Predictors of Suicide and Suicide Attempt in Subway Stations: A Population-based Ecological Study

Thomas Niederkrotenthaler, Gernot Sonneck, Kanita Dervic,
Ingo W. Nader, Martin Voracek, Nestor D. Kapusta,
Elmar Etzersdorfer, Ellenor Mittendorfer-Rutz,
and Thomas Dorner

ABSTRACT *Suicidal behavior on the subway often involves young people and has a considerable impact on public life, but little is known about factors associated with suicides and suicide attempts in specific subway stations. Between 1979 and 2009, 185 suicides and 107 suicide attempts occurred on the subway in Vienna, Austria. Station-specific suicide and suicide attempt rates (defined as the frequency of suicidal incidents per time period) were modeled as the outcome variables in bivariate and multivariate Poisson regression models. Structural station characteristics (presence of a surveillance unit, train types used, and construction on street level versus other construction), contextual station characteristics (neighborhood to historical sites, size of the catchment area, and in operation during time period of extensive media reporting on subway suicides), and passenger-based characteristics (number of passengers getting on the trains per day, use as meeting point by drug users, and socioeconomic status of the population in the catchment area) were used as the explanatory variables. In the multivariate analyses, subway suicides increased when stations were served by the faster train type. Subway suicide attempts increased with the daily number of passengers getting on the trains and with the stations' use as meeting points by drug users. The findings indicate that there are some differences between subway suicides and suicide attempts. Completed suicides seem to vary most with train type used. Suicide attempts seem to depend mostly on passenger-based characteristics, specifically on the station's crowdedness and on its use as meeting point by drug users. Suicide-preventive interventions should concentrate on crowded stations and on stations frequented by risk groups.*

KEYWORDS *Transportation, Prevention, Subway, Suicide, Suicide attempt, Risk factors, Epidemiology, Poisson regression, Austria*

Niederkrotenthaler is with the Department of General Practice and Family Medicine, Center for Public Health, Medical University of Vienna, Vienna, Austria; Sonneck is with the Ludwig Boltzmann Institute for Social Psychiatry, Vienna, Austria; Dervic is with the Department of Psychiatry, Faculty of Medicine and Health Sciences, United Arab Emirates University, Al Ain, United Arab Emirates; Nader and Voracek are with the Department of Basic Psychological Research and Research Methods, University of Vienna, Vienna, Austria; Kapusta is with the Department of Psychoanalysis and Psychotherapy, Medical University of Vienna, Vienna, Austria; Etzersdorfer is with the Furtbachkrankenhaus, Hospital for Psychiatry and Psychotherapy, Stuttgart, Germany; Mittendorfer-Rutz is with the Department of Clinical Neuroscience, Division of Insurance Medicine, Karolinska Institutet, Stockholm, Sweden; Dorner is with the Department of Social Medicine, Center for Public Health, Medical University of Vienna, Vienna, Austria.

Correspondence: Thomas Niederkrotenthaler, Department of General Practice and Family Medicine, Center for Public Health, Medical University of Vienna, Vienna, Austria. (E-mail: thomas.niederkrotenthaler@meduniwien.ac.at)

INTRODUCTION

Subway suicides only account for a small minority of all suicides in urban areas, but there is concern about their impact on urban health because of their occurrence in public settings with direct or indirect exposure of many people to the suicidal incidents.¹ Persons who died by subway suicide have repeatedly been found to be younger than completed suicide cases in general, with most but not all studies suggesting a peak in the age group between 30 and 40 years,^{1–6} which means a considerable number of years of potential life lost. Subway suicides and suicide attempts do not seem to be equally distributed across subway stations. Factors such as the crowdedness of stations, the location of the station in the urban context as well as technical features of the trains have been discussed to impact on suicide and suicide attempt risk.¹ To date, there is no study available which provides multivariate testing of associations of potentially influential station characteristics with suicides and suicide attempts.¹

Categorization of Stations Characteristics

We categorized potentially influential station characteristics into structural station characteristics (that is, characteristics related to the construction and design of the station including the trains serving the station), contextual station characteristics (characteristics related to the location of the station in its urban context and to media reporting about subway suicides) and passenger-based characteristics (characteristics related to the individuals frequenting the station and/or to the population living nearby the station).

Structural Station Characteristics

A surveillance unit with on-site security personnel may allow for an early detection of deviant behavior on the subway platforms.^{1,7,8} To our knowledge, this is the first study to investigate possible differences of suicide and suicide attempt rates in stations, with and without surveillance units.

Furthermore, the train types used in a station have been hypothesized as an influential factor in the literature.^{1,9} Train types using electrified third rail power supply that causes severe electrocution in case of bodily contact as well as high train speed seem to impact subway suicide risk.^{1,9,10} In Vienna, two different train types have been operative since the opening of the subway system: the first train type (the so-called Silberpfeil—"Silver Arrow") uses third rail power supply and has a maximum speed of approximately 80 km/h (50 mph). The second train type is tramlike, which uses overhead power supply and has a lower maximum speed (60 km/h, 37 mph).

A further structural factor differentiating subway stations is their location on the street level versus underground construction or construction as an elevated railway above the street. Stations on the street level may be perceived as more readily accessible than other stations. Deviant behavior occurring in such stations may be harder to detect due to the generally smaller amount of video surveillance systems in these stations.⁷

Contextual Station Characteristics

A Canadian study showed that 70% of the individuals who died by subway suicide used the station closest to their place of residence.^{1,4} Based on this finding, there is some reason to hypothesize that the size of the catchment area, defined as the

distance to the nearest neighboring subway station, may impact on the frequency of suicidal behavior in a station.

A further potentially relevant contextual factor is the station's neighborhood to important historical sites. Historical sites have often been identified as hot spots of suicidal behavior, which may be due to the symbolic meaning and the public attention to such places attracting certain groups of suicidal individuals.^{11,12}

Also, media reporting on suicidal behavior in the subway has been shown to be associated with increases in this suicide method and seems to contribute to the attraction of a suicide site. Specifically, on the Viennese subway, there was a sharp increase of suicidal incidents between 1983 and 1987, which was a period of sensationalist media reporting about subway suicides.^{3,13,14} In 1987, a moratorium on the reporting of subway suicidal behavior was implemented. Suicidal behavior and media reporting decreased immediately afterwards and have remained at a low level up until today.¹⁵ Based on the extensive promotion of subway stations as suicide sites from 1983 to 1987 in the media, there may be a sort of "public memory" of subway stations that were once promoted as suicide sites, and suicidal individuals who plan a subway suicide may tend to select the few stations that "are publicly known" for suicide based on former media reporting. Both short-term copycat behaviors occurring in specific, often high-profile locations shortly after media reporting about suicidal behavior and long-term effects of media reporting on the force of attraction of suicide sites have been discussed in the literature.^{11,12}

Passenger-based Station Characteristics

Suicidal behavior has been discussed to increase with the crowdedness of a station in terms of station size and passenger flow.^{1,3,5} On the Montreal and New York subways, a considerable proportion of suicide cases was identified as drug users.^{1,4-6} Consequently, stations regularly frequented by drug users may have higher rates of suicidal incidents than other stations. There is currently no study available which compared the frequency of suicidal behavior in stations with and without local drug scenes.

A further passenger-based factor that may be relevant to suicidal behavior in specific stations is the socioeconomic status of a population living in the neighborhood of the subway station. Socioeconomic status in an area has often been found to be positively associated with total suicide and suicide attempt rates.¹⁶ For a tabulated overview of all hypotheses tested in the present study, see Table 1.

MATERIAL AND METHODS

Station Characteristics

Data on the presence of a surveillance unit in the station, the location on the street level versus other level, the stations that were open during the period of extensive media reporting and the train types operating in specific stations were obtained from Vienna Underground.¹⁷ These variables were coded as categorical variables.

Proximity of a station to a main historical site listed by Tourism Vienna was defined as a <3 minute walking distance from the subway station, as calculated with Google maps (maps.google.com), and was coded as a categorical variable. The distance to the nearest neighboring station was also calculated with Google maps and used as a continuous variable.

Subway operations (personal communication, Wiener Linien) provided us with information on the average number of passengers getting on the trains each day for

TABLE 1 Hypotheses on associations between station characteristics and suicide/suicide attempt

Type of station characteristics	Main hypotheses
Structural	Surveillance unit attached to a station is associated with lower rates of suicide and suicide attempt. The use of faster trains is positively associated with suicide. Construction on the street level is positively associated with suicide and suicide attempt.
Contextual	The distance to the nearest neighboring subway station is positively associated with suicide and suicide attempt. Proximity to historical sites is positively associated with suicide and suicide attempt. Operating in the years of extensive media reporting is positively associated with suicide and suicide attempt.
Passenger-based	The average number of passengers getting on the trains per day is positively associated with subway suicide and suicide attempt. Use by local drug scene is positively associated with suicide and suicide attempt. Socioeconomic status of the population in the station's neighborhood is positively associated with suicide and suicide attempt.
	Supplemental hypotheses
Structural	The proportion of suicide completion in suicidal behavior (lethality) is higher in stations with faster trains than in stations with tramlike trains.
Passenger-based	Suicide and suicide attempts per rider are higher in more crowded stations than in less crowded stations. ^a

^aCrowded stations were defined as stations with average daily access numbers above the mean value of all stations, less crowded was defined as access numbers below the mean

each station in the years 1993 and 2009 (Mr. Hermann Walter, e-mail, May 2010). The counts in 1993 and 2009 were highly correlated (Pearson's $r=0.91$). Based on this finding, we used the continuous data from 2009 in the analyses.

Data on the local drug scenes at specific subway stations were obtained from the Ludwig-Boltzmann Institute for Addiction Research for the year 1996, from the Viennese Drug Coordination for the years 2003 to 2005 and from Street Work Vienna for the year 2007.^{18–20} Each station that was mentioned in at least one of these reports as being frequented by a drug scene was coded as a meeting point of a drug scene.

A classification of the 23 Viennese districts into four classes with low to high socioeconomic status was obtained from the Austrian Geographic Society.²¹ This classification was based on the educational and occupational levels of the population and the proportion of citizens from the European Union in the year 2001. The classification results have been reported to be very stable over time (Pearson correlation of classification in 2001 with 1991: $r=0.97$).²¹

Data on Subway Suicides and Suicide Attempts

Data on the type and date of the suicidal incident, name of the subway station where the suicide or suicide attempt occurred, and sex and age of the individuals were

obtained from the subway operator for the whole observation period (1979 to 2009). Suicide attempt was defined as a nonlethal act with suicidal intent as confirmed in the police report, which involved jumping, lying, or standing in front of the subway with subsequent collision and bodily injury. Incidents without any injury were not registered as suicide attempts. Completed suicide was defined as any such act with lethal outcome. The corresponding codes in the International Classification of Diseases (ICD) were E9580 (ICD-9) and X81 (ICD-10).

Statistical Analysis

Station-specific suicide rates and suicide attempt rates were modeled in bivariate and multivariate Poisson regression models. The rates were defined as the suicides/suicide attempts per linemonths. Linemonths were defined as the station-specific time span the subway has been operative since its opening up until the end of the observation period (December 31, 2009), summed up for all lines operating in the station. For example, if subway line A has operated for a total of 36 months in a particular station up until December 2009 and subway line B has operated for 12 months, the number of linemonths would be 48 for the station. In Poisson regression, the use of rates as a dependent variable is handled using offset variables. The station-specific counts of suicides/suicide attempts were used as dependent variables, and the log (linemonths) was used as the offset variable. The parameter estimates were converted into relative risks by taking exponents. Data on the opening (and closing) dates for all stations and subway lines were obtained from the subway operator.

Two covariates were designed to control for changes in the subway system over time: first, we introduced a covariate to control for the changing frequencies of total suicidal behavior on the subway system over time. Some stations have predominantly been operative in times of low total suicide/suicide attempt rates, and others operated in years with higher frequencies of subway suicides or suicide attempts. The station-specific covariate controlling for this time trend was defined as the frequency of total subway suicides/suicide attempts per operative year.

A second covariate was introduced to control for the total number of stations operating at the same time as the respective individual station. It seems plausible to assume that newer stations have lower suicide and suicide attempt rates than older ones because of the increasing total number of stations over time. This covariate was defined as the total number of stations per operative year.

Associations of suicide rates and suicide attempt rates with explanatory variables were tested in three different Poisson regression models. First, only the dependent and one explanatory variable each were entered into the model (crude analysis). Second, this crude model was extended to include the two covariates described above (adjustment for total subway suicides and number of operative stations). Third, all explaining variables and the two covariates were used in a single multivariate model (full adjustment).

Because of underdispersion in the suicide attempt data, variance estimates were corrected using dispersion factors estimated from the data, which has the effect of narrowing confidence intervals in underdispersed models. Parameter estimates remain unaffected by this procedure.²² Likelihood ratio test Chi-squared statistic was used to determine the overall significance of the fully adjusted models.

Two supplemental hypotheses on the association of station characteristics with suicidal behavior which were deemed important to gain a more detailed insight into any associations identified in the regression models were tested with

independent groups *t*-test for unequal variances (Welch’s test, see Table 1 for supplemental hypotheses).

Data analysis was performed with PASW Statistics 17. The study was approved by the Research Ethics Committee at the Medical University of Vienna, Austria.

RESULTS

An overview on the age and sex of suicide cases and suicide attempters and of the frequencies of assessed station characteristics is shown in Tables 2 and 3, respectively. Most explanatory variables were not substantially intercorrelated. Moderate intercorrelation occurred between the variables “crowdedness of a station” and “use as meeting point by drug users”: (Pearson’s $r=0.50$, $N=84$, $p<0.001$).

Subway Station Characteristics Associated with Subway Suicides and Attempts

Completed Subway Suicide In the crude analyses, subway suicide rates were positively associated with the presence of a surveillance unit, with the use of the faster train type, and with the station operating in the period of extensive media reporting of subway suicide. Further, suicides increased when the station was used as a meeting point by drug users and with the number of passengers getting on the trains per day (Table 3).

After adjustment for the frequency of total suicides and total number of operative stations, the presence of a surveillance unit, the use of the faster train type, and the number of passengers getting on the trains per day remained positively associated with subway suicide rates (Table 3).

After full adjustment, only the use of the faster train type remained positively associated with suicide rates (Table 3). The overall model was statistically significant with likelihood ratio Chi-square=39.02, $df=13$, yielding a p -value<.001.

The proportion of completed suicide in total suicidal behavior was higher in stations served by the faster train type ($M=0.67$, $SD=0.29$) than in other stations ($M=0.42$, $SD=0.37$; $t(14.17)=2.23$, $p=0.043$).

There was no significant difference in the number of completed suicides per riders in more crowded stations ($M=0.15$, $SD=0.13$) compared to less crowded stations ($M=0.14$, $SD=0.21$; $t[82]=-0.30$, $p=0.76$).

TABLE 2 Suicides and suicide attempts on the Viennese subway and total suicides, 1979–2009

Characteristics of suicides		Subway suicide attempts ($N=107$)		Completed subway suicides ($N=185$)		Total completed suicides in Vienna ($N=10,319$)	
		<i>N</i>	Proportion	<i>N</i>	Proportion	<i>N</i>	Proportion
Sex	Male	62	0.58	132	0.71	6,660	0.65
	Female	45	0.42	53	0.29	3,659	0.35
Age group ^a	<30	40	0.37	58	0.34	1,601	0.16
	30–64	45	0.51	99	0.58	5,464	0.53
	>64	4	0.04	13	0.08	3,254	0.31

^aFor 15 (8.1%) of completed suicides and for nine cases (8.4%) of suicide attempt, the information on age was missing

TABLE 3 Associations of station characteristics with subway suicide rates

Station characteristics	N (%) / mean (SD) ^a	(A) Crude RR (95 CI) ^b	(B) First adjustment RR (95 CI)	(C) Full adjustment RR (95 CI) ^c
Structural				
Surveillance unit present	16 (19.0)	1.65 (1.21, 2.22)	1.44 (1.03, 1.99)	1.44 (0.90, 2.27)
No surveillance unit (Ref.)	68 (81.0)	1	1	1
<i>p</i> -Value		0.001	0.031	0.13
Fast train type used	64 (76.2)	3.10 (1.81, 5.89)	2.42 (1.32, 4.80)	3.53 (1.57, 8.37)
Tramlike train type used (Ref.)	20 (23.8)	1	1	1
<i>p</i> -Value		<0.001	0.004	0.002
Not street level	57 (68.8)	1.37 (0.98, 1.95)	1.34 (0.96, 1.91)	1.01 (0.64, 1.60)
Street level (Ref.)	27 (31.2)	1	1	1
<i>p</i> -Value		0.08	0.09	0.97
Contextual				
Next to historical sites	8 (9.5)	1.11 (0.76, 1.58)	0.88 (0.59, 1.27)	0.71 (0.44, 1.11)
Not near sites (Ref.)	76 (90.5)	1	1	1
<i>p</i> -Value		0.59	0.50	0.13
Distance nearest other subway station (km)	0.89 (0.69)	0.99 (0.81, 1.17)	0.90 (0.73, 1.08)	0.82 (0.65, 1.01)
<i>p</i> -Value		0.92	0.28	0.06
Passenger-related				
Time period of media reporting	35 (41.7)	1.82 (1.30, 2.59)	1.14 (0.44, 3.00)	0.34 (0.08, 1.40)
No media reporting	49 (58.3)	1	1	1
<i>p</i> -Value		0.001	0.79	0.14
Passengers getting on trains per day (in thousands)	15.9 (11.1)	1.02 (1.01, 1.03)	1.01 (1.003, 1.02)	1.01 (0.99, 1.02)
<i>p</i> -Value		<0.001	0.015	0.37
Presence of drug scene	30 (35.7)	1.49 (1.11, 2.03)	1.17 (0.84, 1.66)	1.11 (0.71, 1.74)
No presence of drug scene (Ref.)	54 (64.3)	1	1	1
<i>p</i> -Value		0.009	0.36	0.66
Lowest socioeconomic status in district (level 1)	20 (23.8)	0.78 (0.51, 1.16)	1.00 (0.64, 1.55)	1.58 (0.85, 2.91)
Socioeconomic status Level 2	25 (29.8)	0.61 (0.38, 0.92)	0.77 (0.48, 1.21)	1.22 (0.67, 2.19)
Socioeconomic status Level 3	5 (6.0)	0.84 (0.44, 1.45)	0.92 (0.47, 1.66)	1.35 (0.61, 2.84)

TABLE 3 (continued)

Station characteristics	N (%) ^a /mean (SD) ^a	(A) Crude RR (95 CI) ^b	(B) First adjustment RR (95 CI)	(C) Full adjustment RR (95 CI) ^c
Highest socioeconomic status (level 4) (Ref.)	34 (40.5)	1	1	1
<i>p</i> -Value [*]		0.11	0.71	0.53

CI confidence interval, RR relative risk
^{*}*p*-Value (statistical significance; two-sided)
^aN (%) is given for categorical variables, arithmetic mean and standard deviation (SD) for continuous variables
^bAdjusted for frequency of total subway suicides per operating year and number of total stations on the system per operating year
^cAdditionally adjusted for all other explanatory variables

Attempted Subway Suicide In the crude analyses, subway suicide attempt rates were positively associated with the presence of a surveillance unit, with the neighborhood to historical sites, with the station operating in the period of extensive media reporting of subway suicide and with the station's use as a meeting point by drug users. Furthermore, suicide attempts increased with the number of passengers getting on the trains per day (Table 4).

After the first adjustment step, the presence of a surveillance unit, the use as a meeting point by drug users and the number of passengers getting on the trains per day remained positively associated with suicide attempts (Table 4). After full adjustment, stations used as meeting point by drug users and the number of passengers getting on the trains per day were positively associated with suicide attempt rates (Table 4). The overall model was statistically significant with likelihood ratio Chi-square=41.42, df=13 yielding a p -value<0.001. There was no significant difference in the number of suicide attempts per riders in more crowded stations ($M=0.08$, $SD=0.07$) compared to less crowded stations ($M=0.08$, $SD=0.14$; $t(81.06)=0.24$, $p=0.81$).

Power Analysis The fully adjusted Poisson regression model for completed suicides achieves 36%, 95%, and 100% power at the 0.05 significance level to detect a small (relative risk [RR]=1.2), medium (RR=1.9), and large (RR=3.0) effect, respectively, due to a change in a binomial independent variable with proportion 0.25 (positive in 16 and negative in 64 cases, as it is the case for the variable surveillance unit).²³ For attempted suicide, the respective power values are 26%, 81%, and 100%, respectively. These values indicate that the power is acceptable for the detection of medium to large effects but too low for small effect sizes.

DISCUSSION

Train Types Serving the Station

Completed suicide was associated with the train type used, which is in accordance with earlier related literature.^{1,9,10} Also, the proportion of completed suicide in total suicidal behavior (as a measure of lethality) was greater in stations served by the faster train type. The two train types used in Vienna vary with regard to the type of power supply (third rail versus overhead power supply), with regard to their maximum speed (50 mph versus 37 mph) and with regard to the required braking distance. All these technical differences show that the so-called Silver Arrow is the more powerful and potentially more dangerous train type. However, it remains unclear from this study which technical difference may explain the identified association. Since there was not a single case of suicide or suicide attempt by electrocution due to bodily contact with the electrified third rail of the faster train type in the observation period, the use of third rails can be ruled out as an explanatory factor of the association. Rather, the higher train speed together with the slightly longer braking distance may explain the higher number of suicides in stations served by the Silver Arrow train type and the higher lethality compared to stations served by tramlike trains. Interestingly, suicides have been shown to be generally much less common for tramways than for subways.²⁴ It has been suggested that people "show less respect for tramways than for other types of transport," which may explain the higher frequency of unintentional injuries with tramways.²⁵ For subway suicide, which has been described as a highly aggressive

TABLE 4 Associations of station characteristics with subway suicide attempt rates

Station characteristics	N (%) / mean (SD) ^a	(A) Crude RR (95 CI) ^b	(B) First adjustment RR (95 CI)	(C) Full adjustment RR (95 CI) ^c
Structural				
Surveillance unit present	16 (19.0)	1.93 (1.30, 2.84)	1.76 (1.16, 2.66)	1.15 (0.65, 2.01)
No surveillance unit (Ref.)	68 (81.0)	1	1	1
<i>p</i> -Value [*]		0.001	0.008	0.62
Fast train type used	64 (76.2)	1.55 (0.90, 2.90)	1.03 (0.51, 2.13)	1.09 (0.45, 2.73)
Tramlike train type used (Ref.)	20 (23.8)	1	1	1
<i>p</i> -Value [*]		0.12	0.94	0.84
Not street level	57 (68.8)	1.54 (0.98, 2.53)	1.53 (0.97, 2.51)	0.86 (0.49, 1.53)
Street level (Ref.)	27 (31.2)	1	1	1
<i>p</i> -Value [*]		0.06	0.07	0.60
Contextual				
Next to historical sights	8 (9.5)	1.78 (1.14, 2.69)	1.49 (0.94, 2.32)	1.35 (0.78, 2.32)
Not near sights (Ref.)	76 (90.5)	1	1	1
<i>p</i> -Value [*]		0.012	0.09	0.29
Distance nearest other subway station (km)	0.89 (0.69)	1.17 (0.95, 1.38)	1.09 (0.88, 1.31)	1.09 (0.85, 1.38)
<i>p</i> -Value [*]		0.13	0.40	0.49
Time period of media reporting	35 (41.7)	1.71 (1.11, 2.70)	0.83 (0.26, 2.63)	1.06 (0.20, 5.42)
No media reporting	49 (58.3)	1	1	1
<i>p</i> -Value [*]	35	0.014	0.75	0.95
Passengers getting on trains per day (in thousands)	15.9 (11.1)	1.03 (1.02, 1.04)	1.03 (1.02, 1.04)	1.02 (1.002, 1.04)
<i>p</i> -Value [*]		<0.001	<0.001	0.030
Presence of drug scene	30 (35.7)	2.56 (1.68, 4.04)	2.38 (1.48, 3.90)	2.20 (1.24, 3.94)
No presence of drug scene (Ref.)	54 (64.3)	1	1	1
<i>p</i> -Value [*]		<0.001	<0.001	0.008
Lowest socioeconomic status in district (level 1)	20 (23.8)	0.68 (0.37, 1.18)	0.85 (0.45, 1.51)	1.00 (0.44, 2.18)
Socioeconomic status Level 2	25 (29.8)	0.87 (0.51, 1.41)	1.08 (0.62, 1.81)	1.39 (0.69, 2.76)

Socioeconomic status Level 3	5 (6.0)	0.88 (0.37, 1.79)	0.92 (0.38, 1.91)	2.08 (0.82, 4.77)
Highest socioeconomic status	34 (40.5)	1	1	1
(level 4) (Ref.)				
<i>p</i> -Value [*]		0.59	0.92	0.34

CI confidence interval, *RR* relative risk
^{*}*p*-Value two-sided
^a*N* (%) is given for categorical variables, arithmetic mean, and standard deviation (SD) for continuous variables
^bAdjusted for mean count of suicide attempts per operating year and the mean number of total stations on the system per operating year
^cAdditionally adjusted for all other explanatory variables

suicide method involving a deep “wish to be murdered or overwhelmed,” the reasoning may be the other way round.²⁶ The different train appearance, together with the outlined technical differences, may influence individuals who intend to die by subway suicide to choose the faster train type. Of note, differences with regard to behavior patterns shown in subway suicides and suicide attempts have repeatedly been discussed in the literature. In particular, on the Viennese subway, completed suicides have been described to be typically carried out at the beginning or in the middle of the platform, which may indicate a more pronounced intent to die in suicide cases compared to suicide attempters.³

Crowdedness of Stations

A finding, in accordance with earlier studies, is that the station's size in terms of crowdedness was associated with suicide attempt rates. Similar results were shown for suicides and suicide attempts on the London subway and for suicide attempts on the Toronto subway.^{27,28} In the present multivariate models, the association remained only significant for suicide attempts, supporting an assumption made earlier that the station's crowdedness may be a particularly relevant factor in subway suicide attempts.³ However, when suicide attempts per riders were considered, there was no preference of crowded stations compared to other stations. Suicide attempts seem to increase with the number of passengers in a station, but still, there is no overrepresentation in terms of suicide attempters per riders in crowded stations. Therefore, there is no clear indication from the present study that crowdedness is a factor relevant to the choice of a station as a suicide attempt site, which would probably be reflected in an overrepresentation of suicide attempts per riders in crowded stations. The dose-response relationship between suicide attempts and number of riders may rather reflect the higher likelihood of a suicide attempt to occur in a larger crowd of individuals. With regard to completed suicide, the number of riders does not seem to explain the frequency of incidents in a station in the fully adjusted models. However, cautious interpretation is required regarding the lack of a significant association between completed suicide and passenger counts due to the relatively low statistical power of the adjusted analysis. Studies using larger sample sizes are needed to further investigate this question.

Presence of a Drug Scene

Earlier findings showed a high prevalence of psychiatric illness and substance use in subway suicide cases.^{1,4-6} The present study adds that both suicides and suicide attempts were associated with the presence of a drug scene in the station. The relative risk estimates were considerably higher for suicide attempts than for completed suicide and remained only significant for suicide attempts when controlling for other potentially influential factors. Of note, drug users who frequent the street drug scene, particularly subway and train stations, are not representative of drug users in general and more frequently socially disintegrated, unemployed, polydrug using and injecting drugs.^{18,19} A study from Australia found that violent methods were frequent in injecting and often polydrug-consuming cocaine users, accounting for approximately 22% of suicide attempts in this group.²⁹ This finding is divergent for drug users in general, who have repeatedly been shown to use poisoning as the most frequent method for suicide and suicide attempt.^{29,30}

Based on the generally considerably higher risk of suicide (and suicide attempt) in drug users compared to the general population and the relatively high proportion of injecting drug users among those who frequent the street drug scenes in subway

stations, the association between suicide attempt and the station's use as a meeting point by local drug scenes may reflect the presence of risk groups in those stations, which warrant specific attention from public health services.^{18–20} Individual data from interviews with suicide attempters and autopsy toxicology are needed to further investigate the association between drug use and suicidal behavior on the subway.

Further Noteworthy Findings

The direct association of subway suicides and suicide attempts with the presence of a surveillance unit in the crude analyses does not support hypotheses on a protective effect of surveillance units on suicidal behavior.^{1,31} However, it does not disprove a protective effect either, and suicide and suicide attempt rates may be even higher in the absence of such units. Of note, surveillance units in Vienna have not been built as a reaction to suicide or injury problems in specific stations, but were generally opened at the same time as the respective station. Consequently, it can be ruled out that the association was present in the crude analysis only due to higher counts of suicidal behavior before the opening of the surveillance units but not afterwards. An in-depth analysis about how these surveillance units may most effectively contribute to suicide prevention is warranted in the Viennese context. At present, surveillance officers in the Viennese subway do not receive specific training in suicide prevention or violence prevention (Wiener Linien, oral communication, April 2011). The tasks of officers involve the use of a video surveillance system and the conduction of security patrols in the station area to prevent waste contamination of the station, to provide help in medical emergencies and to help control and/or prevent violent or criminal behaviors. They also serve as contact persons for passengers who have concerns or questions. In the case of an emergency, the officers are able to initiate an emergency braking of incoming or outgoing trains and to make public announcements to the passengers on the platforms (Wiener Linien, oral communication, April 2011).

The direct association of stations operative in the period of extensive media reporting on subway suicide with suicide and suicide attempt rates in the crude analyses diminished after introducing covariates into the models, particularly due to the effect of adjusting for the total prevalence of suicides and suicide attempts across stations. This finding indicates that there was no “public memory” of specific stations reported as suicide spots in the media which persisted after the stop of media reporting.^{3,11,15}

Strengths and Limitations

The most important strength of the present study is its focus on a wide set of station characteristics that may impact on suicidal behavior. Changes in the subway system over time, in terms of increasing number of stations and changing frequencies of total suicides and suicide attempts, were taken into account in the assessment of associations of station characteristics with suicidal behavior.

The present study also has several limitations. The ecological design does not allow establishment of causality, but provides a framework for the formulation of new and more fine-grained hypotheses related to the effects of station characteristics on suicidal behavior. Several variables, most importantly, the crowdedness of stations and the station's function as meeting points for drug users, were assessed at two and three points in time, respectively. A more frequent assessment was not possible due to the lack of data. For the crowdedness of stations, the strong correlation of passenger counts in the years 1991 and 2000 ($r=0.91$) indicates high

stability of this variable between 1990 and 2000. Nevertheless, substantial variations particularly for the time periods before 1990 and after 2000 may result in biased estimates. Concerning the assessment of stations used as meeting points for drug users, data before 1996 was not available. The Viennese drug scene was relatively compact up until approximately 1985 and has spread across more stations in the decades that followed.¹⁸ It seems likely that most stations which have ever been major meeting points by drug users were identified for the present study, but still, the identified subway stations can neither be considered of constant importance over time nor of equal importance in terms of the size of the drug scenes and in terms of drug types present. Also, it was not possible to obtain data on toxicological analyses in subway suicide and suicide attempt cases, which would be necessary to assess individual drug consumption. Due to the relatively small power to detect small effects, we cannot rule out that variables not significantly associated with suicidal behavior may have a small effect. Finally, it was not possible to test all of the hypotheses on structural station characteristics that have been discussed in the literature. Most importantly, the finding that proximity to psychiatry facilities is associated with suicidal behavior could not be tested in the Viennese sample because there is only one psychiatric facility built in the neighborhood of a subway station.²⁷

CONCLUSION

As witnessed in many other urban areas, subway suicide cases on the Viennese subway were younger than suicide cases in general, often below 30 years of age (Table 2). The train types used, the crowdedness of stations and the presence of risk groups such as drug users seem to be the most important factors related to suicidal behavior by jumping in front of subway trains. Suicides seem to vary most with train type used, whereas attempted subway suicide seem to be closely associated with stations' crowdedness and the presence of drug users. Suicide preventive measures should, therefore, focus on the safety of train types and on crowded stations as well as on risk groups such as drug users in subway stations.

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