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# Train suicide mortality and availability of trains: A tale of two countries



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## ABSTRACT

When compared to German rates, train suicides in the Netherlands have made up a larger proportion of the total number of suicides. This study examines whether this difference is attributable to railway parameters, familiarity with rail transport, or population density.

Dutch and German train suicide rates from 2000 to 2007 were compared by means of Poisson regression analyses. Train suicide rate ratios were calculated and related to the railway parameters or population density in a Poisson regression model. The Dutch–German general suicide rate ratio was 0.72. In contrast, the train suicide rate in the Netherlands exceeded the German rate by 1.23. In the Poisson regression analyses, where suicide rate was related to railway density or passenger traffic intensity, the Dutch–German train suicide rate ratios became 1.49 and 1.20 respectively. When related to train traffic intensity or population density, however, rate ratios turned into 0.74 and 0.59 respectively. Train traffic intensity contributes to train suicide frequency. Population density also contributes, whereas railway density and familiarity with rail transport do not. In a cross-national comparison the availability hypothesis regarding the number of trains passing was confirmed, which leads to the recommendation of limiting access to the railway tracks.

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## 1. Introduction

The extent to which train suicides contribute to the total suicide mortality varies considerably between countries. This proportion is highest in the Netherlands (Krysinska and De Leo, 2008; Ladwig et al., 2009). This raises the question of whether this difference is possibly related to a higher availability of trains in the Netherlands as a means to commit suicide. Such a relationship between availability and use as a means for suicide has convincingly been demonstrated in the case of firearms, especially handguns, and toxic coal-based gas for domestic purposes (Clarke and Lester, 1989; Miller and Hemenway, 2008). So far, few authors have tried to explain train suicide rates. As early as 1879, the association between the incidence of train suicides and the availability of railway tracks was noticed by Enrico Morselli who reported that the highest proportion of train suicides in Italy occurred in the region of Piedmont, the Italian region with more railways than any other in his time (Morselli, 1881, 1882, 1975). A few years later,

Durkheim wrote that “the more the land is covered with railroads, the more general becomes the habit of seeking death by throwing one’s self under a train” (Durkheim, 1897, 1952), a hypothesis that was supported by Clarke’s study on train suicides in the era of railway development in England and Wales (Clarke, 1994). However, Clarke had also noticed that the size of the increase in train suicides was closer to the increase in the number of passengers than to the increase in the amount of railway track. According to Clarke, the number of passengers indicates how familiar the public is with this suicide method (Clarke, 1994). This idea, that being familiar with a means for suicide may influence the degree in which this method is used, was formulated before regarding firearm and car exhaust suicides (Marks and Abernathy, 1974).

As clusters of train suicides were found near major cities or towns (Abbott et al., 2003), the number of people living near railways, expressed in terms of population density, may also have an influence on the number of train suicides.

On the basis of the evidence described above, we formulated four separate hypotheses that might explain the observed difference in train suicide mortality between countries: 1. the availability hypothesis regarding railway density, where railway density is an indication of the average distance people have to travel to reach railway tracks; 2. the availability hypothesis regarding train traffic intensity, i.e. the

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number of trains passing; 3. the familiarity hypothesis regarding passenger traffic intensity, indicating the familiarity of the wider public with rail transport; 4. the population density hypothesis, which relates train suicide mortality to the number of potential users of this means i.e. the inhabitants of a country.

We set out to test the validity of these four hypotheses by investigating the difference in train suicide rates between the Netherlands and Germany in a comparative study. These two neighbouring western European countries, located on the West European continent, share many cultural and socio-economic characteristics. The proportion of train suicides to the total number of suicides was found to be 1.6 times higher in the Netherlands than in Germany, however, and amounted to 11.5% and 7.0% respectively (Baumert et al., 2005; Van Houwelingen et al., 2010). That both countries have a tradition of train suicide research was helpful in getting access to adequate data.

## 2. Methods

### 2.1. Sample and data source

In order to investigate the contribution of railway and population parameters to the incidence of train suicides, an ecological study was carried out involving the entire railway system in the Netherlands and Germany in 2000–2007 using the two following datasets:

#### 2.1.1. Dutch data

Data regarding Dutch train suicides were obtained from the Department of Corporate Communication of the NV *Nederlandse Spoorwegen* (the Netherlands Railways), who keep records of all suicidal behaviour on the national railway network, with the exception of underground, light rail and tram systems. Records are based on statutory investigations of every unnatural death by the local police and coroner. The railway infrastructure manager ProRail and the Netherlands Railways provided data on the length of the national railway network, national and international passenger train and freight train kilometres as well as on passenger kilometres by all carriers on Dutch territory. Passenger kilometres by other companies were estimated by the Netherlands Railways and included in the dataset. National suicide statistics, national population figures, population density and data on surface area were obtained from the *Centraal Bureau voor de Statistiek* (Statistics Netherlands; <http://statline.cbs.nl>). Annual train suicide rates and general suicide rates (per 100,000 inhabitants) were calculated on the basis of the January 1 census. In the study period the Netherlands had 16.2 million inhabitants on average, which corresponded to a population density of 478 inhabitants per km<sup>2</sup>.

#### 2.1.2. German data

Data regarding German train suicides in the study period were obtained from the German Event Database Safety (EDS), a national central registry of personal accidents on the German Railway Company network (*Deutsche Bahn AG*). Misclassifications or missing records were unlikely to occur, as, just as in the Netherlands, every unnatural death is investigated by the local police and coroner. Fatal outcome was defined as “death within 30 days”.

*Deutsche Bahn AG* provided data on the length of the national railway network and on national and international passenger train and freight train kilometres by all carriers on German territory. Data on passenger kilometres were obtained from the *Statistisches Bundesamt Deutschland* (Federal Statistical Office of Germany). National suicide statistics, national population figures, population density and data on surface area were obtained from the Federal Statistical Office of Germany. Annual train suicide rates and general suicide rates (per 100,000 inhabitants) were calculated on the basis of the census records of December 31 of each preceding year. The average German population size was 82.4 million with a population density of 231 inhabitants per km<sup>2</sup>.

In both countries train suicides were defined as all suicides caused by train-person collisions or deliberate car crashes into moving trains, including those of non-residents.

### 2.2. Description of parameters examined

- Railway density* was defined as railway length in kilometres  $\times$  1000 divided by km<sup>2</sup> surface area, excluding water surface (for the Netherlands: excluding water surfaces with a width of  $>$  6 m). Railway length was defined as the number of kilometres of railway in use for scheduled passenger or freight trains, regardless the number of tracks. Railway tracks on private industrial plants and harbour complexes with non-scheduled low-speed freight trains exclusively were not included in this study (availability hypothesis 1).

- Train traffic intensity* was defined as the number of train kilometres divided by railway length in kilometres, calculated per year. Train kilometres were defined as the actual annual number of kilometres run by national and international passenger and freight trains, by all companies, on the Dutch and German territories respectively (availability hypothesis 2).
- Passenger traffic intensity* was defined as passenger kilometres divided by the national population as a measure of the use of railway transport and as an indication of familiarity with overground railway transport. Passenger kilometres were defined as the distance covered by all individual passengers per year (familiarity hypothesis).
- Population density* is the number of inhabitants per km<sup>2</sup> surface area, indicative of the number of potential users in an area (population density hypothesis).

### 2.3. Statistical analysis

In order to assess the significance of possible differences in suicide rates between the Netherlands and Germany, a Poisson regression analysis was performed (McCullagh and Nelder, 1989) using the following regression equation:

$$\log(\text{number of suicides}) = \text{intercept} + b \times \text{country} + \log(\text{population number}) + \text{error term}$$

and by calculating the respective rate ratio for suicides in the Netherlands compared to Germany by the rate ratio =  $\exp(b)$ .

First, we estimated the rate ratio for general suicides and train suicides in the Netherlands compared to Germany. Second, the train suicide rate ratio was related to the amount of railway density, train traffic intensity, passenger traffic intensity or population density by using the annual values of each parameter as additional offset terms in the Poisson regression model. This approach relates changes in the suicide rate to changes in the examined parameters in the observation period and it can explain possible reasons for differences in train suicide rates. The suicide rate ratios with their 95% confidence interval (CI) and *p*-values were calculated from the resulting models. In case of over-dispersion of the Poisson regression model, the dispersion parameter was estimated by using the ratio of the deviance to its associated degrees of freedom. In all statistical analyses, a *p*-value of less than 0.05 was considered statistically significant. All evaluations were performed with the statistical software package SAS 9.1 for Windows.

## 3. Results

A total number of 1475 Dutch and 6105 German train suicides were observed over an 8-year observation period from the years 2000 to 2007.

### 3.1. Railway parameters

The rail infrastructure and the use of the networks differed between the countries. In the study period mean railway length in the Netherlands was 2816 km and in Germany 35,124 km. The mean number of train kilometres was 134 million and 997.5 million km respectively. Railway density in Germany, which has half the population density of the Netherlands, was 20% higher than railway density in the Netherlands, whereas train traffic intensity was substantially higher in the Netherlands (Table 1). With the exception of the year 2001, passenger traffic intensity was slightly higher in the Netherlands (Table 1).

### 3.2. Train suicide and general suicide figures

General suicide rates were lower in the Netherlands than in Germany (Table 2). Correspondingly, the regression analysis resulted in a Dutch–German general suicide rate ratio of 0.72 (95% CI 0.66–0.80, *P* < 0.001; Table 3). On the other hand, train suicide rates were higher in the Netherlands (Table 2). The Dutch–German train suicide rate ratio was 1.23 (95% CI 1.12–1.36, *P* < 0.001; Table 3). The proportion of train suicides to all suicides (general suicides) appeared to be substantially higher in the Netherlands (mean 12.3%) than in Germany (mean 7.2%).

**Table 1**  
Railway system and population parameters in the Netherlands and Germany in 2000–2007.

Year	The Netherlands				Germany			
	Railway density <sup>a</sup>	Train traffic intensity <sup>b</sup>	Passenger traffic intensity <sup>c</sup>	Population density <sup>d</sup>	Railway density <sup>a</sup>	Train traffic intensity <sup>b</sup>	Passenger traffic intensity <sup>c</sup>	Population density <sup>d</sup>
2000	83	47,216	936	468	105	26,900	918	230
2001	83	46,280	914	472	103	27,152	921	230
2002	83	45,937	910	475	103	27,019	866	231
2003	83	46,781	879	479	102	27,764	864	231
2004	83	48,275	894	481	100	28,824	879	231
2005	83	47,743	931	483	98	29,163	908	231
2006	82	49,027	976	483	98	29,788	955	231
2007	86	49,378	984	484	97	30,870	961	231

<sup>a</sup> Railway length in metres per km<sup>2</sup> surface area.

<sup>b</sup> Average number of train movements per kilometre railway.

<sup>c</sup> Number of passenger km per inhabitant.

<sup>d</sup> Number of inhabitants per km<sup>2</sup> surface area.

**Table 2**  
Train suicides and general population suicides in the Netherlands and Germany in 2000–2007.

Year	The Netherlands					Germany				
	Train suicides <i>N</i>	Train suicide rate <sup>a</sup>	General suicides <i>N</i>	General suicide rate <sup>a</sup>	Train/general suicides in %	Train suicides <i>N</i>	Train suicide rate <sup>a</sup>	General suicides <i>N</i>	General suicide rate <sup>a</sup>	Train/general suicides in %
2000	184	1.16	1500	9.5	12.3	807	0.98	11,065	13.5	7.3
2001	202	1.26	1473	9.2	13.7	832	1.01	11,156	13.6	7.5
2002	177	1.10	1567	9.7	11.3	843	1.02	11,163	13.5	7.6
2003	175	1.08	1500	9.3	11.7	779	0.94	11,150	13.5	7.0
2004	170	1.05	1514	9.3	11.2	762	0.92	10,733	13.0	7.1
2005	184	1.13	1572	9.6	11.7	705	0.85	10,260	12.4	6.9
2006	190	1.16	1524	9.3	12.5	673	0.82	9765	11.8	6.9
2007	193	1.18	1353	8.3	14.3	704	0.86	9402	11.4	7.5

<sup>a</sup> Per 100,000 inhabitants.

**Table 3**  
General suicide rate ratio, train suicide rate ratio and train suicide rate ratio related to railway system-related parameters and population density over 2000–2007 of the Netherlands (*n*=1475) compared to Germany (*n*=6105) by Poisson regression analyses.

Model	Rate ratio (95% CI)	<i>P</i>
General suicide rate	0.72 (0.66–0.80)	< 0.001
Train suicide rate	1.23 (1.12–1.36)	< 0.001
Train suicide rate related to railway density	1.49 (1.38–1.60)	< 0.001
Train suicide rate related to train traffic intensity	0.74 (0.63–0.86)	< 0.001
Train suicide rate related to passenger traffic intensity	1.20 (1.06–1.37)	0.005
Train suicide rate related to population density	0.59 (0.54–0.66)	< 0.001

### 3.3. Train suicide rate related to railway density, train traffic intensity, passenger traffic intensity or population density

When train suicide rates were related to railway density, the Dutch–German train suicide ratio became 1.49, which was significantly higher than the unrelated train suicide rate ratio of 1.23 (Table 3). However, when train traffic intensity was taken into account, the higher train suicide mortality in the Netherlands (1.23) decreased substantially to a rate ratio of 0.74, which is very similar to the rate ratio comparing the Dutch and German general suicide rates (0.72). When train suicide rates were related to passenger traffic intensity, the train suicide ratio did not change (Table 3). When population density was taken into account, a rate ratio of 0.59 (95% CI 0.54–0.66, *P* < 0.0001) was found. This train suicide rate ratio was significantly lower than the rate ratio found when train suicide rates were related to train traffic intensity (0.74) and also significantly lower than the general suicide rate ratio of 0.72 (Table 3).

## 4. Discussion

This is the first cross-national study evaluating the impact of railway-related parameters and population density on train suicide rates. In a direct comparison between the Netherlands and Germany a substantial difference in train suicide proportions to total suicide mortality was confirmed. Although Germany had a substantially higher general suicide rate, the Netherlands showed a substantially higher train suicide rate.

### 4.1. Railway density as availability parameter

When the differences in railway density were taken into account, the Dutch/German train suicide rate ratio increased: the difference in train suicide rates between the two countries did not decrease, but increased. This outcome would suggest a positive effect of railway density. But as railway density in the Netherlands was lower to start with, this parameter, which is indicative of the average distance

people have to travel to reach railway tracks, did, therefore, not explain the higher Dutch train suicide rates. An explanation for this may be that well-established railway networks in some countries have reached such high levels of saturation that relative railway density has ceased to matter, and that a ceiling effect exists. We therefore conclude that the results of this study do not support the availability hypothesis as once formulated by Durkheim (1897, 1952).

#### 4.2. Train traffic intensity as availability parameter

The most important finding of the present study was that the excess risk of train suicide in the Netherlands not only disappeared, but reversed when train traffic intensity was taken into account. It suggests that train traffic intensity has a major impact on train suicide rates and explains the higher train suicide mortality in the Netherlands. This finding confirms the availability hypothesis indicating that higher train traffic intensity is associated with more train suicides. It means that a 10-minute instead of a 20-minute interval between trains would make a significant difference to a suicidal person. Higher availability, meaning shorter intervals between trains, would appeal to the impulsivity that characterises many train suicide cases (O'Donnell et al., 1996; Miller and Hemenway, 2008). 24% of the people who made near-lethal suicide attempts took less than 5 min between the decision to kill themselves and the actual attempt, and 70% less than 1 h (Miller and Hemenway, 2008). Furthermore, many suicidal crises are self-limiting, with the urge to attempt suicide subsiding as the acute phase of the crisis passes (Miller and Hemenway, 2008). Therefore, train frequency is crucial for suicidal persons who have found their way to the tracks and are waiting or wandering around there for some time (Rådbo et al., 2005). Trains passing at higher frequencies may elicit more impulsive responses, while lower frequencies allow for more reflection time, with a greater chance that a potential suicide will refrain from jumping.

The data also showed that, related to train traffic intensity, the train suicide rate ratio reversed to a value of 0.74, which is similar to the general suicide rate ratio (0.72). This finding stresses the influence of the general suicide rate on the train suicide rate and corroborates the observed influence of general suicide figures on train suicide frequency found in a longitudinal study in the Netherlands (Van Houwelingen et al., 2010).

The different outcomes regarding availability for railway density and train traffic intensity suggest that these two components may act differently at different stages in the evolution of railroad transportation, from the expansion of the railway network in the 19th century to the growth in transport volumes on consolidated networks in recent history. In this day and age it may not be the actual number of tracks that determines train suicide, but the intensity with which these tracks are used. Retrospectively, railway density may never have been an important factor at all, not even in the time of Morselli and Durkheim. What was seen as a relationship between train suicide rates and railway network expansion may have been a relationship based on railway traffic intensity. Regardless the degree of railway density, it is probably train traffic intensity that counts. Moreover, the relationship with the number of passengers, interpreted by Clarke as the outcome of familiarity with rail transport, may have been a relationship based on train traffic intensity as well.

#### 4.3. Familiarity with the railway system

This study has also demonstrated that the part of the population that is familiar with the train system, as indicated by passenger traffic intensity, cannot explain the differences in train suicide rates between the Netherlands and Germany. This finding

corroborates an earlier observation from the Netherlands which showed that a sudden increase in student railway transport due to the introduction of free transport for students in 1991, did not result in more train suicides (Van Houwelingen et al., 2010). The conclusion seems justified that the number of commuters on board of trains is not relevant to the train suicide problem.

#### 4.4. Population density

Obviously, the number of train suicides depends on the presence of a potential public that can use this means. Population density reflects the number of people with potential physical exposure to railways in their environment. When train suicide rates were related to population density, we found that the train suicide rate ratio was reversed, as was the case with train traffic intensity. However, in this case it was reduced to a value (0.59) even smaller than the general suicide rate ratio (0.72) and the train suicide rate ratio after adjustment for train traffic intensity (0.74). This finding suggests that population density has an even stronger impact on train suicide rates than train traffic intensity.

As population density and train traffic intensity are obviously highly correlated (highly populated areas have more trains running), it is rather difficult to assess independently for each parameter which of the two does more to explain the differences in train suicide rates between the Netherlands and Germany. As population density is a parameter that cannot be manipulated, it is better in this case to target train traffic intensity for preventive action.

#### 4.5. Other considerations

The impact of availability also depends on the accessibility of the railway tracks. The present railway networks in the Netherlands and Germany are the product of 150 years of railway history in which keeping people away from moving trains has never been an issue. Even today, railroads are easily accessible in both countries.

It has been observed that widely available means, like ropes for hanging, are applied in varying degrees in different countries. This might be caused by differences in the acceptability of the means (Farmer and Rohde, 1980). Regarding train suicide in the Netherlands and Germany, there is no empirical evidence that the acceptability of this suicide method may differ, although it could be argued that the higher proportion of train suicides in the Netherlands might act as a self-propelling phenomenon through a sustained awareness of this suicide method in the general population.

#### 4.6. Strengths and limitations

As full datasets were employed, there was no sampling bias. Sampling bias due to culturally-determined differences in the certification of suicides has been described (Farmer and Rohde, 1980; Burrows and Laflamme, 2007). As medico-legal assessment procedures are similar in the two countries and no known negative financial or legal consequences of the act of train suicide exist that might influence the process of assessment in a subtle way, the authors do not consider assessment bias accountable for the rate differences that were found.

One major limitation, connected with the ecologic design of the study, needs to be mentioned, though. The aggregate data on the national level may have been influenced by the heterogeneous character of the Dutch and German regions. Therefore, prudence is required when making causal inferences between train traffic intensity and the incidence of train suicides on the basis of the results of this study. At the same time, this study

highlights the necessity of carrying out further studies in regions with high and low train traffic intensity.

The finding that train suicide is dependent on train traffic intensity suggests that increased overground rail-based mobility, resulting in higher train traffic intensity and thus in increased availability, may elicit more train suicides. From this point of view we first of all recommend that the capacity of individual trains be increased. We should bear in mind, though, that this approach may be inadequate to meet the demand for high-frequency transport connected with socio-economic developments in our societies. However, the results of this study indicate that both availability and quantity are important: the number of trains passing and the number of potential users of this method. In this scenario a strategy of controlling the environment by designing out suicide opportunities seems imperative (Clarke and Lester, 1989; Prüss-Üstün and Corvalán, 2006). Convincing evidence suggests that reducing access to lethal means does in fact result in a decrease of suicides by those same means (Beautrais, 2007; Law et al., 2009; Yip et al., 2010), while the substitution risk is small (Daigle, 2005). Regarding train suicide, we would propose the building of fences along railways in high-risk areas and replacing level crossings with viaducts or tunnels, in order to reduce the availability of trains by limiting access to railway tracks.

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