

MATHEMATICAL ANALYSIS ON ROAD ACCIDENTS

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Abstract:

Road Accidents are unplanned incidences which involve injuries and deaths. The affected persons are not only individuals but also groups or families. Any such rider or passenger met accident unexpectedly and their lives are unguaranteed. The admitted injured persons to the hospitals are analysed based on their arrivals and services. So queueing techniques are applied and the suggestions are carried out.

Keywords - Accident, Injured patients, arrival rates, service rates and queueing parameters.

1. INTRODUCTION

Transportation is the backbone of all economic activities because people want to move themselves and send their materials from one location to another. In the modern world, the decision to avail a particular mode of transportation depends mainly on its availability and efficiency. The alternatives will be road, rail, air and water transportation facilities. Compared to other modes of transportation, road transportation has some peculiarities and advantages such as: it is easily available and well – connected mode of travel, it can be used for non-motorized and motorized transport, it could also be used as an intermediate mode of transportation even to reach other modes to travel. These advantages attract a major portion of passenger and material transportation to be done through road network. Normally, land transportation assumes the form of surface transportation. In certain locations, it is converted to underground or elevated transportation. Roads, like all other modes, are used for passenger transportation and freight (goods) Transportation. The overdependence on the road transportation because of the advantages it offers causes a set of ill effects like air pollution, noise pollution, congestion and road accidents. Of all the ill-effects, road traffic accidents have become one of the major social and economic problems facing the world today.

It has been assessed that world-wide, every year, millions of people died and also get injured, due to road accidents. Road accidents are now the leading cause of death for people aged between 5 and 44 years, which shows that a good number of world's productive people are being lost in road transport accidents.

India registers high road accident rate in the world. The number of persons killed per one lakh population is 11 which is very high for India compared with developed countries where it is below 5 per one lakh population. (Dinesh Mohan 2009)

There is a phone call or a knock on the door that we all dread, in which we are told that a loved one has been killed or seriously injured in traffic crash. We shiver as emergency vehicles past us on the road to attend a crash. Our heart misses a beat as we hear about a road accident on the news. But road traffic crashes are not accidents. They are completely preventable. This report shows us that the problem is getting worse. Millions of people are injured or disabled every year, people who suffer life altering injuries with long – lasting effects. These losses take a huge toll on families and communities. There are many reasons for this trend: rapid urbanization, poor safety standards, lack of enforcement, people driving distracted or fatigued others under the influence of drugs or alcohol, speeding and a failure to wear seat belts or helmet, break failures, due to bad road conditions and rash driving in ghats and curvy roads etc., Strict action is taking against the rule breakers then people will start taking caution when driving which may not completely stop road collisions from happening but it could definitely reduce the amount of accident that takes place. Accidents do not just happen because of ignorance but also due to over confidence, thoughtlessness. They also can be collisions between two vehicles, between vehicle and pedestrian, between vehicle and animal, or between a vehicle and an architectural obstacle.

World Health Organization has defined accident as an unplanned occurrence which may involve injury. The global status report on road safety 2018, launched by World Health Organization in 2018, highlights that the number of road traffic death has reached 1.35 million. Road traffic injuries are now the leading killer of people aged 5 to 29 years. The burden is disproportionately borne by pedestrians, cyclists, and motorcyclist, in particular those living in developed countries. The report says that the price paid for mobility is too high, especially because proven methods exist. Drastic action is needed to put these measures in place to meet any future global that might be set and save lives. Majority of the world's fatalities on the road occurs in low income and middle income countries, even though these countries have approximately half of the world's vehicle.

2. CAUSES OF ACCIDENTS:

Road accident is becoming, to a greater extent, common in today's world and contributes to a major number of deaths as a result. Road accidents are usually caused due to the following causes in present days: (<http://hdl.handle.net/10603/410513>)

Poor Road Designs is one of the most important causes of road accidents. This can happen when roadways are not constructed properly and lead to conditions that allow for accident take place. Some of these include upkeep, unclear road signs and poorly placed guard rails, barriers, and speed bumps. Lacking proper road markings and poor condition of road surface also makes it more likely for accidents to occur.

Defects in Vehicle like low maintenance of vehicle, breakage of tie rod of a running vehicle, tyre bursting, wheel coming loose or failure of brakes.

Human Negligence like lack of traffic sense, overtaking from wrong side, using cell phone while riding the vehicles, over loaded vehicle, sleep-deprived driving and reckless driving.

Drunken driving (intoxicated) is a major cause in many serious accidents. Advertisement Boards which are mostly blared at traffic points and curved roads.

Inadequate traffic signs like absence of major road signs, cautionary road signs, information road signs and speed limit signboards.

Weather condition like heavy rainfall, hail storms, fog snow and wind storms.

Violating traffic rules like driving without obtaining license, signal jumping, avoiding safety gears like seat belts and helmets, illegal bike racing within city limits. General sight at road intersections is that the vehicles cross without caring for the light. The main motive behind Red light jumping is saving time and sometimes urgency. The frequent conception is that stopping at red signal is wastage of time and fuel. A red light jumper not only jeopardizes his life but also the safety of other road users. This act by one driver incites other driver to attempt it and finally causes chaos at crossing. This chaos at intersection is the main cause of traffic jams. Eventually everybody gets late to their destinations. It has also been seen that the red light jumper crosses the intersection with greater speed to avoid crash but it hampers his ability to judge the ongoing traffic and quite often crashes.

3. TRAFFIC CONGESTION

Traffic congestion in Indian metropolis roads is extended enormously due to the growing rate of

urbanization. Globalization of the Indian financial system and the improvement in economic fame of the residents has as well brought on better effect on the transport system. Growing insufficiency of public transport, growing price of automobile ownership and immigration of people to city outer edge has brought about big use of private modes, congestion the road system. The site visitor's actions in metropolis roads were compounded by means of not unusual interruptions, ensuing in excessive decrease in velocity, most vital to congestion.

Traffic congestion in metropolis areas has broad problem observed by people of Central Business District (CBD), except it has now stretched and intensified within the city periphery and close via suburban areas additionally. People make use of mixture of modes of transport to assemble their travel require. The development in automobile technological know-how has brought in a combo of two wheelers and four wheelers available in the market same to ones financial plan and cause, thereby adding collectively more congestion. The homework of suburban areas will not be sustainable and isn't flourishing in containing the journey demand of the individuals inside the region. The men and women from the newly developed areas travel closer to the town for their requirements adding extra congestion. The congested traffic flow has lead to enlarge in vehicular emissions which have spoiled the urban air superiority. Traffic congestion has a ways achieving multiplying possessions on the economic, climate, environment and universal exceptional of lifestyles.

Now not any of the cities in India has an affordable stability of the modal divide of diverse transport modes. Restricting the growth of the usage of motor vehicle doesn't look to be possible in the close future, given the fiscal and other benefits of expanded mobility. Development of road infrastructure can't be matched with the transport demand as a result of financial and spatial restrictions. The available choice is to mitigate congestion with the aid of use of the accessible resources optimally. Steady efforts were taken by way of the transportation authentic and authorities in developed countries to measure and devise method of reducing congestion. The causal reasons of congestion in Indian context need to be understood to reach at insurance policies for mitigation. A transparent understanding of the heterogeneous traffic operations on urban artenals and quantitative measure of congestion is required to plan policies to manage the usage of motor cars causing minimal damage to the environment. No longer have many reports been carried out in India to quantify congestion for the heterogeneous visitors drift prevailing on urban roads. For that reason, on this be taught, an effort has been made to construct a mathematical relationship to quantify traffic congestion for heterogeneous traffic flow. Traffic congestion may lead to the following issues: (<http://hdl.handle.net/10693/84137>)

Delays: during the morning commute there is additional stress because delays caused by traffic can make people late for work or others places. Then, at the end of the day, the afternoon rush hour is again a frustrating time because the workday is done and people want to get home to relax and traffic is preventing it.

Road rage: road rage is a senseless reaction to traffic that is common in congested traffic areas. If someone is not driving as fast as the person behind him thinks he should, or someone cuts in front of someone else it can lead to an incident that is dangerous to the offender and those around him on the road

4. MAJOR REASONS FOR CONGESTION

Traffic congestion is always increasing vehicles in particular place with slower speeds and longer times and its enlarged vehicular queuing.

Big vehicles: big vehicles like lorry, trucks, bus compare to other vehicles these vehicles very huge ones. Unplanned cities the roads are very small, when this type vehicles arrived the cities may congested to the traffic.

No parking place: If we are parking vehicles in no parking will cause traffic congestion.

Absence of traffic signal: if we are not putting the signals in suitable place and in necessary traffic place, heavy crowds may occur and it will cause traffic congestion.

Accident incident: if any accidents happens in the traffics may cause heavy congestion.

Natural disaster: sometimes Heavy rain, building collapse, tree fall, electrical pole fall, land slide in traffic roads may cause traffic congestion.

Road shows: bicycle rally, bike ride shows and political rally may cause traffic congestion.

5. MATHEMATICAL ANALYSIS:

Road accidents occur whenever roads formed. Pedestrians, riders and vehicle passengers are getting killed and injured every minute due to road accidents. The heavy traffic on the roadways is rapidly increasing daily which lead to major accidents. It is important for every human being to strictly follow certain road rules which safeguard them from unexpected accidents. Road safety rules have some conditions and regulations that should be followed by pedestrians as well as drivers. Road safety is global concern for many countries and they are planning and implementing different methods.

Road accidents and related deaths are rapidly increasing due to several reasons. Police department and

government officials have imposed strict rules and heavy penalties but the riders of two wheelers, drivers of four wheelers and that of heavy vehicles do not follow the rules. Moreover, the accidents that lead is deaths that are caused by high speed, un ruled overtaking drunken drivers and careless drivers. The daily Tamil newspaper, “Dinakaran” dated 16.12.2024 explained the causes of accidents and tabulated the number of deaths for the last two decades and that are presented in table 1.

Table 1 – Deaths occurred in Accidents.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of Deaths	164	172	208	207	236	286	276	297	298	296	291

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Numbers of Deaths	249	307	267	221	247	102	321	296	334	260

(*upto Dec.13)

On seeing the date, the number of deaths during the years 2004 and 2005 are low as compared with that on other years. But during corona period, ie, 2020 the numbers of accident deaths are very low. The severe actions and punishments given by police department reduced the death rates in the year 2024.

In the roadways different types of vehicles such as two wheelers, autos, cars, jeeps, mini load vans, buses, lorries, tarus lorries, container lorries and others are running here and there on the roads. This study describes the arrival and service rates of patients who met accidents on roadways. The injured patients are brought to the hospital through any vehicle such as Ambulances, cars, autos and so on. The observations are measured for 45 days from June 1 to July 15 and that between 6.00 am and 6.00 p.m. The arrival rates of injured patients and their service rates are recorded. They are analysed by applying some queueing parameters that are extracted from Kanti Swarup et al (2022) and yaduvanchi et al (2019) and are given below.

1. Average number of patients in the queue is given by

$$Lq = \frac{\lambda^2}{\mu (\mu - \lambda)} \tag{1}$$

2. Average number of patients in the system is

$$Ls = \frac{\lambda}{\mu - \lambda} \tag{2}$$

3. Average waiting time of patients in the queue is

$$Wq = \frac{\lambda}{\mu(\mu - \lambda)} \quad (3)$$

4. Average waiting time of patients in the system is

$$Ws = \frac{1}{\mu - \lambda} \quad (4)$$

5. The fluctuation (variance) of queue length is stated as

$$V(n) = \frac{\lambda\mu}{(\mu - \lambda)^2} \quad (5)$$

Based on the accidents, the daily arrival rates and service rates of injured patients are recorded for a long six weeks. There is impossible to predict the number of accidents since the accidents are happened suddenly without any expectations. The consolidated arrival rates and service rates are distributed based on time interval and presented in table:2, further, the sum of the observations are given day wise and presented in table:3. The data given in table 3 load to analyses some queueing parameters by using the equations from (1) to (5) and presented by results in table.4. The resultant values showed that the values of queueing parameters are high on Tuesdays. It is remarked that the less number of accidents occurred in the middle of the week.

TABLE 2-ARRIVAL AND SERVICE RATES OF PATIENTS BASED ON TIME INTERVAL

DAY	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY		SUNDAY	
Time	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ
6-7 Am	46	57	43	48	42	65	38	74	44	62	47	68	45	84
7-8	39	52	44	57	41	53	34	71	42	51	45	72	43	57
8-9	37	64	49	59	44	32	44	67	42	64	59	77	52	46
9-10	79	100	85	62	82	104	54	96	59	93	70	90	72	80
10-11	56	67	73	91	48	67	54	82	61	77	66	61	79	95
11-12	105	125	103	132	100	122	66	122	65	69	74	114	77	64
12-01	78	92	72	61	75	115	43	41	46	67	53	82	55	92
01-02	33	67	53	74	43	65	26	48	31	54	48	76	62	51
02-03	48	54	53	82	48	44	33	70	37	63	37	43	51	94
03-04	64	78	67	79	70	92	51	78	67	82	74	108	67	118
04-05	93	104	92	84	96	75	57	74	65	96	73	97	80	104
05-06	77	97	70	91	76	88	57	76	62	88	67	89	76	121
TOTAL	755	957	804	920	765	922	557	899	621	866	713	977	759	1006

Table 3 - ARRIVAL AND SERVICE RATES OF PATIENTS DAYWISE

Day	λ	μ	e
Monday	755	957	0.7837
Tuesday	804	920	0.8739
Wednesday	765	922	0.8297
Thursday	557	899	0.6196
Friday	621	866	0.7286
Saturday	713	977	0.7289
Sunday	759	1006	0.7545

Table : 4 - Queueing Measures

Days Queueing Parameters	Days						
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Average no of Patients in the queue (Lq)	3	6	4	1	2	2	2
Average no of Patients in the System (Ls)	4	7	5	2	3	3	3
Average w.t. in the queue (Wq)	14	27	19	7	11	10	11
Average w.t. in the system (Ws)	17	31	23	11	15	14	15
Fluctuations	17	55	29	4	9	10	13

6. CONSLUSION

This study described the accidents on road and the admissions of injured persons to the hospital and departures. Based on time interval, the arrivals and services are observed and that lead to compute some queueing measures such as the average number of patients waiting in the queue and their waiting times, The results revealed that the more number of accidents happened in the beginning of the week as well as that at the end of the week. It is suggested that the high penalties and punishments may reduce the incidences of vehicle accidents.

References

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