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Research Article

Association Between Rail Systems and Total/Child Traffic Fatality Rates

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Abstract

Objective: Traffic fatalities are a global public health concern and are influenced by several factors. We evaluated the association between the number of regional rail lines and traffic fatalities and investigated whether this association affected traffic fatality rates.

Methods: We obtained traffic fatality data, the number of regional rail lines, and motor vehicle registrations of 34 U.S. and 8 non-U.S. cities from 2018. Pearson correlation (linear regression) analyses were performed for all variables.

Results: The correlation coefficients (r) for the number of regional rail lines (n=42) and total traffic fatality rates, child traffic fatality rates, and number of motor vehicle registrations per capita were −0.49 (p=0.0009), −0.31 (p=0.04), and −0.46 (p=0.002), respectively, whereas the correlation coefficients for the number of motor vehicle registrations per capita and all traffic fatality and child traffic fatality rates were 0.54 (p=0.0002) and 0.18 (p=0.24), respectively.

Conclusion: The number of regional rail lines was negatively correlated with traffic fatalities in children and adults, and motor vehicle registrations per capita. These results highlight the potential benefit of regional rail line development for reducing traffic fatalities.

***Keywords:** regional rail lines; traffic fatality; motor vehicle registrations; public transportation*

1. Introduction

Motor vehicle injuries and fatalities pose a serious public health problem in the United States (Gopalakrishnan, 2012). In the 1970s, the United States was the safest country in the world in terms of traffic fatalities per registered vehicles. However, this is no longer true (Evans, 2014); more than 35,000 people die in traffic accidents every year in the United States, resulting in a daily death toll of 100 individuals (National Center for Statistics and Analysis, 2019). Globally, 1.35 million deaths per year and 3,700 deaths per day are attributable to traffic accidents (World Health Organization, 2018). Several factors, such as the number of motor vehicles, traffic control features, engineering design and conditions of the roads, pedestrian safety features, and utilization of public transportation influence traffic fatalities (Rolison et al., 2018). Tokyo and New York City have large populations but low traffic fatality rates, which could be related to these city's large and complex rail systems (Calimente, 2012; King, 2011). In contrast, other cities, which have either limited or nonexistent rail systems, report high traffic fatality rates. Railways have the added advantage of being more protected and isolated from pedestrians and motor vehicles than bus systems.

Regional rail systems possess several complex factors, and it is not simple to investigate the association between regional rail systems and traffic fatalities. We hypothesized that the number of regional rail lines would have an impact on traffic fatality rates in cities, and we aimed to investigate this association macroscopically.

2. Methods

2.1 Materials

We obtained data on traffic fatalities, number of regional rail lines, motor vehicle registrations, and city populations of select cities in and outside the United States in 2018. We deliberately chose large cities with extensive, intermediate, and few or no rail lines to obtain sufficient diversity.

Furthermore, we characterized the regional rail lines by the total number of rail lines running in the city and the stations on the line connecting at least two places within the city. As we could not obtain complete data for some cities, even after extensive database search and direct and telephonic correspondence with the local officials, we excluded those cities. We collected data on total and child (age 0–17 years) traffic fatalities. Data from each city were obtained from multiple sources including the U.S. National Highway Traffic Safety Administration, the local city government, and departments of police, transportation, and public safety within each city. Data on the number of registered motor vehicles were obtained from the city government or the respective Departments of Motor Vehicles, such as licensing and revenue/tax collection. The 2018 city population estimates were derived from the United States Census Bureau and the United Nations (Appendix 1).

2.2 Equalization

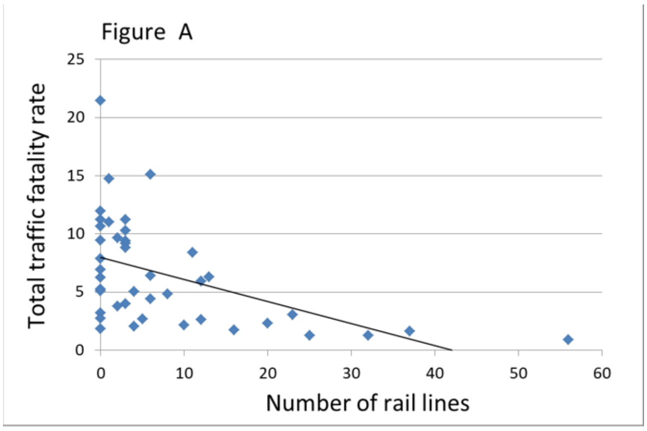
We adjusted traffic fatalities, child traffic fatalities, and the number of total motor vehicle registrations according to the corresponding city population to obtain total traffic fatality rates, child traffic fatality rates, and motor vehicle registrations per capita, as follows:

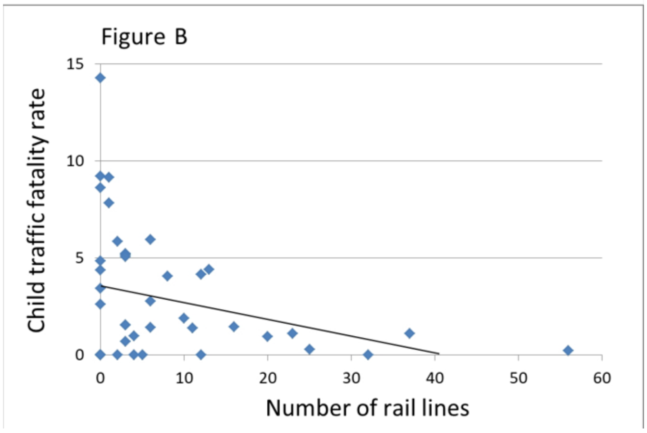
- $$\text{Total traffic fatality rate} = \frac{\text{Total traffic fatalities}}{\text{Total Population}} \times 100{,}000 \qquad (1)$$
- $$\text{Child traffic fatality rate} = \frac{\text{Traffic fatalities in children}}{\text{Total Population}} \times 1{,}000{,}000 \qquad (2)$$
- $$\text{Motor vehicle registrations per capita} = \frac{\text{Number of motor vehicle registrations}}{\text{Total Population}} \qquad (3)$$

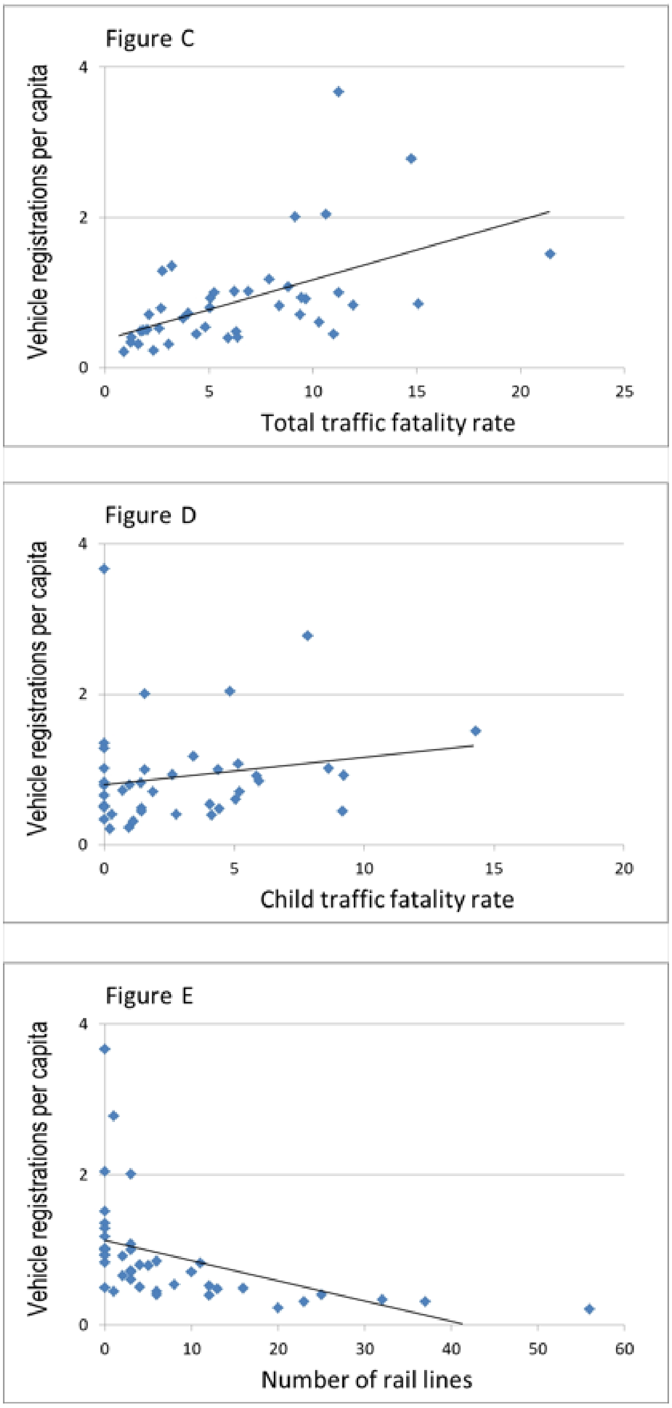
Note that in the child traffic fatality rate, we used the total population (not just the child population) as the denominator because for many of the cities, we could not obtain the child population.

2.3 Statistical analyses

We acquired the complete data for 34 U.S. and 8 non-U.S. cities: London, Berlin, Delhi, Seoul, Vancouver, Sydney, Tokyo, and Osaka. We performed Pearson correlation linear regression analysis for the following pairs of variables (Akoglu, 2018): (A) number of regional rail lines vs. total traffic fatality rates, (B) number of regional rail lines vs. child traffic fatality rate, (C) total traffic fatality rate vs. motor vehicle registrations per capita, (D) child traffic fatality rate vs. motor vehicle registrations per capita, and (E) number of regional rail lines vs. motor vehicle registrations per capita. We analyzed the data using Microsoft Excel (Microsoft, Redmond, WA).







Figures: 1: *Scatter plots and regression lines for each comparison*

A. Rail lines (X-axis) by total traffic fatality rates (Y-axis) shows reductions in traffic fatality rates with increasing rail lines (negative correlation).

B. Rail lines (X-axis) by child traffic fatality rates (Y-axis) shows reductions in child traffic fatality rates with increasing rail lines (negative correlation).

C. Total traffic fatality rates (X-axis) by motor vehicle registrations per capita (Y-axis) shows increasing traffic fatality rates with increasing motor vehicle registrations per capita (positive correlation).

D. Child traffic fatality rates (X-axis) by motor vehicle registrations per capita (Y-axis) shows no significant correlation.

E. Rail lines (X-axis) by Motor vehicle registrations per capita (Y-axis) shows reduced motor vehicle registrations per capita with increasing rail lines (negative correlation).

3. Results

Table 1 shows the number of regional rail lines, traffic fatalities, motor vehicle registrations, and populations for each city included in our analysis. The data are sorted in ascending order according to the number of rail lines in the city.

Table 1. Number of regional rail lines, traffic fatality rates, and motor vehicle registrations per capita according to city.

City	Number of rail lines	Total traffic deaths	Child traffic deaths	Total population	Motor vehicle registration	Total traffic fatality rate	Child traffic fatality rate	Motor vehicle registration per capita
Tokyo	56	86	2	9,551,763	1,963,971	0.90	0.21	0.21
Osaka	37	44	3[a]	2,725,006	848,863	1.61	1.10	0.31
London	32	112	0[a]	9,045,485	3,070,043	1.24	0.00	0.34
Berlin	25	45	1	3,552,123	1,422,065	1.27	0.28	0.40
Seoul	23	304	11[a]	9,963,497	3,121,687	3.05	1.10	0.31
New York City	20	195	8	8,398,748	1,912,468	2.32	0.95	0.23
Boston	16	12	1	694,583	335,200	1.73	1.44	0.48
Philadelphia	13	100	7	1,584,138	753,339	6.31	4.42	0.48
San Francisco	12	23	0	883,305	459,034	2.60	0.00	0.52
Delhi	12	1690	118[a]	28,514,000	11,204,227	5.93	4.14	0.39
Denver	12	60	1	716,492	591,459	8.37	1.40	0.83
Sydney	11	102	9	4,792,281	3,372,090	2.13	1.88	0.70
Chicago	10	131	11	2,705,994	1,442,827	4.84	4.07	0.53
Washington DC	8	31	1	702,455	310,052	4.41	1.42	0.44
Los Angeles	6	255	11	3,990,456	1,614,196	6.39	2.76	0.40
Dallas	6	203	8	1,345,047	1,139,863	15.09	5.95	0.85
Seattle	6	20	0	744,945	588,089	2.68	0.00	0.79
San Jose	5	52	1	1,030,119	823,755	5.05	0.97	0.80
Vancouver	4	13	0	635,700	320,000	2.04	0.00	0.50
San Diego	4	57	1	1,425,976	1,030,321	4.00	0.70	0.72
Oklahoma City	3	73	1	649,021	646,001	11.25	1.54	1.00

Cleveland	3	36	2	383,793	270,500	9.38	5.21	0.70
Las Vegas	3	59	1	644,644	1,294,567	9.15	1.55	2.01
Houston	3	205	12	2,325,502	2,504,309	8.82	5.16	1.08
Milwaukee	3	61	3	592,025	356,759	10.30	5.07	0.60
El Paso	2	66	4	682,669	626,922	9.67	5.86	0.92
Minneapolis	2	16	0	425,403	276,909	3.76	0.00	0.65
Phoenix	1	245	13	1,660,272	4,609,073	14.76	7.83	2.78
Charlotte	1	96	8	872,498	391,334	11.00	9.17	0.45
Anchorage	0	23	1	291,538	342,772	7.89	3.43	1.18
San Antonio	0	145	4	1,532,233	1,424,204	9.46	2.61	0.93
Nashville	0	80	0	669,053	558,483	11.96	0.00	0.83
Boise	0	12	1	228,790	229,308	5.24	4.37	1.00
Burlington	0	1	0	53,748	26,668	1.86	0.00	0.50
Fargo	0	4	0	124,844	168,497	3.20	0.00	1.35
Manchester	0	7	0	112,525	113,883	6.22	0.00	1.01
Birmingham	0	45	3	209,880	316,264	21.44	14.29	1.51
Columbia	0	15	0	133,451	488,967	11.24	0.00	3.66
Sioux falls	0	5	0	181,883	233,033	2.75	0.00	1.28
Honolulu	0	24	3	347,397	351,833	6.91	8.64	1.01
Des Moines	0	11	2	216,853	200,174	5.07	9.22	0.92
Louisville	0	66	3	620,118	1,265,281	10.64	4.84	2.04

[a] Child traffic deaths at age <16 years

Table 2 summarizes the results of each Pearson correlation analysis. These show lower total and child mortality rates as the number of rail lines increase.

Table 3 summarizes the results of each Pearson correlation in Table 2—excluding non-U.S. cities—to measure the correlation purely within the United States.

Figure panels A, B, C, D, and E show the corresponding scatterplots and regression lines.

Table 2. Correlations between the number of railway lines, traffic fatality rates, and motor vehicle registrations per capita.

Comparisons	R	R square	P
Number of regional rail lines vs. the total traffic fatality rate	−0.49	0.24	0.0009
Number of regional rail lines vs. the child total traffic fatality rate	−0.31	0.1	0.04
Total traffic fatality rate vs. motor vehicle registrations per capita	0.54	0.29	0.0002
Child total traffic fatality rate vs. motor vehicle registrations per capita	0.18	0.03	0.24
Number of regional rail lines vs. motor vehicle registrations per capita	−0.46	0.21	0.002

Table 3. Correlations between number of regional rail lines, traffic fatality rates, and motor vehicle registrations per capita in U.S. cities.

Comparisons	R	R square	P
Number of regional rail lines vs. the total traffic fatality rate	−0.36	0.13	0.038
Number of regional rail lines vs. the child total traffic fatality rate	−0.23	0.05	0.19
Total traffic fatality rate vs. motor vehicle registrations per capita	0.45	0.21	0.007
Child total traffic fatality rate vs. motor vehicle registrations per capita	0.09	0.01	0.59
Number of regional rail lines vs. motor vehicle registrations per capita	−0.45	0.2	0.008

4. Discussion

This study shows a significant correlation between the number of rail lines and lower total traffic mortality and lower child traffic mortality. The expense of rail systems are justified by reductions in traffic congestion and improvements in movement of the population. This study also demonstrates reductions in traffic mortality which further justifies the construction and maintenance expenses associated with rail systems. Convenience and traffic efficiency are desirable, while reductions in traffic mortality are better characterized as “priceless”.

To the best of our knowledge, no studies have focused on the association between the number of regional rail lines and traffic fatalities within cities. Public transportation is considered a safe and secure transportation mode (Litman, 2014). Public rail transport comprises multiple and complex factors, such as passenger capacity, length of rails, railway throughput, railway schedules, number of rail stations and lines, and percentage of rail-transit mode share (Bešinović, 2020; Francesco et al., 2016). Previous studies have investigated the association between individual rail transportation system factors and traffic fatalities. Increased use of public transportation—including rail transport—can reduce traffic fatalities (Dickens and Shaum, 2018; Soehodho, 2017; Truong and Currie, 2019). The mode of travel also affects the numbers of traffic fatalities (Moeinaddini et al., 2015). The effect is limited, but rail transport typically reduces traffic congestion (Giuliano et al., 2015; Hasiak and Rabaud, 2016). We focused on the number of regional rail lines for comparison to simplify the association between regional rail lines and traffic fatalities. Future studies should evaluate other factors related to rail systems and analyze the associations between each of these factors and traffic fatalities, but with a larger sample size.

Our results show that a larger number of regional rail lines correspond to fewer traffic fatalities and fewer motor vehicle registrations per capita. Table 3 examines only U.S. cities, confirming that this association holds true in the United States. However, the United States only has a handful of cities with extensive rail systems. The sample size was improved with the addition of large international cities. Table 2 shows a significant correlation between the number of regional rail lines and child traffic fatalities; however, when international cities were removed (Table 3), the correlation was not significant, likely because of the insufficient sample size (Looney, 2018).

Cities with more regional rail lines had fewer traffic fatalities and fewer motor vehicle registrations. Densely populated cities must utilize mass transit systems, as private motor vehicles are an inefficient (albeit convenient) means of transporting large populations. Moreover, rail systems have benefits other than merely reducing the number of motor vehicles. In most instances, rail lines are physically shielded/isolated protected from motor vehicle and pedestrian traffic, thus making rail lines faster, safer, and more efficient than private motor vehicles.

5. Conclusion

The number of rail lines was correlated with reductions in traffic fatality rates in children and adults, and motor vehicle registrations per capita.

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Declaration Of Interest

The authors declare no conflicts of interest, and no financial disclosures were reported by the authors of this paper.

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