Contributory factors analysis for road traffic collisions on the basis of on-site accident data collected from National Highway-8 (India)

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I. INTRODUCTION

In this study, conducted by the National Automotive Testing and R&D Infrastructure Project (NATRiP) and the Indian Institute of Technology Delhi (IIT-D) on National Highway-8 (NH-8) from Gurgaon to Jaipur, in-depth road traffic collision (RTC) data were collected by on-site data collection teams [1]. Data were collected for 186 RTCs, which were attended by two teams over a one-year period, on a 200 km stretch of a four-lane divided national highway. Detailed data were collected using crash data collection forms that capture information related to factors contributing to the crash. Analysis of case reports was conducted to identify the contributory factors involved in RTCs that resulted a collision, i.e. the key actions, deficiencies and failures. This study analyses and identifies various contributory factors observed from the collected data.

II. METHODS

A study was commissioned by the Ministry of Road Transport and Heavy Industries (MoRTH) for one year on a National Highway (NH-8), in Northern part of India. This was configured as a pilot in-depth crash data collection and investigation by the Accident Data Analysis Centre (ADAC) of NATRiP and IIT-D. Two four member teams, were deployed to collect on-site crash data as per Collision Deformation Classification (CDC) to describe appropriately a field-damaged vehicle [1]. A Mobile crash lab (MCL) vehicle, equipped with tools and equipment for data recording and measurement was provided to both the teams. The on-board equipment included laser speed measurement equipment, GPS, digital distance and inclination measuring equipment, digital camera and an angle finder.

Signboards displaying an emergency toll-free helpline number (1033) had been installed by the National Highway Authority of India (NHAI) every 500 m along the NH-8. RTC victims could dial 1033 for assistance, and a call centre then relayed the information to ambulances and to the crash investigation team. The target in this pilot study was to reach the crash site within 45 minutes. Of the 186 cases 21 cases were collected without notification through the helpline i.e. either while the team was on patrol or on the way back to centre after attending a case. Analysis of the time difference between notification time (NT) and crash site inspection time (CSIT) for the remaining 165 cases results in a mean of two hours and thirty five minutes and standard deviation value of (SD) of three hours and thirty one minutes. The large difference in mean and SD is an artefact created by a small number of crashes which were notified after the evening shift and attended to by the team in the morning shift. Analysis of 126 cases where the difference between NT and CSIT was less than four hours gives a mean of fifty four minutes and a SD of fifty five minutes.

The data collected can be divided into two categories: On-site data collection, and Off-site data collection. On-site data from the crash site included vehicle damage information, environmental and road conditions, and evidence such as skid marks, vehicle debris, rest position, damage information, blood marks, etc. Off-site data collection included injury reports from hospitals and insurance companies. The data were collected in detailed forms developed by the IIT Delhi (IIT-D) team [2]. A total of eight forms were designed for RTC data collection and analysis activity, including a general information form, a vehicle damage form, a driver interview form, a witness interview form, a pedestrian interview form, first information report (F.I.R) data from police, a hospital data form and a case summary form to record injuries sustained in RTC.

In an RTC there are actions by individuals or vehicle failure which have been ascribed as the cause of RTC. However, a RTC is the result of interaction of many parameters out of which some are attributable to the permanent way and some to transient developments. The approach taken in this pilot study is to establish

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causalities related to vehicle defect, road users, road infrastructure and environmental factors [3]. Certain parameters characteristic of these were examined to establish incidence frequency amongst the cases investigated to identify compounding causes of RTC.

A parameter is described here as contributory factor when in specific instances it differs from coded engineering practice as per Indian Road Congress (IRC) [3, 4] and/or normal road user behaviour. For example, it is not realistic to say that an A-pillar in a type approved automobile restricts field of view. If such is reported, the specific configuration restricting the field has to be established to be attributed as a contributory factor in a particular collision.

Contributory factors related to road environment have been difficult to assess because of their passive nature [3, 5]. For example, in case of an uncontrolled junction, vehicles parked on the side of the road can obstruct field of view of vehicles in stream and may be considered to be a deficient environment. Even though many road users negotiate the uncontrolled junction every day, it's only when two road users approaching along adjacent road at same time exhibit behaviour resulting in a collision that we note the parked vehicles as a violation. The specific behaviour of the road users in the crash can certainly be associated with their perception of road situation which depends on the line of sight available to them. We have hence chosen to look for deviations from the "standard" configuration and road user behaviour at the locale. This has been challenging and subjectivity is introduced by the necessity to discuss some RTC with the people involved and/or with any witnesses in order to reconstruct the pre-crash scenario.

Assessing factors related to vehicle defects was easier than environmental factors as parameters like tyre pressure, wear state of tyres and deficient brakes can be ascertained with relative ease [3, 6, and 7]. But to establish these deficiencies of the vehicles as causative factors in an RTC is sometimes a stretch. In this study an attempt was made to record presence of vehicle related deficiencies without ascribing causality. Factors related to road user behaviour are special because many of them are of transient nature and only few of them persist for longer duration. Involvement of alcohol, pre-collision illness etc. [3, 7] are in this category. But majority of factors were of short-lived errors which are difficult to classify precisely. These factors are divided in 4 categories i.e. errors of omission, failure of judgement, perception failure and behavioural failure.

Error of omission is defined as absence of expected action to be taken for safety. For example, a driver changing a lane is expected to check for other vehicle behind. A pedestrian crossing road is expected to check left or right depending on the traffic flow. A situation when a road user assesses a given situation and makes an incorrect decision refers to as failure of judgement. For example, a pedestrian may view an approaching vehicle, estimate its speed and his decision to cross in front of it is a faulty judgement only if hit by that vehicle. Perceptual failures results when it can be established that the road user has scanned the given situation but failed to register deviant behaviour. An error of omission involves no error of judgement or perception but it is the absence of a normal precautionary action by road user.

Factors related to pathologically discernible conditions, such as presence of alcohol, drugs, illness, physical disability and physical fatigue are included in behavioural failures. Errors causing a RTC may involve lack of judgement and perception but behavioural failures of a road user are considered to be the over-riding factor in many cases for a crash to happen. Incidence of factors related to environment such as presence of fog and storm appear in only few of the recorded crashes.

The Central Motor Vehicles Act 1988 [8] for road safety and the IRC [4] for specifications, standard and design code manuals were used to create a list of contributory factors [see Appendix 1] corresponding to vehicle factor, laws governing road users and road infrastructure standards, as shown in Figure 1. Each crash was investigated to tag the presence of 40 such factors. Some could be ticked off on-site, or from FIRs, while some emerged from subsequent in-depth data analysis based on the injury reports and accident reconstruction. As expected, there is an element of subjectivity in determining the factors which we hope has been drowned by statistics.

III. INITIAL FINDINGS

The frequency related to the 3 categories of contributory factors is shown in Fig. . Incidence related to vehicle defect such as tire defects and non-working of indicator lights was also very low. This is either due to absence of the vehicle from the crash site or due to refusal of the owner to allow inspection of the vehicle. Of the contributory factors 40% were related to road user and 55% related to road infrastructure. Factors related to road user was captured through the detailed driver interview form, witness interview form etc. Through the forms, the pre-crash and post-crash reactions to identify factors present which might have contributed to a crash were assessed.

A number of factors as shown in Fig. 2 and Fig. 3 were not necessarily present in all the cases. For total of 186 RTC collected, it was observed that there are 271 (55%) incidences corresponding to 15 contributory factors under the subset of road infrastructure and environment related factors and 192 (40%) incidence corresponding to 21 contributory factors under road user factors. Multiple numbers of factors related to road infrastructure and road user was present in some cases but in some cases, none of it was captured. Contributory factors were not captured in few RTC where neither driver/occupant nor witness was available and very limited information was obtained from the crash site and the damaged vehicle as well.

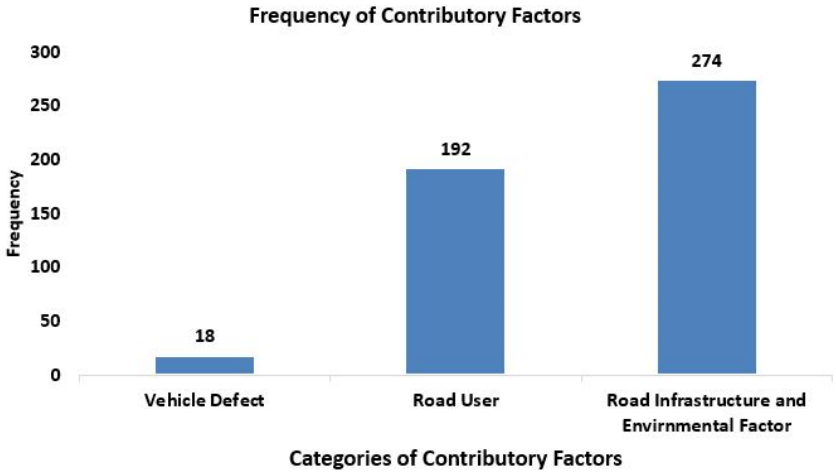

Fig. 1. Frequency of contributory factors.

Further refinement on the basis of contributory factors from subsets of the groups corresponding to road infrastructure and road user is shown in Fig. and Fig. 3, respectively [also see Appendix 1]. Fig. 2 and Fig. 3 shows the distribution of each factors in subset through percentage of incidence of factors for which details are in Appendix 1. The various factors was grouped in 3 sets and shown. But it was observed that they are interlinked and often dependent on each other; usually creating a chain of events involving human error, road infrastructure, vehicle or environmental factors that results in a crash.

Amongst the road infrastructure factors improper lane marking was more than 21%, and nearly 10% corresponds to poor or no street light. Inadequate signboard (for curved road, junction ahead etc.), uncontrolled junction, poor road surface (presence of pot holes or irregular road surface), missing or inconsistent placement of crash barriers and shoulder lane not as per standards (irregular width) also appear as compounding factors to road infrastructure resulting in a crash. Amongst the road user factors, presence of improper or sudden lane change, following too close and improperly parked vehicles in shoulder or emergency lanes was about 15 to 20%. Another 10 % incidence of road user factors such as failed to look or notice, improper overtaking and not using retro-reflective device for vehicles parked in shoulder lanes was observed. Impairment through alcohol was also observed in 7% of cases. Presence of alcohol was confirmed by attending clinicians and corroborated at times by incidences of liquor bottles being found.

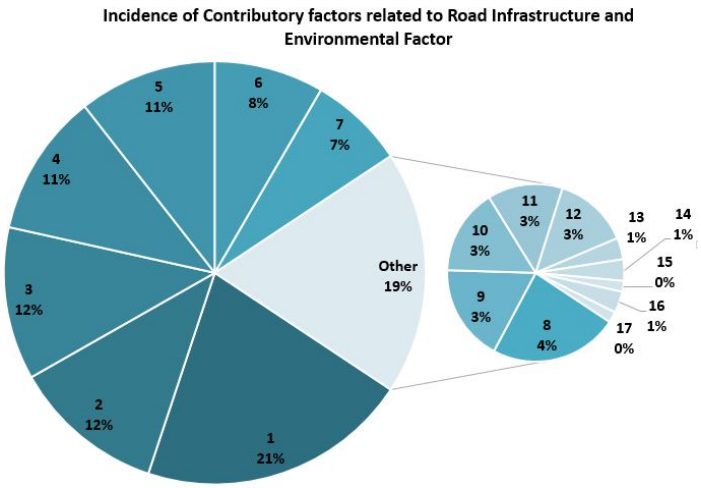

Fig. 2. Frequency of contributory factors for Road Infrastructure and Environmental Factor

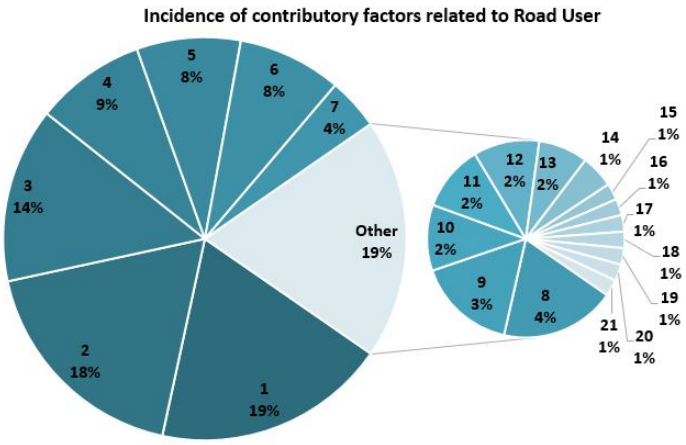

Fig. 3. Frequency of contributory factors for Road User

Analysis of injury severity, corresponding to the three categories of contributory factors is shown in Fig. 2. This injury analysis shows the frequency and types of injury observed corresponding different categories of contributory factors. The numbers in each band for a particular group of contributory factor are number of injury corresponding to minor injury (M.I), serious injury (S.I) and fatality (F). From the 186 RTC collected, injury details were available in 96 cases of which 48 fatality, 92 serious injuries and 304 minor injuries were reported.

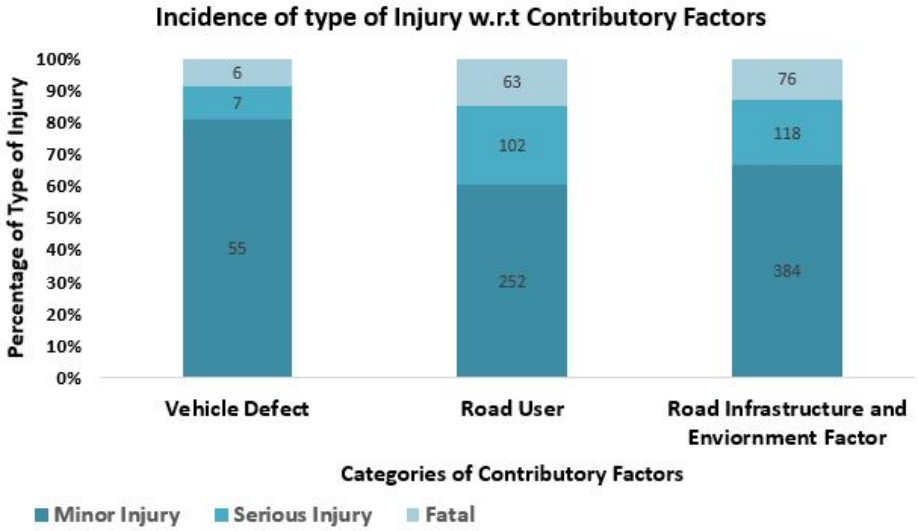

Fig. 2. Distribution of injury with respect to 3 categories of contributory factors.

Environment related deficiencies are more difficult to establish as a factor in a crash. In order to assess vehicle defects, an offsite assessment of vehicle need to be carried out which was not possible in this study. From the on-site data collection, in 37 RTC's it was established that seat-belt was used by 44 occupants (36 drivers and 8 occupants). About 40% of vehicles involved in crash were trucks but seat-belt usage was by passenger car occupants only.

In RTC involving large vehicles such as truck (more than 6 wheels), in a few cases seat-belts was either not present or shoved behind the seat establishing habitual non-usage of seat-belts. Although number of RTC involving powered two wheelers (PTW) were very few (27 only), it was found that in only 7 RTC incidents, helmet was in use by 8 riders and mostly by PTW driver except in one (where both pillion and rider used helmet). In 10 RTC's no helmet was used and for the rest, helmet usage was unknown. As many as 44 riders were injured (20 minor injured and 15 grievously injured) in PTW crash including 9 incidents of fatality. We found only in 2 RTC cases where airbags were known to be deployed.

IV. DISCUSSION

The data reported in this paper are for a limited area of about 200 km on NH-8, under a pilot study conducted by MoRTH and IIT-D, and involving 186 cases collected on-site by the data collection teams. The study yields a breakdown of the different contributory factors in a crash scenario, such as driver behavior, road infrastructure, vehicle and environmental conditions. This itemized information will help in the planning of appropriate interventions to prevent and/or reduce RTC injuries and fatalities. A large-scale database and analysis of the various contributory factors involved is required to gain detailed insight into contributory factors, and the types and frequency of injuries observed corresponding to these factors. This study shows the need yet again for integrated data collection activity through off-site data collection to gather information related to vehicle, interview of occupants or any witness to better understand the road user and vehicle related factors present in a RTC and their interaction with each other. It will also be essential to carry out this type of study at different locations, such as urban, rural and city roads, in order to analyse other types of contributory factors and how they affect the injury distributions.

V. REFERENCES

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[7] Shnieder, H., SAE 1969, Doi: 10.4271/690808
[8] Motor Vehicle Act, India code, 1988

VI. APPENDIX 1

Sr. No.	Contributory Factors Category	Contributory factors subset	Sr. No.	Contributory Factors Category	Contributory factors subset
1	**Vehicle Defects**	(1) Tyre worn or insufficient tread or Tire Failure. (2) Absence of indicator lights.			
2	**Road User Factor**	(1) Improper or sudden lane change. (2) Improperly parked in shoulder lane or emergency lane. (3) Following too close (driver not maintaining safe braking distance w.r.t vehicle moving ahead). (4) Failed to look/notice. (5) Improper overtaking (from left side of the vehicle moving ahead). (6) No use of retro-reflective device/cones/parking signal (in case of parked vehicles). (7) Impairment through alcohol. (8) Improper/protruding load/overload. (9) Lost Control of vehicle. (10) Busy in other activity. (11) Excessive speed. (12) Vehicle moving in wrong direction. (13) No use of helmet. (14) Pedestrian crossing road improperly (running). (15) Ignored/Not able to recognize signboard. (16) Impairment through fatigue/asleep. (17) Inexperience of driving or underage. (18) No license.	**3**	**Road Infrastructure and Enviornmental Factors**	(1) Improper lane markings (not visible or absent). (2) Poor or No street light (3) Inadequate signing (signboard) at crash site (4) Uncontrolled Junction or Median Cut (5) Poor surface at site (irregular or uneven road surface, presence of potholes). (6) Missing crash barriers (to divert traffic away) or Inconsistent placement of concrete barriers. (7) Shoulder lane not as per standard (w.r.t width). (8) Absence of retro-reflective device (tapes/paints to highlight divider/guard rail/concrete barriers/curved roads) (9) Median Divider height not as per standards. (10) Drainage system (invisible/ open/ covered with mud to make way to cross over from service lane to main carriageway or vice-versa). (11) Road works at site (improperly maintained or isolated construction zone). (12) Shoulder lane occupied with loose gravels and mud. (13) Improper construction of speed breaker (14) Improper construction of deceleration lane. (15) Signboard not visible properly (due to presence

		(19) Rule of one-way entry not obeyed. (20) Lane change without using indicators. (21) Vehicle crossing using median divider closed with concrete barrier or improper crossing.			of trees and plants on median divider) (16) Obstruction due to weather or Fog. (17) High winds at site or Storm.