Trailblazing Road Safety and Commuter's "Vision Zero Planning" in NH-55 (Angul Sector)

Abstract

Prelude: Road traffic accidents (RTAs) cause injuries, disabilities, and fatalities and are the major health issues globally in developing countries and also in India. The 29km stretch of NH-55(old NH-42) between Tata steel LTD, Meramundali to Angul has turned into a death trap for the 29km stretch is alarming and highly prone to RTAs after the development of many large-scale industries and townships, which needs planning and formulations.

Objective: To address the death trap in the Angul sector in NH-55, RTAs are collected and alternate commuters for the pedestrians, two or more wheeled motorized/manual vehicles for its road user. The present traffic problems faced include heavy traffic, deteriorated roads, blocking of foresight, traffic jams, RTA's, pollution, etc.

Methods: Present research aims at forming a database for road conditions, vulnerable places, RTAs frequency, and severity data collected from authentic sources from time to time. Analysis of the data is done regarding accident frequency and severity index. A thorough study of causes and types of accidents has been discussed with RTAs addressable.

Conclusions: Frequent RTAs, road traffic injuries (RTIs), are found due to excessive use of mobile phones, busy traffic and fatigue crews, unconscious pedestrians, reckless two-wheelers drivers, and distracted driving of loaded trucks are found to be the major reasons for road crashes in the area. Improvised driver conduct, use of eye tracker, community education, traffic control enforcement, or bypass can address the trend in the frequency of RTAs and RTIs in NH-55. The immediate action plan is the construction of four black spots, overbridges/VUPs, and to complete the under-construction activities to follow the vision zero of SDG 9 and SDG 11.

Keywords: Angul, NH-55, Road safety audit, Road traffic accidents,

Abbreviations:

RTAs: Road Traffic accidents**: RTIs:** Road traffic injuries**; RTDs:** Road traffic deaths; **CAGR:** Compound Annual Growth Rate; **ADT:** Average Daily Traffic; **AADT** Annual Average Daily Traffic; **BAC MORTH**; Ministry of Road Transport and Highways; **PCU:** Passenger Car Unit; **NHAI**: National Highway Authority of India; **RTA**: Road traffic accidents; **ITS:** Intelligent Traffic System; **GOI:** Government of India; **MoRTH:** Ministry of Road Transport and Highways; **NRSP:** National Road Safety Policy; **SSD**: Short sight distance; **MVKY**: Million Vehicle-Kilometre-Years; **DL**: Driving Licence; **CCTNS**: Crime and Criminal Tracking Network and Systems; **ERSS**: (Emergency Response Support System; **VLT:** Vehicle Location Tracker; **IRAD**: Integrated Road Accident Database; **OPTICS**: Odisha Public Transport & Integrated Commuter System; **IPC:** Indian Penal Code; **SDGs:** Sustainable development goals

Introduction

The road system in India has developed based on industrial growth, population rise, and urban agglomeration. Roads such as National Highways (NH), State highways (SH), and other district roads (ODRs) are insufficient to accommodate the rising traffic. Severe

road traffic accidents (RTAs) are in increasing order due to the surge in vehicles on road and causing fatalities/traumas daily. RTAs, Climate Change (CC), and environmental deterioration are inviting Health care issues like deaths, disablement, mental agony, property, and social suffering, etc.

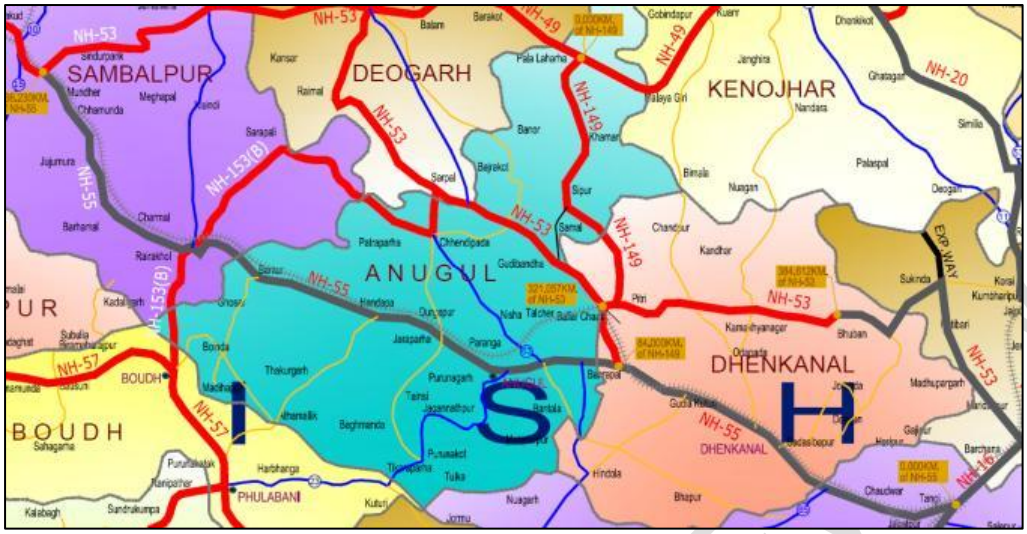

Fig 1: The NH-55 (Cuttack –Angul – Sambalpur) (source: CE: NH; Odisha)

The onset of the Anthropocene epoch replaced 11800 years old Holocene from 1950 onwards. The chronology and stratigraphy in geologic time scale have introduced global environmental changes (GECs) resulting from solely human activities (Cruzen 2002[1], Mishra S.P.2017[2], Zalasiewicz, et al., 2014 (a) [3]). The 2030 sustainable goal Agenda, the sustainable affordable transport structures reasonably placed. They are reasonably priced, reliable, sustainable, innovative energy services, quality pavements, resilient transport infrastructure, and other national policies that can build concrete economic pavement for all nations (Bilgili et al, 2022[4]). As per Paris, 2016, the Sustainable development goals (SDGs 9 &11), are the transport infrastructure built with limited environmental expenditure, clean energy consumption, green transport, etc. (Hussain et al., 2021[5], Kuskaya et al, 2022[6]), health, transport and environment, and urban environment and public transport system (Alonso et al., 2020[7], De Maria et al., 2021[8]).

NH-55 (old NH-42) connects Cuttack (East Odisha) to (west Odisha) Sambalpur which caters to transportation needs passing through districts Dhenkanal, and Angul. The study was on road NH-55 from Angul (Tata Steel) to Panchamahala of Angul town with an expanse of Km 150/0 to Km179/0 in Odisha state. The NH-55 encompasses the coal-based power plants (CPPS), aluminum (NALCO), and steel industries. The stretch commute to several large-scale industries like NALCO, TATA steel, Jindal steel, GMR, Essar steel, Adani Power, Monnet, and several small-scale industries and coal mines, etc. at Talcher and Angul. There were 258 deaths in 496 RTAs with 227 severely traumatized in 2018. In 2019, RTDs 222 in 423RTAs sustained severe injuries to 219 persons where the numbers were two figures from 2002-2010, (Kalinga TV, 29th Oct 2020). In India, the RTAs and RTDs during 2019 were 151113 (10% more than global statistics) and severely injured 451361 persons. The death toll was 131714 in 2020 (12.8% less) but RTIs were 348279 (22.8% less) in 2019, (Sikdar et al 2022, Naqvi et al 2022). So it is effective to conduct RSA, record the number of RTAs, RTDs, and RTIs in that stretch, and study black spots. It is high time to plan, design, and implement curative measures.

Review of Literature:

Road safety audit (RSA) is the technique adopted to recognize and adopt the road

safety engineering tools to maintain safety and security which starts from planning, design, construction, and maintenance, (Naci et al, 2009[9], Shah et al, 2018[10], Dehury et al, 2021[11], Jena et al, 2022[12], AlHamad et al, 2022[13], The Lancet, 2022[14], Sikdar et al., 2022[15]). The RSA and traffic improvement should stress the valuation that involves the placing of equal emphasis on all road users and stakeholders, (Bagh et al, 2022[16]). About 3000 people lose their right to live each day due to traffic accidents, (Vardaki et al, 2014[17], Kalpita et al 2022[18]). RTAs have turned out as anthropogenic catastrophe that has been caused on a worldwide scale as a silent disaster against life risks and pays a cost of 3% of GDP, (Bakhtari et al 2020[19], WHO 2022[20]). The unfortunate distinction of having the most road accident fatalities worldwide has been attained by India. Around the world, especially in India, road safety is becoming a key social concern (Shivkumar et al., 2020[21], Raju et al, 2022[22]).

Road traffic accidents are a major health concern and have turned out anthropogenic reported by WHO in 2009 (the global status report). In time, steady financing, better roads, and enhancing public awareness are urgent to reduce RTA by identifying vulnerable vehicles, unworthy drivers, and inattentive peddlers by training about road safety rules that can ameliorate RTAs (Gopal Krishnan., 2012[23], Safayan, 2017[24]). Research reveals that the perception hazards, vulnerable groups, young, careless, and inexperienced drivers cause more accidents, (Keall et al. 2004[25], Deery 2011 [26]). They have prototype patterns of injuries, (Bezabih et al., 2022[27]**).** The legal low drinking age and blood alcohol concentration (BAC) of drivers are susceptible to deaths and particularly at night. Alcohol, intoxication, and illegal narcotics cause fatalities and injuries in automobile accidents (Roeper et al., 1998[28], Borowsky et al., 2013[29], Das et al., 2022[30], Živana et al., 2022[31], Seresirikachorn et al., 2022[32]),

As the impact of climate change, topography, air pollution, and extreme weather have increased the RTAs and RTIs. There was a decrease in GH gas emissions, and economic activities. The RTAs have varied during pre-restrictions, confinements, and post-restrictions in the pandemic period but accident severity was high causing less difference in fatalities, (Solanki et al., 2016[33], Chan et al., 2022[34], Gopalkrishnan et al., 2022[23], Alsofayan et al, 2022[35]).

State-wise, nationwide and globally there were studies on RTAs and a general perception has been reported in the literature. General conceptual policies are prescribed to follow and many guiding factors to follow. But individual Road safety audits (RSA) are scanty in the available literature. The present study is to conduct the RSA for accident-prone areas over NH-55 connecting dense industrial areas of Odisha from CPP Bhanarpal to Angul.

Global Road accident statistics:

Globally 1.35millions of passengers (one death every 2.75 minutes) are facing death and 20-50 million die 24 seconds gap on roads as per the report of the World Health Organisation (WHO) in 2018[36]). About 60 billion people died in road accidents from 1870 till date and this has become the maximum from 1980 onwards i.e. from the golden spike period of the Anthropocene (Sikdar 2015, Mishra SP. 2018[37]). Among RTAs about 23% of mortalities are occurring among pedestrians, 28% are motorcyclists, and (03%) are cyclists. Demographically, the first cause of death is reported among children of 5-14years, and juvenile adults between 15-29years. RTAs' death rank 8th and are among the prominent causes of fatalities. Globally fewer RTAs but more deaths occur in low-income countries (1% of total vehicles and 13% of fatalities) whereas 40% of accidents occur causing 7% of all deaths in high-income countries with all Health care facilities, (Tavakkoli et al 2022[38], Sikdar et al, 2022[39] Naqvi et al, 2022[67]).

Road accident statistics, India

It was due to stagnancy in road activities during the Pandemic. The statistics of RTAs both NH (132500km) and SH/others (186528km), totally killed 61.63% and injured

56.85% out of the total accidents 116496 and 90755 accidents in India. The worst sufferers are the two-wheelers and pedestrians (MoRTH 2020[39], Sahu et al., 2022[40], Sikdar et al, 2022[15]). The RTA statistics are as under **Table-1**.

Table 1: RTAs in India (2011-2021) **(**source: Road statistics of India (2021**)**

Number of Road Accidents and Number of Persons Involved: 2012-2021					
Year	Total no of Accidents		Number of Persons		Accident Severity
	Total	Fatal	Killed	Injured	
2012	407498	73656	84678	408,717	20.9
2013	406726	73,585	85998	435,127	21.0
2014	4,29,914	79,354	92,619	464,581	21.3
2015	4,39,258	83,493	94,965	465,252	21.8
2016	4,60,924	93,913	105,746	496,461	22.3
2017	4,79,215	1,01,141	114,448	513,330	23.2
2018	4,84,709	1,06,531	119,868	523,133	24.5
2019	4,86,382	1,10,973	125,667	515,488	25.2
2020	4,99,629	1,19,538	134,518	527,502	26.7
2021	4,97,6860	1,21,678	1,42,489	5,11,364	28.7

Fig 2: Industries/towns making RTAs in 29km of NH-55 from TPP to Angul

On analyzing the road accidents in India, the grounds of clash that are attributable due to **Driver error:** 77.5%, Road condition issues: 1.5%, 1.6% of motor vehicle defects, Bicyclist error: 1.3%, Pedestrian error: 2.4% and **environmental:** 14.8% for all other causes. India in the global context is mostly accident-prone and warrants awareness among road users to avert accidents as per MoRTH -2022. The severity of accidents has increased from 33,7 to 36 between 2019 and 2020 respectively, (Sikdar PK., 2022[15]).

Industrial cluster and commuter NH-55

The cause of RTAs are due to deteriorated road condition that culminates in extra fuel consumption, takes more travel times, vehicle damages, overall financial loss to small roadside vendors, and indirect project-cost overrun. NH-55 connects the major industries around Angul and it commutes between Cuttack, Sambalpur, Keonjhar, Rourkela, and Hydro Electric Project at Rengali (Table-2 and Fig -2).

Table 2: The industries commuting the NH-55 connecting Angul –Meramundali.

Large scaled Industries	Place	Production	Connected	Finally commuted
Mahanadi Coal Field Ltd. (MCL)	Talcher	Coal	NH 149	NH-55 or NH-53
National Aluminium Company (NALCO)	Nalco Nagar, Angul	Aluminium	NH-55	Nh-55
National Thermal Power Corp. (NTPC)	Kaniha	Thermal Power	NH-55	Nh-55
Talcher Thermal Power Station (TTPS)	Talcher Thermal	Thermal Power	NH-55	Nh-55
Heavy Water Project	Vikrampur, Talcher	Heavy Water	NH-149	NH-55
Shree Metalics Ltd	Makundapur	Sponge Iron	NH-63	NH-55
Jindal Steel & Power Ltd.	Nisha, Angul	Steel	NH-63	NH-55
Jindal India Thermal Power Ltd.	Pathamunda, Kaniha,Angul	Thermal power	NH-63	NH-55
Tata Steel Power plant	Meramundali	CPP	NH-55	NH-55
Tata Steel BSL LTD	Meramundali	CPP	NH-655	NH-55
Tata TISCON	Panchmahala	distributor	NH-55	NH-55

Fig 3: The road and traffic conditions and TRAs between Angul and Meramundali

Road selected for study

This study was conducted on the two-lane highways that run along NH-55 from Angul to Bhushan Steel. The stretches below were chosen for data collection. The study area is depicted **(fig. 2).** The road CH150/0Km to 179/0 Km is passing through many large-scale industrial complexes from Meramundali (Tata steel BSP) near the captive power plant (CPP) at Kulad, Jindal steels, Coal mines, and Nalco near Angul city due to bad road condition from Meramundali to Rairakhol. About 15 accidents occurred in August 2022 (The New Indian Expresses 5th Aug 2022.

Objectives of Study

The deaths and injuries on the road in India both scaled up by 5.8% and 2.4%, respectively. Less research has been done to examine accidents on various roads. A present search has been taken over one of the busiest roads (NH 55) of the industrially developing areas in Odisha: To survey the pulsating accidental rate, deaths, and injuries on a particular stretch of road on an annual, monthly, daily, and hourly basis.

1) To investigate the transport parameters such as traffic volume, density, and capacity effect, the frequency of accidents over NH-55 urban two-lane roads.
2) To investigate the impact of accident rates on maintaining the roads and shoulders.
3) Identification of black spots within the stretch and Accident investigation
4) To form a road state, AADT, and roadside feature-based accident prediction mode
5) SDG -9 and SDG -11 correlated with transport infrastructure and road safety with the proposed road under study

Methods and Methodology

The present article investigates the RTAs and RTIs on a 24-hour busy National Highway (NH -55). The road connects several large industries and Captive Power Plants (CPPs) that have been taken up after independence and mainly from 1985 onwards. The accident data is collected from various print media, electronic databases, websites, various literature (Dehuri et al, 2021[11]), and Police stations under area-wise jurisdiction. Analysis of the data is done regarding accident frequency and severity index. The methodology applied is in **Fig 4**.

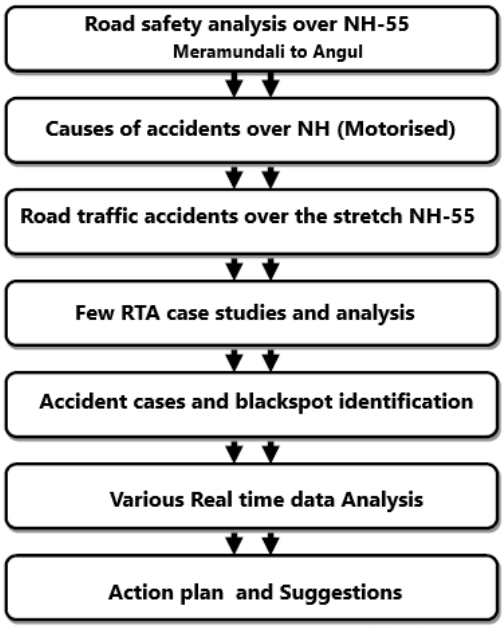

Fig 4: RSA in NH-55 (Meramundali to Angul)

The number of RTAs in an area is under-reported to the police station or NH or state authorities. Vehicles that have been reported to the F.I.R. are being involved in accidents. They are Tempo, cars, mini-truck, mini-busses, tankers, and motorbikes; Tata-407, trucks, and buses are among the several types of vehicles.

Road Safety (NH)

Considering road safety in NH establishments in India are (i) NHs in India is 132500km (March -2020) which comprises 2% of the entire road length of 6.22million Km as per MoRTH - 2022 that carries ≈40% of total motor traffic (Mohan et al, 2009[41]). With much stress on

national highway development, only India could convert less than 23% of its NHs to four-lane and above (MRTH 2017-18). In 2020, the recorded deaths in India were 47384 people (36% of total accidental deaths), and lowers o.77% of the GDP of India. Socio-economic road traffic security raises plans and policies for dropping the chance of road accidents, deaths, and injuries. A selection of routes and designs can keep road user safety and provide a sustainable secured road environment to down surge the RTIs and RTDs.

Various Causes of Accidents: Three major causes that contribute to road accidents are (i) Vehicle; (ii) Environment; (iii) Driver etc. and failures are in Table 2.

Table 3: Various Factors Responsible to Road Traffic Accidents (RTAs) in India

Attribute	The Causes of accidents	Failures
Driver-related; Traumatic fatality	Drink & drugs (BAC<0.4%), age, gender, persona, origin, education	Illness, no helmet, falls, (Shivkumar et al, 2021[21])
	With high refractive error	Lacks distance estimation
	risky speed	Use of Cell Phones
	Drowsing or Fatigue	Way to distract
	Tiredness	improper turning/ passing
	Ignore traffic regulations	Absence of Restrictions
Road related	Poor design, scarce light, many lanes, inapt curves, less SSD, more humps	Skidding, capsizing, slips, system failure, less life, ongoing road structures
Vehicle-related	excess loading	steering mistake
	brake problem	Tire blowout
	slight flaw	wheel alignment issue
Nature & meteorology related	Extreme weather, floods, fog, snow, avalanche, fire, storms, high waves, landslides, etc.	Road damage, traffic fatalities, and Injuries
Environment based related	roadside danger	impediment to vision
	Potholes	bad traffic management
	Garbage or debris on the road	Roadside Risk
	fog or smoke	Fixed Items
	Stare back	Ponding water
	incorrect or ineffective traffic signals	shoulders are damaged
Enforcement, overriding traffic laws	Violation of traffic rule signs and signals, petrol stations, positioned advertisements, animal pass, humps, speed breakers	Loss of life, injury, vehicle damage, etc. Chandraratna et al., (2020)
Anthropogenic	Intentional, Ardent, Invalid DL, not using safety devices, Tripple riding, Distracted driving, Road rage, wrong parking, not using pedestrian tracks.	RTAs, RTDs, and RTIs along with tangential loss, distract nations' CAGR & GDP
Logistics	Male and female drivers and road users	Speeding, non-speeding, and carelessness

Regulating the blood alcohol content (BAC) legal limit is 0.03% or 0.03 mg alcohol in 100 ml blood in India. It is 0.08g, to Brazil drivers in 2020–2022, driver behaviour decreased by 45% and 14% decrease in traffic deaths on-road, (Campos et al., 2021[42]).

Positioning and losses in Road Accidents

The accident has both immediate and long-term costs. Details of types of accidents and the relative positioning of the two vehicles that affects man and money (**Table 3)**

Table 4 Types of Accident, Position of Vehicles, and Consequences

Sl No	Type of Accidents	Position of Vehicles
1	Go for it	Vehicles from the opposite direction
2	Back end	Vehicle in the same direction
3	Turning and angling	Vehicle from adjacent direction Intersection)
4	Leaving or Reversing	Overtaking
5	Turn around	On path
6	Operated	Off path
7	Moped bicycle	On curve turning
8	Fixed Items (Trees and Poles)	Off path curve
9	Road user	
10	Mammal	
	Consequences	
1	Real Estate Loss	Deformity (Head injury, no skin fracture)
2	Detect Death	Shatter
3	consciousness loss	Going to freeze
4	Mutilation (Loss of body part)	Trauma
5	Neck/head injury	Accidental laceration (Injury involving cut)
6	Rubbing	Speech, hearing, or vision impairment
	Increase the risk of injury	Chest discomfort and breathing difficulty

Accident Theory

The impact RTAs in collinear and angular collisions is the main cause of road accidents. Also, collisions can be classified as (i) collision at the back and head-on direct collision which can be explained under two theories. They are (i) the Theory of Poisson Impact and (ii) the Theory of energy

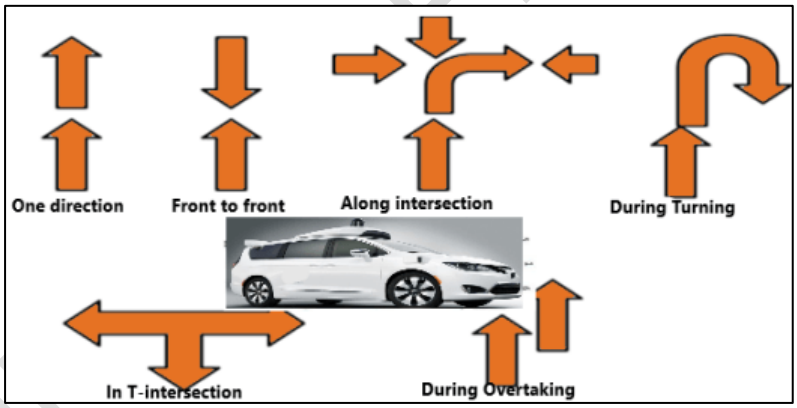

Fig 5: Types of Accidents, Position of Vehicles indicating causes of accidents

Haddon's matrix

The Haddon matrix, (1970), depicts the causative factors linked to people, vectors (or agents), and environmental characteristics before, during, and after RTAs. The Haddon matrix model can determine the relative implication of several elements and emerging treatments, **Table 4.**

Table -5: A typical Haddon Matrix causative factors linked to RTAs (Wiki [43])

Phase	Human Factors	Vehicles and Equipment Factors	Environmental Factors

Well before (Pre)	Knowledge, Skills Depreciation putting into practice by Police	Road dullness, Light Lowering Speed Control	Planning and design of roads limiting speed, Pedestrian zebra cross.
Collapse (during)	Impaired by the use of restraints	securing the occupant other security measures a crash-safe design	Roadside artifacts that can prevent collisions
Well after (Post)	First-aid training getting to doctors	Simple access Fire danger	Rescue services Traffic

Perception that distracts

Using a video-based danger perception test, (Sagberg et al., 2020[44]) found that male beginner drivers had comparatively slower reaction times and higher initial risks. Relative risk is calculated as follows: (Risk related to BAC) x (Risk related to age) x (Risk associated with a passenger)

Loose balance after two pegs

Presently Psychoactive Substances like drugs, narcotics, cannabis, and alcohol consumption is rampant among drivers in Odisha when on a long drive and away from family. Intermittent medical tests are needed and huge legal penalties are required even cancellation of their licenses (Das et al., 2012[45], Goli et al., 2022[46], Zivana et al., 2022[47]).

Speed thrills that Kill

RTAs are the consequences of the surged driving speed, rashness, and attitude of the pilot of the vehicle. RTAs can be lowered if the skill of the driver is raised by proper training and intermittent check in the name of renewal of licenses. Lee's real-time crash prediction model imposes variable speed restrictions that reduce the chance of a crash. Improper street illumination, obstructed sight, and extreme weather can prevent a vehicle from RTA, (Aarts et al., 2006[48], Globe et al., 2020[49], Prabhakharn et al., 2021[50])

Mobiles the door to RTAs

Drivers and road users have been fascinated with music and mobile talk by using headphones while driving. The distraction from driving and not being attentive to the horn and call from behind most invite RTAS.

Fatigue sleep, the heavens pathway:

Driver's nativity, records, time of journey, continuous drive, location, speed and mechanism of the collision, and physical health are various states that invite fatigue and later sleep of the driver and its crews. Pilot gets tired if overeaten, on lengthy trips, and on night journey are prone to accidents and injury severity is high (about 20-40% of severe accidents in the area), (Taylor et al, 2006[51], Tavakoli et al., 2022[38])

Mobile calls may be the last call

The use of a held phone or hearing buds during driving has tainted the driving enactment. Though mobile phone with web-GIS application has fetched expediency in transport activities, long or inappropriate use of mobiles increases the risk of accidents, (Butt et al., 2020[52], Cao et al, 2022[53])

Road safety rules, best tools

To save road users from RTA, it is essential to use Helmets, seatbelts, and road safety accessories fitted in the vehicle or to be put on by the road user. Seatbelt lessens injury severity and saves lives during an accident. Head injuries are not as much of severe on wearing an ISI-branded helmet, in RTAs, where skull injuries are high for bicycle users (Pal et al, 2019[54], Abdi et al., 2022[55]).

Electric Vehicles time/cost saver and comfort donor

Motorized vehicles and particularly electric one is fast, saving, comfortable, flexible, and pocket friendly for both passengers and goods transport from a safety and reliability point of view. But these vehicles have disadvantages of the RTA, RTDs, RTIs, environmental deterioration, and economic loss on collision. This can be the result of poor wheel alignment, burst tires, failed brakes, overloading, one or more headlight, backlight, indication, or steering defects, (Sanguesa et al., 2021[56], Glazener, et al., 2022[57]).

Tyre Defect

Tire defects may result from external impact from potholes, debris, nails, etc., under- or over-inflation, age-related behavior, and over-inflation. All tires, including spare tires, should be replaced after six years from the date of manufacture, (Garg et al., 2006[58], Achari et al., 2022[59]).

Breaks; the bad boy as mechanical failure

The significant mechanical failures observed in motorized vehicles on road are the headlight adjustments (horizontal and vertical), and braking failure. Even mechanical failure occurs causing accidents are undulated roads, the burst of tyres, and defective and not attended mechanical parts of the vehicle causing accidents and causing significant intangible costs. (pain, grief, and suffering). Especially break failures consequences in accidents for overloaded Vehicles, uneven tyre pressure, incorrect brake adjustment, and air or slips in the brake assembly. Broken pipes, low brake fluid levels, shattered brake drums, and hot brakes are all causes of brake failure (Tavakkoli et al., 2022[60], Montero et al., 2022[61]).

The old vehicles carrying overloads

Accidents can be allied to overloading and the age of the vehicles. Timeworn vehicles are inclined to failure and are more disposed to collapses and want of safety. The old Truck's overloading hinders the vehicle's bulk to brake, stability, and overcoming unexpected road flaws and damages and even cause accidents. Overloaded heavy truck fatal collisions rise by 52%. (Chan, 2020, Osama et al., 2021, Wen et al, 2022)

Road building architecture

One of the most important elements that influence, how people drive and perceive safety is the architecture of the roads. The driving metrics for road safety are speed and lane positioning. The combined effects of pavement design elements shoulder width, guardrail, and roadway geometry (curvature), are causes for RTAs (Bassat et al.,2011). The association between lane or shoulder widening and accident reduction rate for a 1.2m width increase might reduce accidents by 21%, (Zegeer et al. in 1991). The highway shoulder determines the association between shoulder-related crashes by type and severity category, data were studied. Relationships between pavement enlargement and accidents are common, (Bamzai et al., 2012). Surface Discontinuity is associated with **RTAs** The association between accident data and surface discontinuities reveals that high broken patches, and potholes of roads, followed by bumps and dips, followed by rocks, ruts, potholes, and tracks, (Forest et al. 2020, Quistberg et al., 2022).

Road Side Geographies and topographies

The RTA frequencies against the roadside features and accident severity have been in active research. The cut side slopes are evaded if the space from the exterior shoulder edge to the guard rail is reduced, the isolated trees on the roadside and the distance between the light posts are decreased. Roadside features including the guardrails, buildings, cut edges, sign signal supports, vegetation, and utility poles that decreases the RTAs,(Jinsun et al;., 2003)

RTA savers the Signs and Signals

The split phase, timing, signal connection, pedestrian zebra cross, and pedestrian allowance are signal-related. The road needs smooth traffic flow, calming solutions, and zero accidents. They have a positive impact on safety. Visible crosswalks, curves, traffic speed restricted zones, posted/digital speed recorders, mandatory roadside, cautionary

traffic, signs, and signals on Indian Road draw the driver's cognitive responsiveness, but in real time they have less impact (Singh et al., 2022[62])

Fog, Dust, and Smoke linked RTAs:

Insufficient street illumination (mainly at night), increases the chances of fog, Smog, smoke, and dust-related RTAs that are at times severe. The danger and its severity surge in head-on collisions and rear-end collisions. High speed, roads without separators, undivided roads, roads without Kerbs/ sidewalks, and SH or ODR roads are more likely increases the frequency and severity, (Srivastav et al., 2021[63]).

Fig 6: Mandatory roadside, cautionary traffic, and signs and signals on Indian Road (Commerce & Transport (Transport) Dept, Government of Odisha GOI)

Traffic Volume

Significantly RTAs, RTDs, and trauma patients are observed during the emergence period of Covid-19 than the pre and post emergencies. The even and unvarying traffic stream fallouts lower RTAs. The RTAs of heavy carrier accidents involving large carrier lorries decreased, and those involving cars remained constant. The road geometry, volume, and variation of speed, high traffic volume at night, endangers the traffic and road users' safety. The RTAs are proportional to Annual Average Daily Traffic (AADT), the radius of curvature, road cross-section, road condition, and design hourly volume (DHV), (Ivan et al., 2019[64], Ma et al., 2022[65]).

The data collection:

Accident data were gathered year-by-year from each police station's records, then sorted out month-by-month. Stretch-wise average annual variation in accidents 2012-2021. The Police Station s under whose jurisdiction the Road section is from KM150/0 to Km 179/0 on NH-55 is from Angul and passes through major industrial areas like Nalco, CPP's, TATA steel, JSPLA to Meramandali via Banarpal for the period 2013 to 2020 (Dehuri et al, 2013, 2021[66, 11]). The database formed is in Table 5

The RTAs data for the period from 2002 to 2011 were considered for analysis (Dehury et al, 2013) and it was observed that there was less difference in the number of accidents, and RTIs in the road stretch considered. The maximum number of deaths during this period was 21 persons through 105RTAs, (Dehury et al., 2013[66])

Table 6: displays accident information from 2012 to 2021 from Angul to Tata steel

Year	Fatal	Major injury	Minor injuries	Total RTAs	RTDs in areas of accident gravity with remarks
2012	15	16	37	53	More RTAs from Kulad to Bhanarpal (9 pers); followed by Angul to NALCO (6 per)
2013	11	35	50	85	Meramundali to CPP more RTAs (6pers)

2014	16	25	45	70	More RTAs Angul side last 5kms (11pers)
2015	20	32	39	71	More RTAs from Kulad to Bhanarpal (9 pers); followed by Angul to Nalco (6pers)
2016	21	34	40	74	From Angul to NALCO (10pers); From Meramundali to CPP Chhak (7pers)
2017	18	41	84	125	Meramundali to CPP Chhak (7pers) and from Angul to NALCO (6pers)
2018	4	24	61	85	From Bhanarpal to NALCO areas (2pers)
2019	13	32	81	113	From Angul to NALCO (6pers)
2020	18	34	84	118	NALCO side (8per) and Kulad side (7per)
2021	11	30	58	88	From Tata steel's end 5 persons
Total	147	303	579	882	From the Angul end 68persons dead and Bhusan steel end 61persons

From the analysis of the accident data the numbers of RTAs with higher severity from the Angul township side followed by Meramundali i.e. Tata steel (plant) side. Major injuries in the stretch of 29km are 52.33%. The black spots need to be identified. Data collected from the GOO that the Carriageway width in Mount is 7m; the mount formation width is 12m and the CS width is 45m. In addition to the aforementioned, PWD records were used to acquire data on traffic volume, which are displayed in the data.

Annual Variation in Accidents

Accident rates are seen to be rising generally throughout most of the year. The accident rate fluctuated between high and low in the year 2020. It might be caused by a rise in the number of cars on the road, terrible traffic conditions, population growth, and under the pandemic situation. From the 29km stretch, the accidents are high in the peripheries of Angul Township and the TATA steel side. The increased number of commercial and private cars and the congested traffic conditions are to blame for the higher accident rate. March, April, and May are the summer months when accidents are at their highest rate. This is a result of environmental distraction. The issues throughout these months are glare, weariness, and uncomfortable heat. It is observed the frequency of accidents occurs more between 8 and 9 p.m. when line trucks start their long journey

Table 7: The Accident case studies between the stretch of NH 45 (Tata steel to Angul)

#	Accident type	Location	Date & time	Vehicle-1	Vehicle -2 or object	Fatalities/Injuries
RTA-1	Head -on	CPP gate (NALCO)	MAR 30, 2021 (4.30 PM)	TataTruck no OR-06/ B-6545	Bajaj motor cycle no OR- 05/U-3323	One dead, one sternly injured
RTA-2	Roadside tree (T-Junc.)	Near the police station Angul	13th June 2021(1230 PM)	Ashok Leyland trailer	Tree and Bajaj Auto	Two major injured
RTA-3	Tree & compoun	Smelter traffic	12th Jun 2021	Tata truck	Tree and wall	Severely injured one

	d wall	post; Angul	(6.10 PM)			person
RTA-4	Head on	Jharpada, Angul	21st Mar 2021	Ambulance	Truck; (by Md Suffian)	India Today 4 killed, 3 critical
RTA-5	Back Hit	Maratira Vil. Angul	30th May 2022	Truck	Auto Rickshaw	2 dead 2 critically. injured

The trend of collisions, deaths, and Injuries in 2020-2022

The statistic reveals the accident rate per Million Vehicle-Kilometer-Years (MVKY) is surging year to year.

Fig 7: Some road accidents considered black spot area NH-55 (Angul –Meramundali)

The study of sight indicates that inadequate shoulder size and non-maintenance, roadside electric poles, transformer stations placed near/on the shoulder, old trees with the large girth on road banks, obstruction due to sight distance, poor signs and digital signals at intersections, dense parking of vehicles on the roadside (particularly at Dhaba/motel entries), and lag general cognizance endangers the road safety that causes RTAs, **Fig 7**.

Black Spot Analysis

As per MoRTH list-1;(2015), there were 789 Blackspots in NH of length 1,01,011km, and MoRTH List-2 (2019): 8014 Blackspots within NH of length 132499Km**, (**Sikdar 2022[09]**,** Naqvi et al, 2022[10]**).** As per GOI No RW-NH-29011/0 /2019-S&R(P&B) MoRTH (S&R(P&B: Section), a Black Spot is one "Within a 500m in length stretch of NH either 5 RTAs (in all the three years put together involving [fatalities; grievous injuries) took place during the last 3 calendar years or 10fatalities (in all three years put together) took place during the last 3 calendar years. The RTAs data have been collected, a field study has been done and the Black spot is prioritized **(**Table 8**).**

Table *8:* RTAs analysis and fixing the black spot amid TATA steel to Angul (1917-2021)

Proposed long-term majors	Accident Points/priority	RTAs all	Probable reasons	reasons Short-term measures
T-junction; Traffic/signal	Raj cinema hall/ P-3	15nos	Due to irregular traffic in the Cinema Hall	Enhancing shoulder/ sight distance visibility/signals

T-junction; Traffic/signal	Raj Hotel/P-3	16	No Signal, no mark on Shoulder Trans-former on the blind corner, road parking	obstacle on shoulder and sight visibility to clear
T-junction; Traffic/signal	Police training College/P-2	20	No mark on paved shoulder, roadside parking	Putting in Speed Breakers and Marking
T-junction; Traffic/signal	Turanga/p-2	21	Street parking, country Area, bad shoulder, Trees/ electric Poles on Shoulder	Speed limiters, awareness, and removing obstacles
Overbridge; T-junction; Traffic/signal	Kandasara /p-1	43	Village; School Area, Shrubs/trees & Poles on Shoulders, Steep Gradient	Speed limits fixing & obstacles removal, from the shoulder
T-junction; Traffic/signal	Sahid petrol pump/ p-3	15	Bad Shoulder, Front area of Petrol Pump damaged	Shoulder repairs, the shift of the pump-unit.
T-junction; Traffic/signal	SBI Kandasar/p-2	20	Petrol Pump, Taxi Stand. Trees and Poles on The Shoulder	remove shoulder blockage by vehicle halt to be limited
T-junction; Traffic/signal	Smelter Gate /p-3	15	Median without Sign on the Road, Temple on the Shoulder, Trees on the Shoulder	Painting Medians & obstacles on The Road Should Be Removed
T-junction; Traffic/signal	Bhanarpal Hat/ (p-3)	15	Trees, Edge drop	Maintainance of the road and shoulders;
Over Bridge with a traffic signal	Bhanarpal Chawk/p-2	24	On-road Cars, Taxis, Bus Stops, small vendors Shop, zigzag Shoulder	Need new bus stop, clear and maintain shoulder and junction perfections
Tata Steel side; VUP	Santri Chawk/ (p-2)	21	Dhabas, a car showroom, and shoulder ponding by a drain	Off-Street Parking Area, Shoulder
Overbridge	Nua Hata Tata steel end (Priority-1)	44	Blockage from trees, the Dhaba, and shops on Shoulder, &Curve.	Curves visibility improve, & shoulders fix speed limit and off-street parking
Vehicle Under Pass (VUP)	Joradia / (Priority – 1)	32	Shoulder diverts, trees block the view at curves, trees cover the shoulder, and sight is poor.	upkeep shoulders, visibility improve close off-street parking near curves

Many small and minor accidents are not reported in general. Observing the accident frequency and severity of RTAs only five stretches of NH between Meramundali to Angul have been considered priorities. **(**Fig 8**)**

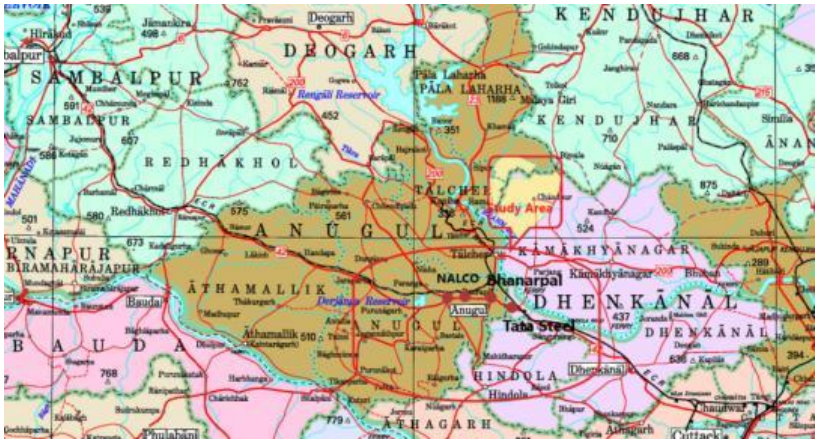

Fig:8: The prioritized Black spot areas in NH-55 between Tata steel to Angul town.

Discussions

Accidents are a burden on the national economy and human health injuries, death, property, social and psychological suffering, and overall environmental deterioration. The multifaceted road users in India, including low age group, pedestrians, animal-driven carts, bicycles, rickshaws, hand carts, tractor trolleys, as well as several types of two- and three-wheeled vehicles, motor vehicles, buses, trucks, and multi-axle commercial vehicles. The changes in people's lifestyles, vehicle types, and human attitudes have increased traffic turmoil during the golden spike period of the Anthropocene (Mishra et al, 2020[68]).

A variety of elements interact to cause RTAs by different types of road users, including pedestrians, go-carts, bicycles, rickshaws, tractor trolleys, as well as electric/motorized fuel-driven two- and three-wheeled vehicles, motor vehicles, buses, trucks, and multi-axle commercial vehicles. Due to changes in people's lifestyles, and attitudes, without a proper driving Licence (DL), the number of vehicles has been constantly raising the number of vehicles/volume of traffic. The causes of accidents in the Indian scenario, their ameliorative measures, and actions against road safety have been investigated presently. Some modification on the horizontal and vertical design of the emerging edge has been innovated from the Cuttack side.

The research on the road from Meramundali (TATA Steel) to Angul is highly essential. The various Real Time data needed are:

1. Vehicle Data Analysis
2. Type of vehicle information and target of the journey using digital speed recorders
3. Cameras before all black spots to monitor locations 24 hours
4. Plan and construct for all major vehicles underpasses (VUPs) and flyovers.
5. Regular public awareness and driver training programs for reducing RTAs
6. Construct more trauma aid centers to provide all health care support after RTAs.
7. Enforcing integrated action plans like imposing penalties (e-Challan, Vahan and Sarathi 4.0) for data access along with Crime & Criminal Tracking Network and Systems (CCTNS) project, and Emergency Response Support System (ERSS) based on the severity of accident and irregularity.
5. Highway Patrol, Interceptors, IRAD, and VLT for data access and transactions.
6. Automated Fine Calculation based on the severity of and dis-tracking adhering to guidelines of MV Act and its implications with Traffic Rules.
8. Investigation of carriers carrying on the road stretch with OPMS (Odisha Permit Management system) and application for recording their period and trip schedule.

9. Dashboard can be viewed from across any office or establishment under the Static timing analysis (STA).

11. Ensuring road safety throughout the NH/SH.

10. Constant vigilance and e-challan is warranted for the drivers and passengers of vehicles violating the traffic rules and nonuse of seat belts and eye trackers.

The future solution rest on stretches on the road, places, video images, provable evidence, and serving suitable challan to the offender and the legal formalities, admissibility in courts with prevailing legacy systems. The Government of India (GOI) is deeply concerned about the snowballing road accidents caused due to roads, traffic, vehicles, and governance. Regardless of jurisdiction, GOI and state exchequers have combined obligations to lessen the safety index value, and the number of road accidents, injuries, and mortalities. The GOI has focussed on road safety and traffic management. A draft National Road Safety Policy (NRSP) was prepared and accepted. The NRCP footprints are framed by the Government of India (GOI) at line levels to cut down the road safety activities as under:-

Table 9: Road safety recommendations in promoting Road safety

Road safety Recommendations	Concerned activities
Ensure Safer Road (rural and urban) Infrastructure, (Actions of the Government)	Take measures: reviewing standards in road safety: design of roads, actions for consonance with global best practices under Indian traffic settings and Intelligent Transport Systems (ITS)
Safe Vehicles (Action of the Government)	Safety and efficient features are included during design under the national framework.
Safe drivers (State Govt. Human consciousness)	More verification during licensing and verifying skill and hand-in-set training to develop the ability and fitness of drivers
Enforcement of Safety Laws (Government action)	Coordinate, reinforce, and develop the quality of execution to warrant operative and uniform application of safety laws.
Roadside trauma centers and Medical Services to address Accidents	Victims of road accidents need medical help early; adequately and effectively from trauma care centers including rescuing and first aid
Institute Road Safety info Database (Government actions)	Backing local bodies, UTs, and States to improve the quality of crash investigation and data collection, transmission, and analysis. NRSI has to be instigated to provide as per policy
HRD & Research for Road Safety	Research funding after priority areas conducting research, diffusion of the findings through an electronic medium, publication, training, conferences, and workshops by cloud platform
Safety of susceptible road users	Road planners and engineers should design and construct all roads to account for the needs of non-motorized transport and the vulnerable and physically challenged in an appropriate manner.
Reinforcing tool for active coordination among patrons	Consolidating legal, financial, institutional, and environmental for road safety, use of eye tracker
NRSP strategies enforcing	Redressal strategic plan and action on Road safety issues by the provision of NRS funds.

Conclusions

The numbers of RTAs are more than other categories of roads and the black spots are increasing year to year. According to the present research based on available on RTAs analysis, drivers' errors are accountable for road accidents on NH-55. The major accidents that have occurred involved heavy vehicles, such as trucks, and existing and under-construction accident-prone areas Road users should be made more conscious of road safety. From Nuahat Tata steel) to Nua-mouza (TISCON) most of the accidents have occurred. By clearing the sides of the road, maintaining the shoulders properly, and improving junctions, and lighting, the RTAs rate can be reduced. Humps should be installed close to accident areas to lower the speed limit. Three over bridges and two VUPs can address the RTAs prone area along with proper Photo voltaic digital signaling and indicators necessary. Four numbers of black spots need immediate prioritization to minimize the RTAS.

To address SDG 9 and SDG 11, it is high time for Vision Zero (VZ) that targets zero fatalities or serious injuries from RTAs by increasing trauma healthcare centers at regular intervals with full-fledged staff, doctors, and ambulances.

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