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## Studies into train suicide

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# Chapter 7

## Train suicide in the Netherlands: the impact of railway traffic intensity re-examined

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## ABSTRACT

### Background

A recent Dutch-German study has shown the influence of train traffic intensity on train suicide, something which had gone unnoticed in a previous Dutch study, where a relationship had been found between train suicide rates and general suicide rates. This study re-examines the Dutch data to test whether general suicide rates and train traffic intensity combined lead to better predictions of train suicide rates.

### Methods

We compared regression models with general suicide rates, train traffic intensity and combinations of these variables as regressors with train suicide rates as the dependent variable. Data on 1950–2007 were obtained from the Netherlands Railways, ProRail and Statistics Netherlands. Models were tested for this period and three sub-periods marked by major trend breaks in suicide rates: 1950–1969, 1970–1984 and 1985–2007.

### Results

Single regression with train traffic intensity (Model 2, Adj.R2=0.824, s.e.= 0.190, df=55,  $P<0.001$ ) turned out to be a slightly better model than one with general suicide rates (Model 1, Adj. R2=0.753, s.e.= 0.228, df=56,  $P<0.001$ ). Multiple regression with general suicide rates and train traffic intensity performed significantly better (Model 3, Adj.R2=0.938, s.e.= 0.113, df=53,  $P<0.001$ ). Models 1–3 showed large unexplained variances in the sub-period 1985–2007. A model with the product of general suicide rates and train traffic intensity without intercept performed well for the whole period (Model 4, Adj.R2=0.972, s.e.= 0.156, df=56,  $P<0.001$ ) and all sub-periods, for men and women.

### Limitations

none

### Conclusions

Train suicide frequency is proportional to national suicide figures and train availability. High-frequency rail transport may result in more train suicides. This impact may be toned down or boosted through developments in society influencing the suicidality of the population at large. The importance of train availability calls for restricting easy access to the tracks.

## 1. INTRODUCTION

Higher fuel prices, strategies for reducing CO<sup>2</sup> emission, population growth and increasing mobility needs are bound to cause an increase in rail transport volume. It is expected that by 2020 passenger rail transport in the Netherlands will have grown by 42–46 % (www.rijksoverheid.nl). When maximum seating capacity in trains has been reached, transport capacity can only be increased by running more trains. For this reason the Dutch government has launched a High-Frequency Rail Transport Programme (Priority Decision, 2010). An important question is whether this will cause more train suicide fatalities, as higher train traffic frequencies may facilitate impulsive suicidal behaviour (Van Houwelingen et al, submitted). This may result in increased human suffering in survivors, railway personnel and travellers and higher economic costs connected with each incident. Moreover, when tracks are more heavily trafficked, any disruption of the services due to a train suicide is more severe. The relationship between train traffic and suicide was addressed earlier in a Dutch longitudinal study, covering the period 1950–2007 (Van Houwelingen et al, 2010). It showed that the incidence of train suicides was related to that of general suicides but the results also seemed to suggest that train suicide was unrelated to the distance covered by trains each year. While train kilometres continued to increase, train suicide rates decreased after 1989, albeit to a lesser degree than general suicide rates in the same period. Therefore, it was speculated that increased train transportation need not lead to more train suicides. However, a more recent cross-national study on train suicide in the Netherlands and Germany revealed a significant impact of train traffic intensity on suicide rates when multivariate analyses were applied (Van Houwelingen et al, submitted). The availability hypothesis was confirmed: more trains led to more train suicides. Thus, the possibility arose that the impact of train traffic intensity had been underestimated in the previous study where the independent variables had been ascertained separately. The combined influences of general suicide rates and train traffic intensity might provide a better explanation of the observed train suicide rates in the Netherlands, also for the period when rates were declining. To test this hypothesis, the following research question was formulated: Does a model including general suicide rates and train traffic intensity give a better description of observed train suicides rates than one including general suicide rates only or train traffic intensity only? Since in the period of declining train suicide rates this was mainly caused by a decrease of female train suicide rates (Van Houwelingen et al, 2010), the gender specificity of the hypothesis was tested as well. Perhaps train availability works differently for men and women. In the 58-year period of the Dutch study striking trend breaks in the incidence of train suicides and general suicides were observed around the years 1970 and 1985 (Van Houwelingen et al, 2010). Models could be expected to behave differently in sub-periods marked by these years. Therefore the hypothesis was tested for the period 1950–2007 and for three sub-periods as well: 1950–1969, 1970–1984 and 1985–2007.

## 2. METHOD

### 2.1. Sample and data source

Data on train suicides in 1980–2007 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 and include suicides by jumping or lying in front of a moving train or by deliberately crashing a car into a moving train. The database was enlarged by adding the annual frequencies of transportation suicides (overground and underground trains, unspecified) of 1950–1979 from the *Centraal Bureau voor de Statistiek* (Statistics Netherlands, [www.cbs.nl](http://www.cbs.nl)). The proportion of underground train suicides in this period is considered to be very small, as underground systems only started to function on a limited scale in two cities (Amsterdam and Rotterdam) in 1968 and 1977. 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 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 and national population figures were obtained from the *Centraal Bureau voor de Statistiek*. Annual train suicide and general suicide rates (per 100,000 inhabitants) were calculated, based on the January 1 census of the Dutch population. Missing train suicide data for the years 1951–1954, 1956, 1958–1961, 1963, 1964, 1966 and 1968 were generated by linear extrapolation of the known values from other years.

### 2.2. Train traffic intensity

Train traffic intensity was defined as train kilometres divided by railway length in kilometres. Train kilometres are kilometres actually run by national and international passenger trains and freight trains of all companies on Dutch territory. Railway length is the number of kilometres of railway, independent of the number of tracks, in use for scheduled passenger trains and/or freight trains. Railway tracks on private industrial plants and harbour complexes with non-scheduled low-speed freight trains exclusively were not included.

### 2.3. Exploratory data analysis

In order to visually explore the possible association between train suicide rates and the combination of general suicide rates and train traffic intensity during the studied period, train suicide rates were plotted together with a scaled product of general suicide rates and train traffic intensity (Fig.1a-c).

## **2.4. Statistical analysis**

In order to test the hypothesis that general suicide rates and train traffic intensity combined is a better predictor of the frequency of train suicides than either of these variables separately, we fitted three models by means of first-order linear regression. In Model 1 the relationship between train suicide rates (dependent variable) and general suicide rates (independent variable) was examined. In Model 2 the relationship between train suicide rates and train traffic intensity was investigated. In Model 3 we examined the relationship between train suicide rates (dependent variable) and general suicide rates and train traffic intensity as independent variables with multiple regression. In order to simplify Model 3, we formulated Model 4 which included the product of general suicide rates and train traffic intensity as a single regressor and where the regression line was forced through the origin. The fact that without train traffic no train suicides will occur justified the use of a regression model without intercept. The Models 1–4 were also run for gender-specific suicide rates. In order to investigate the quality of the models over the course of the 58-year study period, they were ascertained in three sub-periods separated by the “marker”-years 1970 and 1985. A multivariate adaptive regression spline (MARS) test confirmed the presence of conspicuous trend breaks around these years (Hastie et al, 2001). Model adequacy was checked by evaluating the residual plots and influence measures. We did not notice any serious violations of normality and homogeneity of variance, nor any significant outliers or influential points.

## **3. RESULTS**

### **3.1. Exploratory data analysis**

Visual inspection of the figures representing train suicide rates plotted against the scaled product of general suicide rates and train traffic intensity shows an overall good match of the trends in the two variables in the whole dataset (Fig.1a) over the 58-year time period. The same holds when gender differentiation is applied (Fig.1b,c). We noted some deviations of the observed train suicides rates from the values of the product of general suicide rates and train traffic intensity. In 1950–1970 train suicide rates were lower than expected, most pronouncedly so in women, but in 1985–1995 they were higher. Moreover, the rise in train suicide rates around 1970 seemed to occur a few years later than shown in the values of the product. Besides these differences, the good match in the period after 1989, with male and female train suicide rates displaying different trends, is particularly striking (Fig.1b,c).

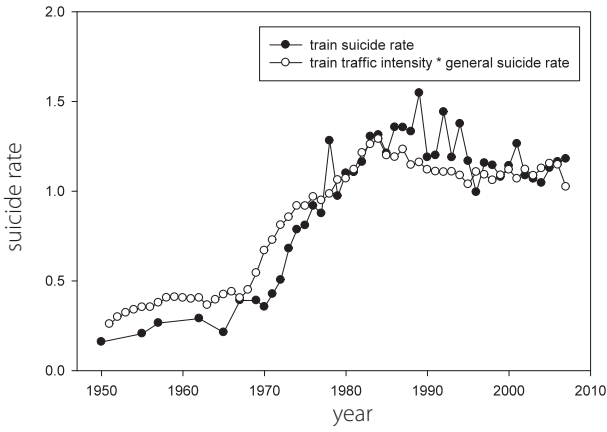


Fig. 1a

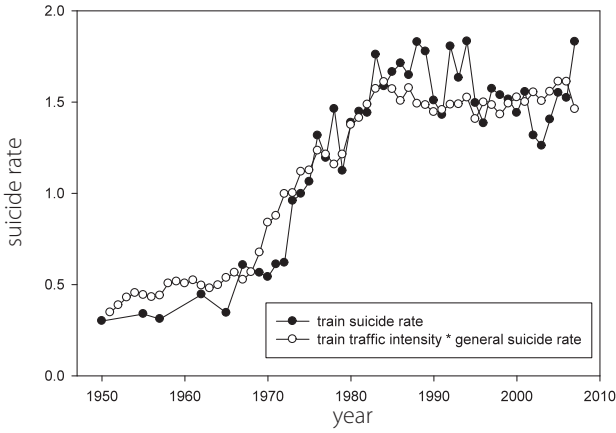


Fig. 1b

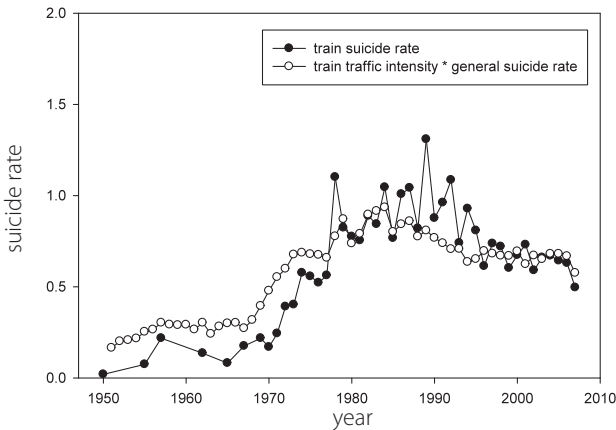


Fig. 1c

**Fig. 1.** Train suicide rates and the scaled product of train traffic intensity and general suicide rates in the Netherlands during 1950–2007. (a) Men and women; (b) men; and (c) women.

### 3.2. Regression analyses

The single-regression Model 2 (train traffic intensity, Adj.R<sup>2</sup>=0.824, s.e.= 0.190, df=55, P<0.001) had slightly better predictive power than Model 1 (general suicide rate, Adj.R<sup>2</sup>=0.753, s.e.= 0.228, df=56, P<0.001) for the period 1950–2007. The multiple regression Model 3, with general suicide rates and train traffic intensity, had significantly better performance than Models 1 and 2 (Adj.R<sup>2</sup>=0.938, s.e.= 0.113, df=53, P<0.001). Models 1–3 had in common that they showed a rather bad fit in the last sub-period of 1985–2007, a period characterised by conflicting trends in suicide rates and train traffic intensity and by substantial annual variations in male train suicide rates. The results for Model 3 are shown in Table 1. However, Model 4 with the product of general suicide rate and train traffic intensity as independent variable without intercept, had a very good fit in all three sub-periods for both men and women (Table 1). The quality of the fit of this model is consistent with the well-matching trends shown in Figures 1a-c.

**Table 1.** Summary of regression analyses predicting train suicide in the Netherlands in different time periods.

		1950–2007			1950–1969			1970–1984			1985–2007		
	Gen- der	Adj R <sup>2</sup>	s.e.	P	Adj R <sup>2</sup>	s.e.	P	Adj R <sup>2</sup>	s.e.	P	Adj R <sup>2</sup>	s.e.	P
Model 3 <sup>a</sup>	MF	0.938	0.113	0.00	0.716	0.034	0.00	0.854	0.120	0.00	0.261	0.117	0.03
	M	0.924	0.154	0.00	0.581	0.065	0.00	0.843	0.147	0.00	0.231	0.147	0.05
	F	0.871	0.126	0.00	0.309	0.038	0.04	0.706	0.150	0.00	0.481	0.139	0.00
Model 4 <sup>b</sup>	MF	0.972	0.156	0.00	0.977	0.040	0.00	0.969	0.168	0.00	0.989	0.128	0.00
	M	0.976	0.185	0.00	0.972	0.068	0.00	0.976	0.187	0.00	0.988	0.172	0.00
	F	0.926	0.171	0.00	0.905	0.039	0.00	0.932	0.182	0.00	0.950	0.181	0.00

<sup>a</sup> Independent variables: general suicide rate and train traffic intensity.

<sup>b</sup> Independent variable: general suicide rate \* train traffic intensity, through origin.

## 4. DISCUSSION

### 4.1. Main findings

This study investigated whether general suicide rates and train traffic intensity together provide a better explanation of train suicide rates than either of these variables on its own. This question was inspired by the separate findings that train suicide depends on general suicide rates and on train traffic intensity (Van Houwelingen et al, 2010; Van Houwelingen at al, submitted). Each of these variables separately was unable to explain the observed train suicide rates in the Netherlands between 1989 and 2007, when general suicides rates were declining and train traffic intensity continued growing.



When the period 1950–2007 was assessed as a whole, a regular multiple regression model with general suicide rates and train traffic intensity (Model 3) was superior to single-regression models using each of these variables separately (Models 1–2). However, Model 3 fell short in the last and more critical sub-period of 1985–2007. Model 4 turned out to be the best model. Although standardised errors were higher than in Model 3, the variance explained was slightly higher and the model performed well for all three sub-periods. To arrive at Model 4 we approached the analysis differently. This single-regression model with the product of general suicide rates and train traffic intensity as independent variable, forced through the origin, is based on the following concept: It presupposes that train suicide frequency is proportional to the general suicide rate, while the proportionality constant depends on the availability of the means to commit train suicide, independently of other means to commit suicide. If the proportionality factor were proportional to train traffic intensity, we would expect a perfect match between train suicide rates and the product of train traffic intensity and general suicide rates. Figures 1a-c show a nice correspondence, but no perfect match. There are several possible explanations for these differences. The lower train suicide rates in the period 1950–1970 and their later rise may be related to the practice of suicide by drowning. In this period suicides by drowning amounted to 19–24 % of all suicides. A steady decrease was observed after 1972 to 6 % in 2007 (Centraal Bureau voor de Statistiek). Domestic gas suicides may have contributed to lower train suicides rates too. Due to the detoxification of gas, gas suicides decreased from 24.5 % in 1960 to 0.5 % in 1970 with a most dramatic decrease in 1965–1966 (Clarke and Lester, 1989). A railway factor that should be mentioned is the conversion of gated level crossings to half-barrier level-crossings starting in 1959–1962, which might explain the lower values before 1960. We do not have a good explanation for the interference in the model that contributed to the overrepresentation of train suicides in the period 1985–1995.

#### **4.2. Gender**

Although more men than women commit suicide in this manner (M/F ratio 1.9) (Van Houwelingen et al, 2010), the Figures 1b and c and the outcomes of the regression analysis of Model 4 show no differences between men and women in the relationship between train suicide rates and the studied variables. This means that, relatively speaking, women use trains as means of suicide just as often as men do and that the M/F ratio is caused by different tendencies for suicide in men and women. The impact of the availability of trains, therefore, does not seem to be gender-specific.

#### **4.3. Limitations**

The independent variable general suicide rates included train suicide figures. In the concept behind Model 4 we did not want to evaluate the influence of other suicide methods on train suicide, but the influence of the national tendency for suicide as indicated by the general

suicide figures. Therefore, in the analyses, we chose not to separate the train suicides from the general suicides.

#### **4.4. Implications**

We found two factors influencing the incidence of train suicide: general suicide rates and train traffic intensity contribute to train suicide in a complementary way. An increase in train suicides is to be expected when overground railway systems evolve into timetable-free high-frequency means of mass transportation (Priority Decision. High-Frequency Rail Transport Programme, 2010). Determinants influencing the tendency for suicide in general in our society are of paramount importance. If collective efforts are to result in decreasing suicide rates for men and women, this type of developments may mitigate the effects of mobility growth. If, on the other hand, national suicide figures were to get worse, this might accelerate the expected increase of train suicides. In all scenarios it would seem necessary to reduce the availability of trains as a means for suicide by limiting access to the tracks.

