accidents. They are then sub-divided as per the type of accident.

Figure 7: Breakup of accidents for analysis.

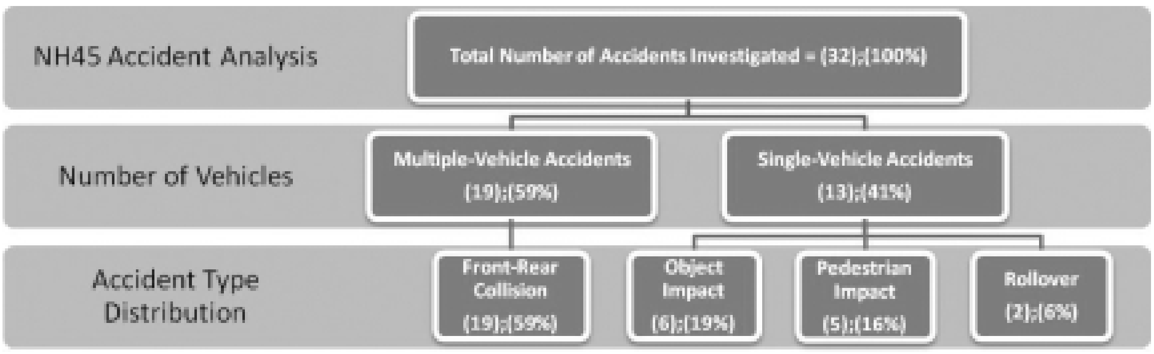
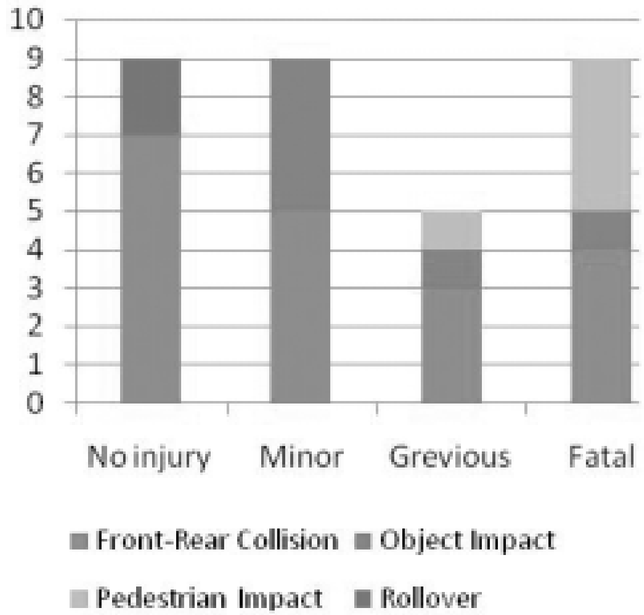


Figure 8: Injury Severity distribution by type of accident.



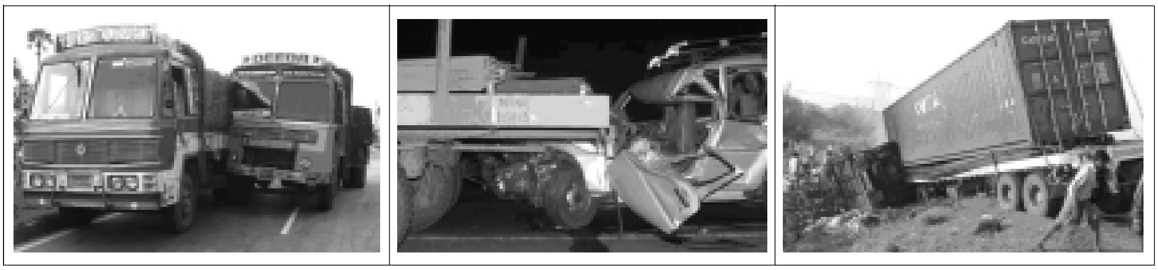
Front-Rear collisions account for 59% of the accidents investigated. If pedestrian impacts are excluded then front-rear collisions comprise 70% of accidents investigated. This is the only Multiple-Vehicle type of accident that has been observed by researchers on the NH45. Head-on collisions were not observed as this 4 lane highway has a wide centre median separating traffic flowing in opposite directions. A look at the injury severity distribution in figure 8 gives a clearer indication of the injury contribution of each type of accident event. Front-Rear Collisions and Pedestrian Impacts dominate fatal accidents, followed by Object Impacts, while Rollovers involved no injuries in this study. The following sections provide insights into Front-Rear Collisions, which form the highest number of accidents on NH45.

FRONT-REAR COLLISIONS

Based on the study of 19 Front-Rear collisions, the following are some important observations:

1. Of the two vehicles involved, one is a “leading” vehicle while the other is a “following” vehicle.
2. The “leading” vehicle suffers either a rear impact (13 out of 19) or a side impact (6 out of 19), while the “following” vehicle suffers a frontal impact.
3. Occupants of the “leading” vehicle usually suffer no or minor injuries, while those of the “following” vehicle have a greater tendency to suffer severe injuries.

Figure 9: Examples of front-rear collisions.



The “leading” and “following” vehicles are studied separately to understand their composition and effects on injury severity.

"Leading" Vehicle Characteristics: Figure 10 describes the types of leading vehicles investigated and their effect on injury severity. From the graph it can be noted that:

1. Trucks (14) form the majority of leading vehicles involved in Front-Rear collisions, while Buses (3) come a distant second.
2. The injury severity distribution clearly indicates that larger vehicles (trucks and buses) inflict serious injuries as leading vehicles to occupants of the following vehicles.
3. In the case involving the passenger car as a leading vehicle, fatal injuries were suffered by the occupants of the car and not the following vehicle.

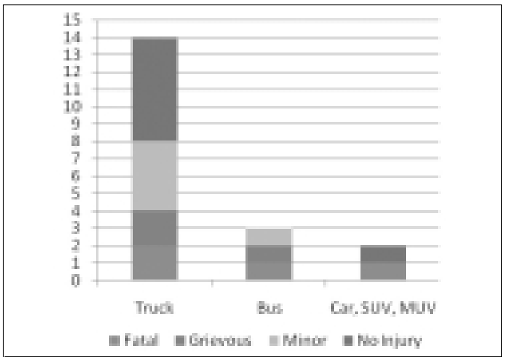


Figure 10: Accident distribution by leading vehicle type and injury severity of the following vehicle.

"Following" Vehicle Characteristics: Figure 11 describes the types of following vehicles and the severity of injury suffered by their occupants. From the above graph it can be summarized that:

1. Following vehicles have a larger distribution of vehicle types. Again trucks (8) form the majority of following vehicles.
2. The injury severity distribution clearly indicates that smaller vehicles usually suffer fatal or grievous injuries as following vehicles, while larger vehicles usually suffer only minor or no injuries.

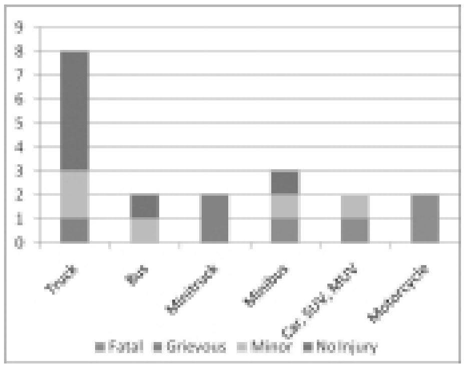


Figure 11: Accident distribution by following vehicle type and injury severity.

Based on the analysis of "leading" and "following" vehicle characteristics, it can be stated that trucks were the "leading vehicles" in 74% of the front-rear collisions. A deeper understanding is required as to why the accidents are initiated in the first place. The pre-accident conditions in each case of front-rear collision were determined and analyzed.

PRE-ACCIDENT CONDITION OF "LEADING VEHICLE" - On studying the 19 Front-Rear collisions, all the 19 accidents could be categorized into the following pre-impact conditions of the leading vehicle.

a. Slowdown: Leading vehicle slows down and following vehicle crashes into it.
b. Stopped: Leading vehicle has stopped/parked for a reason and following vehicle crashes into it.
c. Breakdown: Leading vehicle is broken down/being repaired when the following vehicle crashes into it.
d. Overtaking: While overtaking the following vehicle, the leading vehicle immediately gets in the path of the following vehicle or slows down in front of it, and the following vehicle crashes into the leading vehicle.

Figure 12 shows the leading vehicle condition and the corresponding injury severity of the accident observed. "Slowdown" condition has the maximum contribution to injuries, followed by "overtaking", "stopped" and "breakdown" conditions.

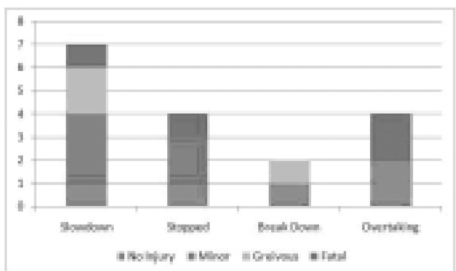


Figure 12 : Accident distribution by vehicle leading condition and injury severity of the accident.

The vehicle types involved in each pre-accident condition is shown in Figure 13. Trucks form the majority and slowdown condition is highest compared to other pre-accident conditions. Thus, we see that Front-Rear collisions usually involve heavy vehicles, majority trucks.

Hence, front-rear collisions involving heavy truck accidents were studied in more detail. The following sections analyze 15 Front-Rear Collisions involving Heavy Trucks and the reasons behind the pre-accident vehicle conditions coded.

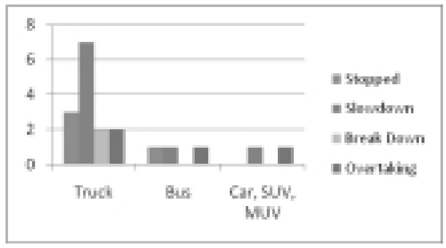


Figure 13: Leading Vehicle Type and Pre- Accident Condition.

ANALYSIS OF HEAVY TRUCK FRONT-REAR COLLISIONS

INFRASTRUCTURE/ENVIRONMENT ANALYSIS

As part of accident scene examinations, researchers carried out an infrastructure assessment, which involves recording details of the roadway and surrounding environment. Data elements collected included road structure, surface condition, road quality, flow of traffic, presence of a divider or median, junction type, road construction material, weather, lighting, etc. Road structure defines the design and layout of the road and researchers code it for each accident spot as being one of the following parameters: Junction/Crossroad, U-Turn, Flyover, Underpass, Roundabout, Bridge, General Road, and Unknown.

On analysis of heavy truck accidents researchers found that all the 18 accidents could be categorized under General Road (no specific feature), U-Turn and Bridge. Figure 14 shows the distribution of accidents by road structure and by type of accident. Front-Rear Collisions, which form a significant number of accidents, occurred mainly at U-turns and on General Roads. Hence these collisions were studied specific to each type of road structure as described in the following sections.

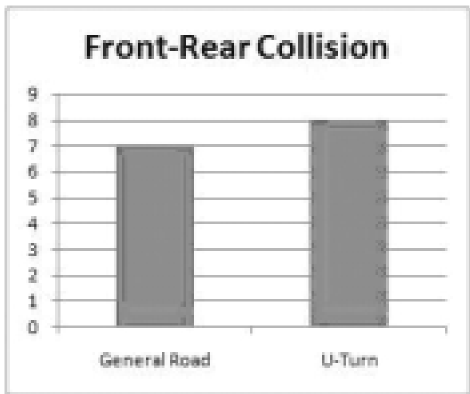


Figure 14: Distribution of heavy truck accidents by road structure

FRONT-REAR COLLISIONS AT U-TURNS:

U-Turn, also referred to as a "Gap in Median", is a road structure which allows vehicles to perform a 180 degree turn in order to reverse their direction of travel. There are numerous U-Turns along the stretch of highway studied. Figure 15 gives the distribution of the 8 front-rear collisions at U-turns by pre-accident condition of the leading vehicle (vehicle that suffered rear impact). Vehicle slowdown condition is prevalent at U-turns, which indicates that U-Turn designs need to be looked into.

Researchers then coded each of the 7 U-Turn locations near which the 8 Front-Rear Collisions took place (one of the U-Turn locations witnessed two separate accidents) to determine if the specifications laid down [4] are being followed. Figure 16 shows the results of the analysis. The absence of warning signs and, most importantly, deceleration lanes, clearly indicate that:

1. Drivers are not being fore-warned of approaching U-turns.
2. Vehicles in the high speed lane which need to use the U-turn, necessarily have to slowdown, hence increasing the chances of vehicles following them to rear end.

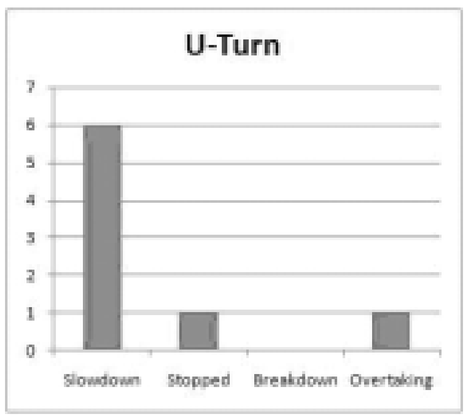
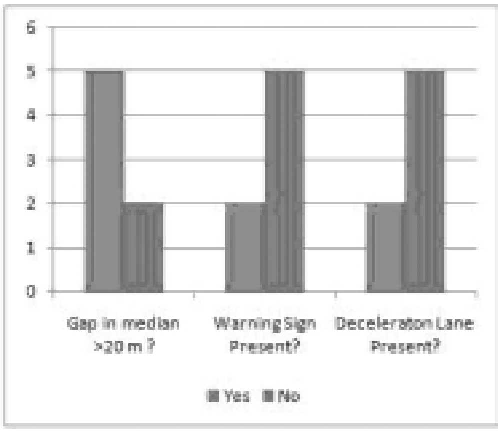


Figure 15: Distribution of front-rear collisions by road structure and pre-accident condition of "leading" vehicle.

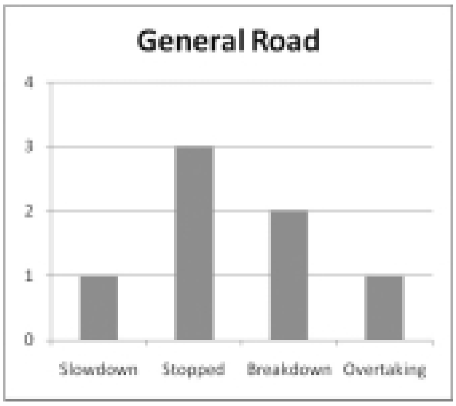
Figure 16: U-turn standards and specification compliance.



FRONT-REAR COLLISIONS AT GENERAL ROADS:

General Road implies a simple layout of a 4 lane road with a median. To get a better understanding of collisions in such locations, researchers analyzed the distribution of accidents based on the pre-accident condition of the leading vehicle (vehicle that suffered rear impact). As can be noted from figure 17, stopped and broken down vehicles are involved in 5 of the 7 accidents. Although researchers could not pin-point a common problem to all accidents involving stopped or breakdown vehicles, some of the points noted during the study are presented below.

Figure 17: Distribution of front-rear collisions at general roads by pre-accident condition of the leading vehicle.



1. At many places on the highway, it was observed that sufficient space was not available for parking vehicles well outside the carriageway. Hence, in case of an emergency or break-down, trucks were often parked such that part of the truck intruded into the carriageway. As per specifications [5] the shoulder should be paved for 1.5 m and should be earthen ground for 3 m. But it was observed that the earthen ground was not suitable or sufficient enough for parking heavy trucks, as can be seen in figure 18.
2. It was also observed that entrances and exits to truck lay bys, gas stations and restaurants did not have a separate acceleration/deceleration lane, and in many cases lacked sufficient warning/information signs. This causes vehicles to immediately slow down or stop on arriving at a facility and this results in front-rear collisions with vehicles travelling behind them.

Figure 18: The shoulder width is not sufficient for parking heavy trucks.

3. Two of the front-rear collisions involving stopped vehicles took place at merging lanes. There were no warning/information signs and also the lane merging distance was found to be too short, as can be seen in figure 19.

4. Adequate signs about restaurants, rest areas, gas stations, service centers, etc., posted well in advance, may help motorists make better decisions and avoid sudden stopping or slowing down.

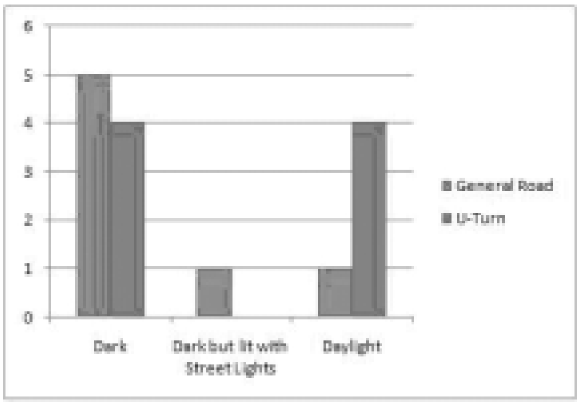
Figure 19: No deceleration lane or sign post at the entrance to a truck lay by.

Figure 20: View from an accident spot near a lane merge.

Figure 21: Truck being repaired at the side of the road. Note the minimal warning signs, lighting and insufficient road shoulder width.

LIGHTING - An analysis of front-rear collisions by lighting, in figure 22, shows that front-rear collisions at U-turns are equally distributed between daylight and dark conditions, while a disproportionate amount of accidents on General Roads took place at night.

Figure 22: Accident distribution by lighting conditions and by road structure



VEHICLE ANALYSIS

For this analysis, heavy trucks involved in all types of accident have been studied. Researchers found that out of all the vehicles involved in crashes reported on the NH45 during the study span, 25 of them were trucks. Among them only 22 trucks could be inspected for this study. The other three could not be examined because in these cases, no other details were available apart from the fact that the accident involved a heavy truck, which the researchers found from the police records. 18 of the 25 trucks examined in this study were single unit trucks, or large trucks on a single frame and walled sides. In addition to this there was one tipper, two tractor- trailers and one tractor without trailer.

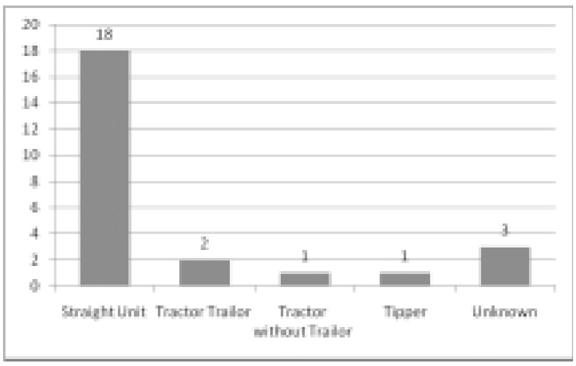


Figure 23: Types of trucks examined in the study.

VEHICLE DEFORMATION

Utilizing the methodology laid out by the Truck Deformation Classification (TDC), [2] damage and crush location was coded for all trucks examined in the study. After coding the TDC for the trucks involved in the study, a couple of trends were noted. Most of the cases involved damage to the frontal or rear planes of the vehicle. In addition, it was noted that for all of these front or rear cases, only part of the front or rear area was involved, i.e. the direct damage was not over the entire front or rear area of the vehicle. It was also determined that crush was always more severe for the vehicle sustaining a frontal impact than the vehicle that was rear-ended.

Researchers also examined intrusions to passenger compartment of the trucks involved in the study. It was determined that in 8 of the cases, there was intrusion to the passenger compartment, while in 13 of the cases there was none. In other 4 cases intrusion was unknown. One explanation for the low number of trucks with passenger compartment intrusion is that 14 of the vehicles involved in the study were rear-ended. For a rear ended vehicle to sustain intrusion into the passenger compartment, the vehicle would have to crush an immense amount, at least 3/4ths of the vehicle's overall length.

VEHICLE MAINTENANCE

A visual inspection was conducted for all the tires to determine if the tread depth was sufficient for better handling of the vehicle and if there was any damage to the tires. If for all the tires, the tread depth looked sufficient and the tires were undamaged, a good rating was given. If none of the tires had sufficient tread depths or had damage, a bad rating was given. If some tires were good and some bad, a good/bad rating was given. For this study, it was found that nine of the trucks had good tires. However, 5 of them were rated bad and 3 were good/bad. The tire condition was unknown for 8 of the vehicles. It can thus be noted that only about half of the number of vehicles examined had all good tires, while for the rest, at least one of the tires was not in good condition. Visibility to the rear of a truck is another area where there was not the level of standards seen in the real world that are required by existing laws. Rear visibility is achieved by having functioning tail-lamps and reflectors so that trucks are able to be seen from the rear during night time. In this study only 13 of the vehicles were found to have reflective markings on the rear of the vehicle, 9 did not have any reflectors and in three of the cases it was not known. 17 of the vehicles studied were equipped with tail-lamps; however they were non-functional on one of them. There were no tail-lamps for 5 of the vehicles. Both of these safety features are required by law and the fact that many of the vehicles are not complying with these laws is troubling.

As per Rule 95 of the Central Motor Vehicles Rules (CMVR) 1989 [6], all motor vehicles need to have their tires in good condition with sufficient tread depth. Rule 102 in the CMVR mandates that all trucks have functioning tail-lamps while Rule 104 requires all trucks to have rear reflectors. In this study it was quite evident that the rules were not being followed. This is an area where the enforcement of existing rules could be made more effective through more vigilant vehicle inspections.

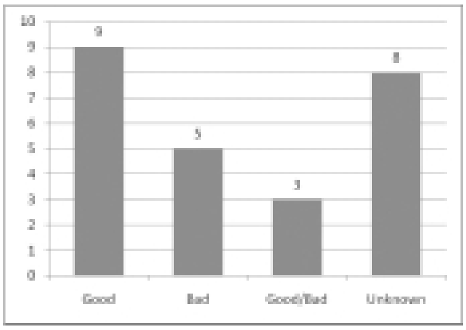


Figure 24: Tire conditions of heavy trucks examined.

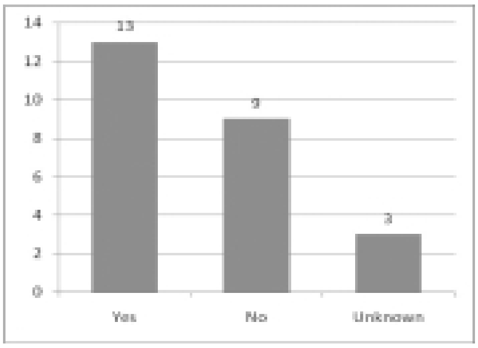


Figure 25: Rear reflector presence

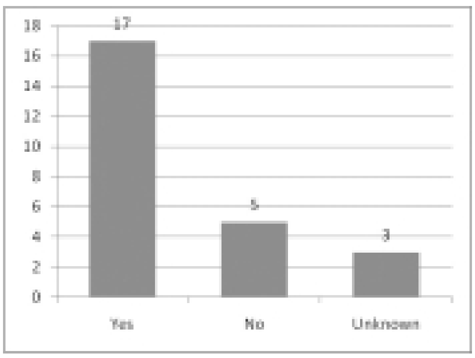


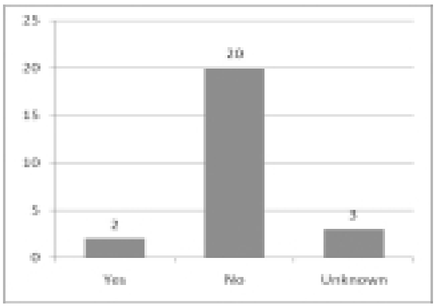
Figure 26: Rear tail lamp presence

VEHICLE SAFETY SYSTEMS

Underride protection is an important area for truck safety when they interact with smaller vehicles. Because a bumper on a truck is much higher than that of a passenger car or jeep, it is imperative that trucks have underride guards. If a vehicle rear-ends a truck which has no underride protection, it is likely that the vehicle enters into the rear overhang of the truck and will sustain the impact with its A-pillars rather than the bumper, which is an area where the vehicle is not engineered to absorb the impact. This is especially important since it has been established in this study that most trucks were rear ended more than they were rear-ending other vehicles. Only two of the vehicles involved in this study had underride protection while 20 of the vehicles did not have any underride protection. For three of the vehicles, underride protection was unknown. Although it is required by Rule 124 of the CMVR for trucks to have underride protection, this rule only went into effect in 2003 so as more post-2003 vehicles are on the road, hopefully there will be more vehicles equipped with underride protection.

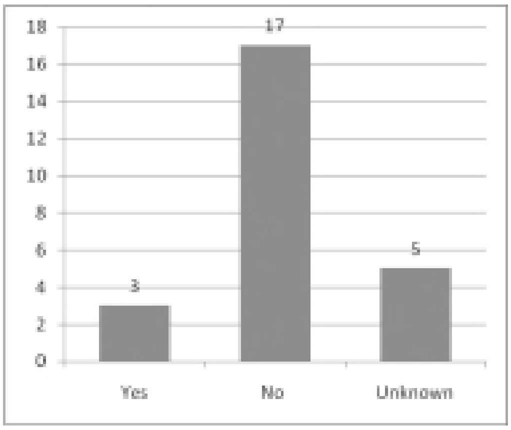
Figure 27: Illustration of vehicle override/underride.

Figure 28: Underride protection presence.



When conducting the interior vehicle inspection, researchers also noted if a seat belt was present in the truck and whether or not it was used. In this study there were no instances of belt use among the truck drivers. However, this could be seen as a symptom of a bigger problem because 17 of the vehicles inspected were not equipped with a seat belt while only three of the vehicles were equipped with them. In 5 of the cases it was unknown whether a belt was present. The fact that the overwhelming majority of trucks are not equipped with seat belts is a serious safety problem. Seat belts are by far the cheapest and most effective piece of safety equipment available for trucks, but without them as a standard piece of equipment, it is impossible for them to be utilized.

Figure 29: Seat belts availability



TRUCK DRIVER ANALYSIS

This area of research aims to understand the socio-demographic profile of truck drivers as it is also important to know the kind of road user being dealt with for road safety measures to be more effective. During this study researchers could not get detailed information about the drivers in many cases. To get a greater insight into truckers and cleaners (or helpers), researchers reviewed studies performed in Tamil Nadu in relation to the risk and control of HIV amongst truckers and helpers [7]. The following table provides a comparison of socio-demographic profile of truckers and helpers in Tamil Nadu (based on a study of 800 truckers and helpers in Tamil Nadu) and their counterparts in USA [8].

Table 3: Socio-demographic profiles of truckers in Tamil Nadu, INDIA and USA [7 & 8]

	Tamil Nadu, INDIA	USA
Average Age (Truckers)	34.2 years	43.1 years
Average Age (Helpers)	24.3 years	NA
Literacy Rate	96.1 %	100%
Basic Qualification Required	Eighth Standard	High School Pass
Average Monthly Income (Truckers)	Rs. 3,720	$3,115
Average Monthly Income (Helpers)	Rs. 2,220	NA
Average Number of nights spent away from home per month	17.1	60 hours per week

As can be seen, the profile and working conditions of truckers in Tamil Nadu, and in general across India, is well below par with their counterparts in USA. The mean age of truckers in India is much lower and also the basic qualification required is only eighth standard pass. These indicate that more effort is needed to educate truckers about safe practices while driving on roads. Hence, a concerted effort is required from various departments towards improving the working conditions of truckers by providing them with better designed and maintained vehicles, improved infrastructure and highway amenities. These improvements would also help reduce the stigma of trucker drivers being known as "killers" on the road.

When examining national data, researchers found that truck accidents are actually a national problem. Data collated from police records by the National Crime Records Bureau (INDIA) for year 2005, 2006 and 2007, shows that truckers have suffered the highest fatalities on Indian road [10].

Table 4: Fatalities in India [10]

Year	Truck/Lorry Fatalities (All India)	% of Total Fatalities (All India)	Total Fatalities (All India)
2005	21,864	23	98,254
2006	23,350	22.6	1,05,725
2007	23,991	21.5	1,14,590

When state data was compared it was found that 14 of the 28 states recorded truck occupant fatalities higher than or equal to the national average of 22%, while 13 states (red bars) recorded truck occupant fatalities as the highest. This indicates that truck accidents are a national problem and hence, truck accidents on highways need to be studied in greater detail.

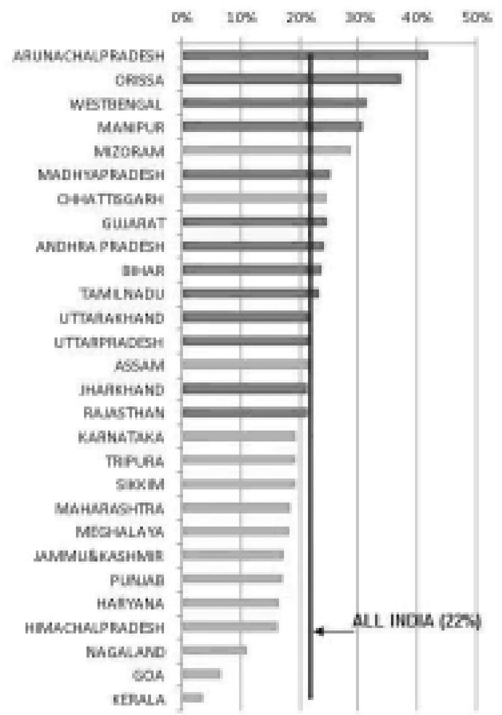


Figure 30: State-wise percentage of truck fatalities [10] compared with percentage of All India truck fatalities. Bars in red indicate truck fatalities as highest in that state.

CONCLUSIONS

Based on the above study on heavy truck accidents on national highways, the following points can be concluded:

INFRASTRUCTURE -

1. U-turns and sections of highways close to facilities/amenities are black spots for heavy truck accidents, as trucks tend to slow down or stop in these areas.
2. Proper design of U-turns and implementation of acceleration and deceleration lanes, as per specifications and standards laid down, can help mitigate accidents and injuries.
3. Providing sufficient shoulder widths, as per specifications, for heavy trucks to park safely will help reduce front-rear collisions due to stopped or parked trucks.
4. Effective driver communication, through clear and well placed sign boards, warning signs and information signs, can help drivers make decisions well in advance and give proper indications to other vehicles around them.

TRUCK DESIGN -

1. Tire quality was poor for at least one tire on about half of the cases examined.
2. The amount of vehicles with seat belt availability was extremely low for this study, and no occupants were observed to be wearing a seat belt.
3. Vehicles equipped with working tail-lamps and reflectors on the rear would have much greater visibility and therefore would be less likely to get rear ended.
4. Trucks need to be equipped with underrun protection to make sure that the structural members of smaller vehicles are engaged in the event of a front rear collision.
5. Enforcement of rules 95, 102, 104, 124 and 125 as specified in the CMVR would greatly improve safety of trucks on the road by ensuring that vehicles have acceptable tires, tail-lamps, reflectors, underrun protection and seat belts, respectively.

TRUCK DRIVERS -

1. Working conditions of truck drivers in India is well below par of those in developed countries like USA.
2. The basic educational qualification and average income is relatively low.
3. More efforts and understanding are required to educate and train truck drivers to encourage safe practices on Indian roads.

Finally, the authors would like to mention that heavy truck accidents are an increasing phenomena and hence government authorities should focus on heavy truck accident studies on highways in order to take quick corrective actions and to keep a check on the rising number of fatalities on Indian national highways.

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ACKNOWLEDGEMENTS

The author would like to thank Mr. K.P. Jain, Director General of Police, Tamil Nadu, and Mr. Satish Dogra, Additional Director General of Police, State Traffic Planning Cell, Tamil Nadu, for giving the opportunity to collect and study accident data on the NH45. The author also thanks all the personnel of Kanchipuram District Police Headquarters and the police stations for their co-operation in accident intimation and in providing accident-related information and documents.

APPENDIX A: LIST OF VARIABLES

Accident Details Variables

1. Date and time of accident
2. Accident location and the area
3. Police Station
4. Record number
5. Number of entities/events involved
6. Type striking
7. Type struck
8. GAD (general area of damage) striking
9. GAD (general area of damage) struck

Infrastructure Variables

10. Date and time of accident scene inspection
11. GPS coordinates
12. Accident scene diagramming
13. Road type
14. Traffic-way Flow
15. Road structure
16. Number of lanes
17. Roadway Alignment
18. Roadway Profile
19. Roadway Surface Type
20. Roadway Surface Condition
21. Light Conditions
22. Atmospheric Conditions
23. Road Speed Limit

24. Traffic Control Device
25. Traffic Control Device Functioning
26. Warning signs
27. Pictures taken

Vehicle General Variables

28. Vehicle make
29. Vehicle model
30. Chassis number
31. Engine number
32. RTO
33. Driver age and sex
34. Driver license effectiveness and type
35. Vehicle insurance effectiveness and type
36. Class of vehicle
37. Body type of vehicle
38. Vehicle Special Use
39. Vehicle transmission type
40. Fuel type
41. Number of Occupants
42. Occupants injured?
43. Injury details
44. Injury coding and scaling

Vehicle Inspection Variables

45. Manufacturer's specifications
46. Vehicle damage measurements and sketch
47. Vehicle interior/intrusion sketches
48. Collision Deformation Classification (CDC)/Truck Deformation Classification (TDC)
49. Tire wheel damage
50. Tire tread depth
51. Seatbelt availability and use
52. Odometer reading

Truck/bus

53. Power steering available
54. Steering disabled due to accident
55. Underrun protection
56. Type of load
57. Rear view mirror availability
58. Rear view mirror dimensions
59. Driver seat construction
60. Tail lamps availability and functioning
61. Windshield type
62. Wipers

Car/SUV

63. Occupant seating positions
64. Location of direct damage
65. Location of field L
66. Location of maximum crush
67. Field L
68. Direct damage width
69. Crush profile measurements (C1 to C6)
70. Delta v / ETS
71. Occupant area Intrusion Details
72. Occupant Contact Details

Two Wheelers

73. Front and rear brake type
74. Leg guard availability
75. Rear view mirror availability
76. Tail lamp functioning
77. Front and rear side indicators
78. Number of pillion riders and position
79. Helmet use
80. Helmet manufacturer/ISI mark
81. Luggage carried type/location

APPENDIX B: TDC / CDC FOR CRASHED VEHICLES EXAMINED IN THIS STUDY

Front-Rear Collisions:

S.NO	LEADING VEHICLE TYPE	TDC/CDC FOR	FOLLOWING VEHICLE TYPE	TDC/CDC FOR FOLLOWING VEHICLE
1	STRAIGHT UNIT TRUCK	06BLAWA	STRAIGHT UNIT TRUCK	12FRAW9
2	STRAIGHT UNIT TRUCK	05BZAWA	STRAIGHT UNIT TRUCK	01FZAW8
3	UNKNOWN	-	TIPPER	12FYHW7
4	STRAIGHT UNIT TRUCK	05RPEN1	MOTORCYCLE	11F
5	TRACTOR WITH TRAILER	06BRARA	SUV	12FLAA9
6	STRAIGHT UNIT TRUCK	06BRAEA	STRAIGHT UNIT TRUCK	12FLAE9
7	UNKNOWN	-	STRAIGHT UNIT TRUCK	12FYAW9
8	STRAIGHT UNIT TRUCK	07BRAWA	TRACTOR WITH TRAILER	11FLAW7
9	UNKNOWN TRUCK	-	MINI-TRUCK	12FDHR7
10	STRAIGHT UNIT TRUCK	08LBWUA	CAR	02FZEW3
11	TRACTOR WITHOUT TRAILER	05RKLN1	MINI-BUS	12FY
12	STRAIGHT UNIT TRUCK	06LBWU1	STRAIGHT UNIT TRUCK	12RPAS3
13	STRAIGHT UNIT TRUCK	06BRAE1	SCHOOL BUS	12FL
14	STRAIGHT UNIT TRUCK	06BRAE1	BUS	12FL
15	BUS	06BZ	STRAIGHT UNIT TRUCK	12FYAW6

Note: Although CDC [11] and TDC do not apply to motorcycles and buses, the first three or four characters were coded in order to describe the primary direction of force and the general area of damage.

Object Impacts and Rollover:

S.NO	VEHICLE TYPE	TDC
1	STRAIGHT UNIT TRUCK (OBJECT IMPACT AND ROLLOVER)	12FLWN8 00LDAO3
2	STRAIGHT UNIT TRUCK (OBJECT IMPACT)	12FRLE9
3	STRAIGHT UNIT TRUCK (ROLLOVER)	00LDAO4