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Trends in Causes and Impacts of Accidents in Indian Railway

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ABSTRACT Indian Railways is fully owned and operated by Ministry of Railways, Government of India. Like any other transportation system, it is technology intensive not only for ensuring high productivity of its assets but also for safety in train operations. But the safety on the railways is the end product of the coordination among all the factors. The recent rail accidents have drawn the attention of everyone in the country. Considering the facts, an analysis of accidents that occurred in Indian Railway during 2000-2016 (16 years) was carried out to study the trends in causes and impacts (both casualty and economic loss). A compressive examination of past 16 year data revealed that, the dominating accidents, derailment and level crossing mishaps together constituted ninety percent of total rail accidents in India. Out of the total accidents, eighty-five percent accidents were caused due to human error. Among the total people affected by railway accidents, twenty-seven percent lost their life while seventy-three percent got injured and IR faced a total loss of 86,486 crore INR. It means every fourth person affected by railway accidents lost his life. On an average, 0.76 persons got killed and caused a loss of Rs.31 crore per accident to Indian Railway in past 16 years. The total number of accidents and their causes in Indian Railway were found in decreasing trend over the years but the number of persons killed and economic loss associated per accident showed an increasing trend indicating an increase in severity of the railway accidents.

INTRODUCTION

Railways are one of the most prominent modes of transportation in the world. Indian Railways is one of the largest railway systems in the world and is fully owned and operated by Ministry of Railways, Government of India. It plays a significant role in driving economic growth of the country, offering highly affordable, environment-friendly transportation to passengers and freight, especially bulk commodities, across the country. Indian Railways, like any other transportation system, is technology intensive not only for ensuring high productivity of its assets but also safety in train operations (Government of India 2012).

Indian Railway (IR) is a vast system comprising of nearly 64,000 route kilometers with over 7000 block stations and holding nearly 9000 locomotives, 43500 passenger coaches, 7500 electrical and diesel multiple units and 220 thousand wagons. Further the IR system has 13.62 lakh strong work force, handles 20 million passengers and 2.45 million tonnes of freight and earns Rs.245 crores on daily basis (Government of India 2012) which makes the Indian Railway network (IRN) one of the busiest railway networks in the world, handling massive numbers of passengers and quantities of goods daily (Banerjee 2011). The IR has long served as the backbone of this nation's economy by being the most popular means of long distance transportation in India. Besides the huge network, heavy traffic, over-saturation of rail tracks, extreme weather conditions and many more challenges; IR is committed to safe journey to avoid loss of life and property through continuous modernization and strengthening the infrastructure, adopting latest technologies, engagement of experienced and trained manpower, periodic maintenance and checkups, safety audits etc. Indian railway also has its own disaster management plan to manage the railway accidents in all the phases *viz.* pre, during and after the disaster. But the safety on the railways is the end product of the coordination among all the factors. A single flaw in the complex network of track that crisscross the country, a defect in over several hundred locos, coaches and lakh of wagons that haul about millions of passengers and nearly several million tonnes of freight every day, an incorrect indication on one of the thousands of signals that dot the rail landscape, a mistake or an act of negligence by one of its staff directly associated with train running, even a rash act by one of the millions of road users who daily negotiate

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around odd level crossing gates spread across the system, an irresponsible act of carrying inflammable goods, any one of these multiple possibilities has the potential to cause a major tragedy. Added to these are the acts of sabotage by misguided elements spanning the whole country (Ministry of Railways 2014a). The consequential train accidents include mishaps with serious repercussion in terms of loss of human life or injury, damage to railway property or interruption to rail traffic in excess of laid down threshold levels and values which include collisions, derailments, fire in trains, road vehicles colliding with trains at level crossings, and miscellaneous train mishaps. The train accidents trends, fatalities, causes and management has been continuously studied worldwide (Rautji and Dogra 2004; Aguirre et al. 2013); the human error induced factors being the major contributor for railway accidents. The railway accident analysis in different countries like Britain (Santos-Reyes et al. 2005; Evans 2011a), Europe (Evans 2011b), Australia (Baysari et al. 2008), Indonesia (Iridiastadi and Ikatrinasari 2012), United Kingdom (Kyriakidis et al. 2015) and China (Liu et al. 2015) supports the argument.

The recent rail accidents have drawn the attention as the railway is directly or indirectly connected with the life of everyone in the country. The systemic analysis of railway accidents help to identify 'learning points', which are relevant for preventing accidents in the railway industry (Santos-Reyes et al. 2005). The increasing population demanded the increase in the number of trains and frequency of the existing trains which resulted in unbalanced rise in rail traffic over several years leading to tremendous pressure or over-saturation of rail tracks which exceeded the 'safe' limit. The immediate cause for accidents are numerous but unbalanced rise in traffic is one of the primary contributing factors. Considering these facts, present analysis was conducted to study the trends in occurrence of accidents, their causes, casualties and economic loss.

METHODOLOGY

Data Collection, Compilation and Analysis

In order to fulfill the objectives of the study, the secondary data with respect to number of railway accidents, financial losses, deaths, injuries, the causes of railway accidents etc. for last 16 years (2000-2016) was obtained from authentic databases such as Indian railway website, publications, media, Government of India websites, disaster management authorities, management institutions, libraries and railway authorities (Indian Railways 2016; Government of India 2017). The collected data was compiled and subjected to statistical analysis for computation of averages and standard deviations. The trend analysis was studied using simple linear regression by computing the coefficient of determination (r^2) as follows:

$$r^2 = \frac{[n(\sum xy) - (\sum x)(\sum y)]^2}{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}$$

RESULTS

Accidents in Indian Railways

The study of railway accidents that occurred during last 16 years (2000-2016) revealed that, there are four major categories of accidents *viz.* derailment, level crossing accidents, collisions and fire in trains. The rest were categorized under miscellaneous accidents. The data pertaining to the year wise accidents occurred and their trends over 16 years in Indian Railways are presented in Table 1.

Total 3515 accidents occurred during the study period in which the major accident type was train derailment followed by level crossing accidents. The accident type which occurred in Indian Railways over the years followed the trend:

Derailment > Level crossing accidents > Collisions > Fire in trains > Miscellaneous accidents

The year wise total accidents ranged between 107 and 473. The highest number of total railway accidents occurred in the year 2000-01 and a gradual decrease in total number of accidents in the subsequent years except in the year 2014-15 in which total 135 accidents were reported (higher than previous three years). The data revealed that the accidents occurred with an average of 220 accidents per year (Table 1).

Derailments

The derailments are the most common and major contributing accident type in Indian Railways. The data revealed that total 2045 derailments occurred in Indian Railways during 2000-2016 (Table 1). The year wise total derailments

Table 1: Year wise occurrence of accidents in Indian railway (2000-2016)

Year	*Collisions*	*Derailments*	*Level crossing accidents*	*Fire in trains*	*Miscellaneous*	*Total*
2000-01	20	350	84	17	2	473
2001-02	30	280	88	9	8	415
2002-03	16	218	96	14	7	351
2003-04	9	202	95	14	5	325
2004-05	13	138	70	10	3	234
2005-06	9	131	75	15	4	234
2006-07	8	96	79	4	8	195
2007-08	8	100	77	5	4	194
2008-09	13	85	69	3	7	177
2009-10	9	80	70	2	4	165
2010-11	5	80	53	2	1	141
2011-12	9	55	61	4	2	131
2012-13	6	49	58	8	0	121
2013-14	4	53	59	7	3	117
2014-15	5	63	56	6	5	135
2015-16	3	65	35	0	4	107
Total	167	2045	1125	120	67	3515
Mean	10	128	70	8	4	220
SD (±)	6.9	89.3	16.4	5.2	2.4	112.9

showed a decreasing trend over the years but it is an irregular trend. The year wise derailment decreased from 2000 to 2013 except 2007. From 2012 onwards the derailments showed increasing trend. The derailments occurred in Indian Railway with an average of 128 accidents per year.

Level Crossing Accidents

The level crossing accidents in Indian Railway (both manned and unmanned crossing) has been presented in Table 1. The data revealed that it was the major accident type in Indian Railway after derailments. The average level crossing accidents occurred at a rate of 70 accidents per year (2000-2016). There was no significant decrease in the level crossing accidents over the 16 years. The highest level crossing accidents occurred in 2002-03 (96) followed by 2003-04 (95) whereas the lowest were recorded in the year 2015-16. During the 16 year period, total 1125 level crossing accidents were recorded in Indian Railway.

Collisions

The collision is the third major accident type having huge potential to cause very severe impact on life and property in Indian Railways. The data revealed that, there were 167 collisions that occurred during 2000-2016 in Indian Railways. The highest number of collisions were recorded in the year 2001-02 (30) followed by 2000-01 (20). The annual mean collisions in Indian Railway were 10 per year. A decreasing trend in the collisions was observed in Indian Railways over 16 year period (Table 10).

Fire and Miscellaneous

The fire in trains and miscellaneous accidents are the least contributor to total railway accidents in Indian Railways. Thus, the 16 year (2000-2016) Indian Railway accident data revealed that total accidents and type of accidents found decreasing trend over the years in IR (Table 10).

Causes of Railway Accidents

The trends pertaining to the year wise causes of railway accidents in Indian Railways has been presented in Table 2. The data revealed that, out of 3515 accidents that occurred during 2000-2016, 2989 accidents were caused by human error, 164 caused due to equipment failure, 155 were due to sabotage and 168 were due to other reasons whereas the causes of 39 accidents has not been identified or these are under investigation. Thus, the human error is the principal cause of the accidents occurred in Indian Railway over 16 years.

The annual mean cause data showed that, failure of equipments, sabotage and other caus-

es contributed equally towards occurrence of railway accidents. The year wise accidents caused due to human error were found decreasing in subsequent years except in 2005-06 and 2014-15 (Table 2). The reduction in the human error induced accidents indicated adaptation, upgradation and utilization of technological advances by Indian Railway. The railway disaster incident due to failure of equipments during 2000-2016 ranged from 0 to 33. The highest equipment failure occurred in 2000-01 and it continuously reduced and touched zero in 2008-09 but it again started and existed till 2014-15 which shows poor maintenance and management of railway equipment by Indian Railway Staff (Table 2). The railway disaster due to sabotage was recorded higher in initial years which gradually decreased. The railway incidence due to sabotage ranged from 1 (2014-15) to 19 (2000-01) during the data studied (2000-2016). The sabotage activity was found higher during 2000-2003 and 2007-2010 as compared to the 2004-2006 and 2011-2015 (Table 2). The decrease in the sabotage activity revealed the improvement in the Railway Protection Force (RPF) and coordination of Indian Railway with other departments. The cause other than human error, sabotage, equipment failure also contributed for 168 railway accidents out of 3515 during the 16 year data analysis. The cause of 39 accidents were either not identified or under investigation. Thus, human error, failure of equipments and sabotage were the major causes of accidents in Indian Railways. Indian Railway successfully overcame these causes but needs further improvement to eliminate the railway disasters completely or avoiding the loss of life during the accidents (Government of India 2014).

Impact of Railway Accidents

Casualties and Victims

The data pertaining to the year wise casualties, person injured and a total affected person has been presented in Table 3.

In last 16 years (2000-2016), 2297 people lost their life in railway accidents and 6088 people got injured affecting a total of 8385 people in the country. The casualties in accidents ranged between 40 and 315 in the year 2015-16 and 2005-06, respectively. Similarly, the year wise injured people ranged from 94 in 2013-14 to 658 in 2002-03. The total people affected due to railway accidents was found lowest in the year 2013-14 (136) whereas the highest number of victims was recorded in 2002-03 (815). The annual mean data showed that 524 people were affected each year during 2000-2016, out of which, 144 lost their life and 381 left injured (Table 3).

Table 2: Causes of railway accidents in India (2000-2016)

Year	*Human error*	*Failure of equipments*	*Sabotage*	*Other*	*Unidentified/ Under investigation*	*Total*
2000-01	402	33	19	15	4	473
2001-02	351	24	14	20	6	415
2002-03	304	18	10	17	2	351
2003-04	268	18	18	19	2	325
2004-05	197	14	4	17	2	234
2005-06	206	8	5	11	4	234
2006-07	169	9	8	8	1	195
2007-08	156	9	17	8	4	194
2008-09	150	0	13	8	6	177
2009-10	138	6	14	5	2	165
2010-11	113	5	16	7	0	141
2011-12	115	5	6	4	1	131
2012-13	104	6	3	7	1	121
2013-14	105	3	4	4	1	117
2014-15	118	4	3	8	2	135
2015-16	93	2	1	10	1	107
Total	2989	164	155	168	39	3515
Mean	187	10	10	11	2	220
SD (±)	95.5	9.0	6.1	5.4	1.8	112.9

Source: Government of India 2017

Table 3: Casualties and victims of railway accidents (2000-2016)

Year	*Killed*	*Injured*	*Total affected*
2000-01	55	286	341
2001-02	144	595	739
2002-03	157	658	815
2003-04	135	302	437
2004-05	50	191	241
2005-06	315	627	942
2006-07	208	402	610
2007-08	191	412	603
2008-09	209	444	653
2009-10	238	397	635
2010-11	235	358	593
2011-12	100	586	686
2012-13	60	270	330
2013-14	42	94	136
2014-15	118	340	458
2015-16	40	126	166
Total	2297	6088	8385
Mean	144	381	524
SD (±)	83.6	172.0	234.0

Source: Government of India 2017

Economic Loss

The data pertaining to the economic loss due to accidents in Indian Railways in terms of rolling stock loss, permanent way loss and compensation paid to victims has been presented in Table 4.

In last 16 years Indian Railway faced a total loss of Rs.86486 cr. due to accidents. Thus, Indian Railway lost Rs.5405 cr. per year due to accidents. The total loss to Indian Railway due to accidents ranged between Rs.3235 cr. (2004-05) and Rs.9493 cr. (2011-12). Out of total loss of Rs.86486 cr. during 2000-2016, Indian Railway paid Rs.6412 cr. towards the compensation to the incident victims and rest Rs.80073 cr. faced for permanent plus rolling stock. The Indian Railway faced a total loss of Rs.61620 cr. during the 16 year under study as loss due to rolling stock. The rolling stock loss was found highest in the year 2011-12 (Rs.8210 cr.) followed by 2014-15 (Rs.6313 cr.). The lowest loss in rolling stock was observed in 2013-14 in which railway faced a loss of Rs.2003 cr. (Table 4).

Similarly, the Indian Railway lost Rs.18453 cr. as loss in permanent way due to accidents during the period under study. The permanent loss to Indian Railway averaged as Rs.1153 cr. per year in last 16 years. The highest permanent way loss of Rs.1831 cr. was recorded in 2000-01 followed by Rs.1799 cr. in 2013-14, whereas the least loss in permanent way of Rs.497 cr. burdened Indian Railway in 2004-05. Indian Railway paid Rs.6412 cr. towards compensation to incident victims in last 16 years under study which averaged Rs.401 cr. per year. The compensation paid by Indian Railway to accident victims ranged from Rs.121 cr. (2007-08) to Rs. 886 cr. (2000-01) during 2000-2016. Thus, a huge

Table 4: Economic loss associated with railway accidents (2000-2016)

Year	*Rolling stock*	*Permanent way*	*Total*	*Compensation paid*	*Grand total*
2000-01	3693	1831	5524	886	6410
2001-02	3235	1647	4882	482	5364
2002-03	3158	617	3776	489	4265
2003-04	4349	826	5175	757	5932
2004-05	2225	497	2722	513	3235
2005-06	2443	942	3385	222	3607
2006-07	2322	871	3193	501	3694
2007-08	2970	1085	4055	121	4177
2008-09	5012	1053	6065	219	6284
2009-10	4216	1245	5461	266	5727
2010-11	4585	1311	5896	586	6482
2011-12	8210	772	8982	511	9493
2012-13	4142	1282	5424	320	5744
2013-14	2003	1799	3802	149	3951
2014-15	6313	894	7208	127	7335
2015-16	2743	1780	4524	263	4787
Total	61620	18453	80073	6412	86486
Mean	3851	1153	5005	401	5405
SD (±)	1647	427	1602	227	1634

Values in crore INR
Source: Government of India 2017

amount of Rs.86486 cr. was lost by Indian Railway due to accidents.

DISCUSSION

Out of five accident types, the most common and major accident type is derailment. The analysis of 16 years (2000-2016) data of accidents in Indian Railway showed that out of total 3515 accidents, 2045 accidents were derailments which is about fifty-eight percent of total (Table 5).

The level crossing accidents contributed thirty-two percent to the total accidents that occurred during 2000-2016 in Indian Railway. The level crossing accidents included both manned and unmanned crossing. Thus, derailment and level crossing accidents together contributed ninety percent of total rail accidents in India. The collision in Indian Railways, also the frequent occurring accident type ranged from 3-30 collisions year wise during 2000-2016 with an average of 10 collisions per year. The collision contributed five percent to the total train accidents. The trend analysis of total railway accidents, derailments, level crossing accidents and collisions over the 16 year period (2000-2016) revealed the fact that the year wise total accidents as well as accident type *viz.* derailments, level crossing accidents and collisions decreased over the years (Table 10). It indicates the adaptation of preventive measures by Indian Railways. The Indian Railway adopted measures like technological advancements, training to staff, periodic maintenance, safety audit, disaster prevention etc. in management of disasters.

The 16 year (2000-2016) study of railway accidents revealed three major causes of railway accidents in India *viz.* human error, failure of equipment and sabotage (Table 2). Out of 3515 railway accidents which occurred during 2000-2016, the causes of 3476 accidents were identified whereas cause of 39 accidents is either not identified or these are still under investigation. The data revealed the fact that, eighty-five percent accidents were caused due to human error (Table 6).

The number may increase as one percent accidents are still under unidentified/under investigation. Failure of equipments or mechanical reason contributed for five percent of total accidents occurred in Indian Railways. Sabotage was again the important cause of railway accidents which contributed four percent of total railway incidents. The rest five percent railway accidents occurred due to other reasons like natural and other factors. The huge contribution of human error in the railway accidents showed the lack of management, training, coordination etc. among the railway staff and Indian Railway. Aguirre et al. (2013) reported similar findings. The year wise decrease in all the causes and accidents (Table 10) showed the necessary actions taken by Indian Railways to tackle with these cheap causes of accidents. In order to reduce the human induced accidents, Indian Railway initiated and adapted and focused on mechanization and computerization, automatic signaling system, adaptation of newer technologies,

Table 5: Type and contribution of accident in Indian railway (2000-2016)

Year	*Collisions*	*Derailments*	*Level crossing accidents*	*Fire in trains*	*Misc.*
2000-01	4.2	74.0	17.8	3.6	0.4
2001-02	7.2	67.5	21.2	2.2	1.9
2002-03	4.6	62.1	27.4	4.0	2.0
2003-04	2.8	62.2	29.2	4.3	1.5
2004-05	5.6	59.0	29.9	4.3	1.3
2005-06	3.8	56.0	32.1	6.4	1.7
2006-07	4.1	49.2	40.5	2.1	4.1
2007-08	4.1	51.5	39.7	2.6	2.1
2008-09	7.3	48.0	39.0	1.7	4.0
2009-10	5.5	48.5	42.4	1.2	2.4
2010-11	3.5	56.7	37.6	1.4	0.7
2011-12	6.9	42.0	46.6	3.1	1.5
2012-13	5.0	40.5	47.9	6.6	0.0
2013-14	3.2	42.1	46.8	5.6	2.4
2014-15	3.7	46.7	41.5	4.4	3.7
2015-16	2.8	60.7	32.7	0.0	3.7
Mean	5	54	36	3	2
SD (±)	1.5	9.7	9.0	1.9	1.3

Table 6: Causes and their contribution to railway accidents in India (2000-2016)

Year	*Human error*	*Failure of equipments*	*Sabotage*	*Other*	*Unidentified/ Under investigation*
2000-01	85.0	7.0	4.0	3.2	0.8
2001-02	84.6	5.8	3.4	4.8	1.4
2002-03	86.6	5.1	2.8	4.8	0.6
2003-04	82.5	5.5	5.5	5.8	0.6
2004-05	84.2	6.0	1.7	7.3	0.9
2005-06	88.0	3.4	2.1	4.7	1.7
2006-07	86.7	4.6	4.1	4.1	0.5
2007-08	80.4	4.6	8.8	4.1	2.1
2008-09	84.7	0.0	7.3	4.5	3.4
2009-10	83.6	3.6	8.5	3.0	1.2
2010-11	80.1	3.5	11.3	5.0	0.0
2011-12	87.8	3.8	4.6	3.1	0.8
2012-13	86.0	5.0	2.5	5.8	0.8
2013-14	89.7	2.6	3.4	3.4	0.9
2014-15	87.4	3.0	2.2	5.9	1.5
2015-16	86.9	1.9	0.9	9.3	0.9
Mean	85.3	4.1	4.6	4.9	1.1
SD (±)	2.7	1.7	3.0	1.7	0.8

training to the staff and recruitment of adequate staff. The causes and their contribution to rail accidents have been more or less similar worldwide. Okoh and Haugen (2013) stated that lack of maintenance was the causative factor for occurrence of fatal accidents. Baysari et al. (2008) identified that half the incidents resulted from an equipment failure, most of these being the product of inadequate maintenance or monitoring programs. The rest fifty percent were direct human errors like slips of attention (that is, skilled-based errors) and decreased alertness in railway of Australia. Zhan et al. (2017) also reported that human factor has been the prime cause to railway accidents and suggested Human Factors Analysis and Classification System-Railway Accidents (HFACS-RAs) framework for identification and classification of human and organizational factors involved in railway accidents. The Indonesian railway accidents analyzed using Human Factors Analysis and Classification System (HFACS) indicated 72 factors that were closely related to the accidents. Of these, roughly twenty-two percent were considered as operator acts while about thirty-nine percent were related to preconditions for operator acts. Supervisory represented fourteen percent of the factors, and the remaining (about 25%) was associated with organizational factors (Iridiastadi and Ikatrinasari 2012). Besides HFACS, an Intuitionistic Trapezoidal Fuzzy Numbers (ITFNs) method also suggested for railway accident analysis to decrease the occurrence possibilities of similar accidents (Liu et al. 2015). Santos-Reyes et al. (2005) also suggested an analytical model for railway accident analysis based on past accidents that occurred in British Railway. The model was generalized and applicable irrespective of country. Giles (2011) emphasized need and implementation of legislation for prevention of railway accidents.

In last 16 years (2000-2016), 2297 people lost their life in railway accidents and 6088 people got injured affecting total 8385 people in the country (Table 3). Among the total people affected by railway accidents, twenty-seven percent lost their life while seventy-three percent got injured (Table 7).

Table 7: Casualties and injuries in Indian railway accidents (2000-2016)

Year	*% Killed*	*% Injured*
2000-01	16	84
2001-02	19	81
2002-03	19	81
2003-04	31	69
2004-05	21	79
2005-06	33	67
2006-07	34	66
2007-08	32	68
2008-09	32	68
2009-10	37	63
2010-11	40	60
2011-12	15	85
2012-13	18	82
2013-14	31	69
2014-15	26	74
2015-16	24	76
Mean	27	73
SD (±)	8	8

It means every fourth person affected by railway accident lost life. The ratio is very high and needs to be considered seriously while planning for management of disaster in Indian Railway. The trends pertaining to the casualties per accident and economic loss per accident in Indian Railway have been presented in Table 9 and Table 10, respectively. The data on casualties per accident revealed that, it ranged from 0.12 in 2000-01 to 1.67 persons per accident in 2010-11. On an average, 0.76 persons got killed per accident in Indian Railway in last 16 years (2000-2016). The trend clearly indicated that, the casualties per accident has increased from 2000-01 to 2015-16 which is a matter of great concern for Indian Railway. It indicates that the severity of the railway accidents is increasing. Evans (2011b) also found no evidence that average severity of accidents has changed over time. Similarly, Evans (2011a) investigated the fatal accidents and fatalities at level crossings in Great Britain over the 64-year period (1946–2009) and reported that the numbers of fatal accidents and fatalities per year in second half have remained more or less constant at about 11 fatal accidents and 12 fatalities per year. Further, the fatal accident rate has remained remarkably constant over the whole period at about 0.9 fatal accidents per 1000 crossings per year. A study conducted by Rautji and Dogra (2004) revealed that thirty-three percent railway victims died before reaching hospital. Similarly, Wasnik (2010) reported ninety-seven percent victims died on the spot which indicates the severity of railway accidents. The train accidents led to a mortality rate of sixteen percent and morbidity rate of thirty-seven percent in Turkey which has drawn attention to the importance of developing preventive strategies (Akkas et al. 2011). Indian Railway must consider these facts before planning for management of disasters occurring in railway.

In last 16 years, Indian Railway faced a total loss of Rs.86486 cr. due to accidents (Table 4). The economic loss faced by Indian Railway has been classified in three categories viz. rolling stock loss, loss in permanent way and compensation paid to the accident victims. Out of Rs.86486 cr. loss faced by Indian Railway in last 16 years, seventy-one percent loss was in terms of rolling stock loss whereas the loss in terms of permanent way loss was twenty-one percent (Rs.18453 cr.) of total loss (Table 8).

Table 8: Percent contribution of different economic losses due to railway accidents (2000-2016)

Year	*Rolling stock*	*Permanent way*	*Total*	*Compensation paid*
2000-01	58	29	86	14
2001-02	60	31	91	9
2002-03	74	14	89	11
2003-04	73	14	87	13
2004-05	69	15	84	16
2005-06	68	26	94	6
2006-07	63	24	86	14
2007-08	71	26	97	3
2008-09	80	17	97	3
2009-10	74	22	95	5
2010-11	71	20	91	9
2011-12	86	8	95	5
2012-13	72	22	94	6
2013-14	51	46	96	4
2014-15	86	12	98	2
2015-16	57	37	95	5
Mean	70	23	92	8
SD (±)	10	10	4	4

The rest amount was spent towards the compensation to accident victims. The compensation paid to incident victims involved in railway accidents is only eight percent of total loss to Indian Railway. The trend analysis of economic loss to Indian Railway per accident over the period of 16 years clearly indicated the increment in the economic loss per accident over the years (Table 10). The loss per accident ranged from Rs.12.2 cr. (2002-03) to Rs.72.5 cr. (2011-12) which crossed the 16 year mean value of Rs.31.0 cr. Thus, the Indian Railway lost Rs.31.0 cr. per accident (Table 9).

Railway disaster is a serious train accident or an untoward event of grave nature, either on railway premises or arising out of railway activity, due to natural or man-made causes, that may lead to loss of many lives and/or grievous injuries to a large number of people, and/or severe disruption of traffic etc., necessitating large scale help from other Government/Non-government and Private organizations (Ministry of Railways 2014b). The consequential train accidents over the years showed declining trend (Table 10) despite phenomenal growth of traffic but emphasis may be given on improvement of infrastructure, resources and functional empowerment (Government of India 2012).

An unbalanced rise in rail traffic over several years' has led to tremendous pressure or over saturation of rail tracks which exceeded the 'safe'

Table 9: Casualties and economic loss per accident in Indian railway (2000-2016)

Year	*Total accidents*	*Casualties*	*Economic loss*	*Casualties/ Accident*	*Loss/ Accident*
2000-01	473	55	6410	0.12	13.6
2001-02	415	144	5364	0.35	12.9
2002-03	351	157	4265	0.45	12.2
2003-04	325	135	5932	0.42	18.3
2004-05	234	50	3235	0.21	13.8
2005-06	234	315	3607	1.35	15.4
2006-07	195	208	3694	1.07	18.9
2007-08	194	191	4177	0.98	21.5
2008-09	177	209	6284	1.18	35.5
2009-10	165	238	5727	1.44	34.7
2010-11	141	235	6482	1.67	46.0
2011-12	131	100	9493	0.76	72.5
2012-13	121	60	5744	0.50	47.5
2013-14	117	42	3951	0.36	33.8
2014-15	135	118	7335	0.87	54.3
2014-15	107	40	4787	0.37	44.7
Total	3515	2297	86486	-	-
Mean	220	144	5405	0.76	31.0
SD (±)	112.9	83.6	1634.1	0.48	18.1

limit considering the available resources. An unbalanced rise in traffic is one of the primary contributing factors. High amounts of traffic, lower headways, enhanced block-occupancy etc. leave the IR-employees (for example, driver, those in charge of signaling, maintaining the rail tracks, etc.) over-burdened, which might lead to accidents (Banerjee 2011). Bäckman (2002) studied the railway safety, historical railway accident data and consequences of railway accidents and reported that a decrease in the accident rate and the average consequence of each accident has not changed over time. Further, the study showed that people prefer the prevention of small-scale accidents over the prevention of larger, catastrophic accidents. Similarly, the train derailment data of 10 years (2001-2010) for frequency of occurrence by cause and number of cars derailed showed that broken rails or welds were the leading derailment causes followed by human factor related causes such as improper use of switches and violation of switching rules etc. Similarly, at derailment speeds above 25 mph the causes were mechanical such as bearing fail-

Table 10: Trend analysis of accidents in Indian railway (2000-2016)

Category	*Parameter*	*Linear equation*	*Coefficient of determination (r^2)*	*Trend**
Accident	Total railway accidents	y = -21.81x + 405.1	0.845	↓
	Derailments	y = -16.45x + 267.6	0.768	↓
	Level crossing accidents	y = -3.086x + 96.55	0.803	↓
	Collisions	y = -1.145x + 20.17	0.625	↓
Causes of Accident	Human error	y = -18.33x + 342.6	0.835	↓
	Equipment failure	y = -1.608x + 23.92	0.730	↓
	Sabotage	y = -0.780x + 16.32	0.366	↓
	Other causes	y = -0.885x + 18.02	0.616	↓
Loss of Life	Total victims	y = -19.43x + 689.2	0.156	↓
	Casualties	y = -3.595x + 174.1	0.042	↓
	Injuries	y = -15.83x + 515.1	0.192	↓
	Casualties per accident	y = 0.025x + 0.540	0.063	↑
Economic Loss	Total loss	y = 91.93x + 0.4623	0.071	↑
	Permanent loss	y = 122x + 0.3967	0.131	↑
	Compensation paid	y = -30.06x + 656.3	0.398	↓
	Loss per accident	y = 3.134x + 4.329	0.680	↑

*↑-*Increasing trend;* ↓-*Decreasing trend*

ure, broken wheel, and axle and journal defects (Liu et al. 2012).

CONCLUSION

The Ministry of Railways (MoR) has the disaster management plan for management of the Railway Disaster at national, zonal and divisional level. Indian Railway has been continuously making efforts towards prevention, mitigation, preparedness, rescue, relief and rehabilitation of disaster through modernization, planning, capacity building, trainings, mock drills, adaptation of new technologies, reformation, expansion etc. These efforts reflected in terms of reduction in railway incidents over the years. The human error associated factors has been the principle cause of accidents in IR. The total number of accidents in Indian Railway was found in decreasing trend including each accident type and its causative factors over the years. But despite of decrease in the total number of accidents and its causes, the number of persons killed and economic loss associated per accident showed an increasing trend indicating the increase in severity of the accidents in Indian Railway.

RECOMMENDATIONS

The study revealed that the human error associated factors are the major contributors towards accidents in Indian Railway. It is suggested that due emphasis should be given towards skill enhancement of the staff through periodic trainings. The inclusion of computerized management systems for scheduled maintenance of railways throughout the country would be fruitful in eliminating the accidents occurring due to improper/lack of maintenance. Considering the increasing trends in casualties per accidents and economic loss per accidents, it is suggested that the Indian Railway has to update the existing traditional system with modern aids and information technology for eliminating the disastrous accidents.

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