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THE EPIDEMIOLOGY OF SUICIDE ON THE LONDON UNDERGROUND

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Abstract—A database containing details of every incident of suicidal behaviour on the London Underground railway system between 1940 and 1990 was assembled from the records of London Underground Ltd and the British Transport Police. The total number of cases was 3240. The mean annual number of suicidal acts on the London Underground system increased from 36.1 (1940–1949) to 94.1 (1980–1989). There were significantly fewer incidents on Sundays than on the other days of the week and the daily rate was highest in the spring. 64% of incidents involved males and the peak age group for both sexes was 25–34 yr. Suicide verdicts were returned for a greater proportion of women than men. Overall case fatality was 55%. However, case fatality rates differed between stations, environmental factors appearing to influence survival. Possible strategies to prevent railway suicides and reduce the lethality of this method are discussed.

Key words—suicide, underground, railway, prevention

INTRODUCTION

The London Underground is the oldest and most extensive metro system in the world. The first line was opened in 1863 and transported passengers, in carriages pulled by steam locomotives, along the 6 km between Paddington and Farringdon. Lines were electrified in the early 1900s. The present system comprises 273 stations on 10 lines covering 408 km of track, 169 km of which are underground. In 1989 the system carried 815 million passengers [1].

Suicide has been a problem for London's railways since their early years. In 1886 the phenomenon was sufficiently well recognised to elicit the remark that suicide on the railways had, "... only of late years come into use, but [was] now on the increase" [2]. Between 1873 and 1883 suicides on railways accounted for 2.4% of all male suicides and 0.8% of female suicides in England and Wales (1.9% of overall suicide mortality). A greater proportion of railways servants (17%) than any other occupational group took their own lives using this method [2].

From the 1870s to the 1900s the number of suicides on railways increased substantially. In 1909 there were 183 fatal incidents (156 men and 27 women). This represented 5.8% of all male suicides and 3.0% of female suicides [3].

It has been suggested that the railway became popular as a method of suicide only when people learned to perceive it as such [3]. This did not happen immediately. In fact railways had covered England for half a century before they became a significant mode of self-destruction. An analysis of suicide in Victorian and Edwardian England identified the year of 1868 as crucial in creating the public perception of the railway as a potential method of self-destruction. "In that year a total of 20 men threw themselves under trains, as the newspapers reported in some detail, and suddenly this became the fashionable method" [3].

The increasing incidence of suicidal behaviour on railways also appeared to be associated with the steadily increasing availability of this method. Durkheim [4] stated 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". An analysis of the 10,000 suicides which occurred on railways in England and Wales between 1850 and 1949 found support for this claim [5]. Both the number of miles of track on the developing railway system and the number of passengers carried were positively correlated with the number of railway suicides. The number of passengers appeared to be the better predictor.

It is impossible to obtain detailed information on suicide and accidental death on British railways for the first half of this century. Although the Railway Regulation Act 1873 s.5 requires Coroners to provide the relevant state body (the Railway Inspectorate) with details of persons killed or injured on the railways the Inspectorate's archives for the period up to 1964 are incomplete.

Since 1964 full records are available. These reveal that the total number of persons (excluding staff) killed under trains in England and Wales increased steadily from an annual mean of 204 in the 1960s to 315 in the 1980s. Coroners consistently returned suicide verdicts in almost two-thirds of these cases (Table 1). The increase in the mean annual number

Table 1. Mean numbers of deaths in movement accidents on railways in England and Wales

Year	Annual mean	Suicides only	% Suicide
1964–69	204	129	63
1970–79	259	167	64
1980–89	314	179	57

The annual mean comprises suicides plus trespassers.
Source: Railway Inspectorate Annual Reports.

of suicides between 1964–1969 and 1980–1989 was approx. 40%.

The figures in Table 1 underestimate the extent of the problem presented by suicidal behaviour on railways since they refer only to fatalities which are officially recorded as suicides. Many railway deaths which would be considered suicides in a medical/psychological sense cannot be so certified by Coroners' juries due to the high standard of proof required. Thus open verdicts ("injury undetermined whether accidentally or purposefully inflicted") or verdicts of accidental death or death by misadventure are returned in many such cases. Accidental deaths and deaths by misadventure are recorded under the single category of 'Accidental Death' by the Office of Population Censuses and Surveys (OPCS). Also a large proportion of suicidal acts on metros are not fatal [6, 7]. The high survival rate and problems in death certification are discussed in more detail below.

Suicide and attempted suicide affect almost all railway systems [6, 8]. However there have been few investigations of strategies for their prevention despite the costs in terms of personal injuries and deaths, delays to the service and the psychological trauma suffered by witnesses to the act, especially train drivers.

The aim of this study was to contribute to the descriptive epidemiology of suicidal behaviour on railways and to investigate strategies which might prevent suicide by this method or reduce case fatality rates.

MATERIALS AND METHODS

Definition of caseness

For the purposes of this study an incident of suicidal behaviour was defined as any case of a person falling or jumping in front of a moving London Underground Ltd (LUL) train, regardless of outcome; OR any case of a body found on the tracks which had injuries consistent with having been struck by a train; OR any incident involving a person on the tracks while a train was not present which caused a delay to LUL services or whose behaviour resulted in the attention of the British Transport Police (BTP).

This definition was designed to maximise reliability. It left little room for discretion on the part of the data collector. No attempt was made at the data collection stage to attribute motives to persons involved in incidents. It was assumed that the vast majority of these incidents would be deliberate acts.

Some of the cases which satisfied our definition at first sight appeared ambiguous. However, on closer scrutiny it became clear that their inclusion was valid. For example, a man was found in a tunnel when the train stopped short of hitting him. He claimed to have been urinating and was escorted to the platform by the driver. Later the same night he was found on the tracks at another station. A woman over whom a train had passed without causing any injury claimed to have fallen. BTP inquiries revealed that she had left her house that evening after a row with her boyfriend having stated that she was going to kill herself. A woman struck by a train claimed that her heel had broken and that she had fallen onto the track. However, the train driver reported that he had seen her run from a connecting passage, crouch down and hurl herself in front of the train.

It was hypothesised that this definition would include all recorded suicides and suicide attempts without too many false positives (incidents that did not involve suicidal behaviour). It also excluded obvious accidents such as passengers caught in the doors and dragged along the platform; passengers struck by the train while bending down to pick up luggage from the platform; passengers struck while looking over the platform edge at something on the track; passengers who ran to board the train and fell between the carriages. Such accidents are a feature of most busy subway systems.

Sources of data

Information concerning cases which satisfied this definition was gathered from two sources.

The Railway Operations and Passenger Services departments of LUL keep records of all events which result in a delay to the service. The reason for the delay is listed (for example, 'signal failure', 'fire', 'person under train'). The following information was gathered for all incidents concerning 'persons under trains' which satisfied the operational definition of an act of suicidal behaviour: date, time and location of incident, sex of victim (only available after 1950), immediate outcome (dead/alive) and the delay to scheduled services. These data were collected for all such incidents which occurred between 1940 and 1990 ($n = 3240$).

Information regarding the age, inquest verdict and details of persons who were removed alive from the tracks but died later were obtained from the BTP registers which have been maintained by the Coroners' Liaison Officer, since 1975 ($n = 1500$). These data served to validate and supplement the original database.

To test the validity of the definition a 5 yr sample of detailed case files was scrutinised. These files are maintained by the BTP and typically contain statements from the train driver and guard; independent witnesses to the event; and the victim's next of kin. These files also include the BTP and LUL incident reports and a brief summary of the inquest

proceedings. All available case files for incidents occurring between 1985 and 1989 were examined ($n = 409$).

Unusually among suicide methods there is normally at least one witness to LUL incidents. Events where a train runs over a body without the driver or a passenger noticing are rare. Thus by examining witness statements and other documentary evidence it was possible to ascertain whether or not an event was likely to have been deliberate.

Of the cases examined only 7% could be ruled out as definite accidents on the basis of these witness statements. The remainder (93%) were considered to be deliberate acts. Accidents differed from other incidents in that they were more likely to involve alcohol (57% compared to 8%) and men (80% compared to 64%). 17% of accidents involved drunk men of no fixed abode. The number of accidents was so small that it did not distort the overall picture.

To summarise therefore, it was assumed that all incidents of persons under trains which satisfied the operational definition would be deliberate acts. Information was collected accordingly. Over 400 cases were then examined in detail. The validity of our definition was considered to be acceptable.

Information concerning the demographic and psychiatric characteristics of victims of suicide and attempted suicide on the London Underground system has been collected through interviews with survivors of LUL suicide attempts and attendance at the Coroners' inquests held after each fatality. These data are not presented here but will be the focus of future reports.

RESULTS

The data collected were analysed within the following three main categories, each of which is dealt with in turn:

- Time
- Place
- Factors affecting outcome

1. Time

Secular trends. The mean annual number of suicidal acts on the London Underground increased from 36.1 (SD = 14.29) between 1940 and 1949 to 94.1 (SD = 11.03) in the period 1980 to 1989. A 3-yr moving average of annual incidence is shown in Fig. 1. Least squares linear regression analysis showed the upward trend in Fig. 1 to be statistically significant ($R^2 = 0.78$; $P < 0.001$; $r = 0.88$). The mean annual increase since the 1960s was 175%, a far greater rise than that observed for suicides on railways nationwide over the same period.

Monthly and seasonal variation. The distribution of incidents by month is detailed in Table 2. To test the null hypothesis that the daily suicide rate did not differ across months it was assumed that this rate was constant and the estimated expected values were calculated for each month according to Haberman's method for testing seasonal variations in suicide rates [9]. This method is based on the Poisson distribution, a classical probability distribution for frequency counts.

The result in Table 2 suggests that the daily rate was not constant across months. To investigate whether the observed variation was seasonal the year was divided into four portions according to the four

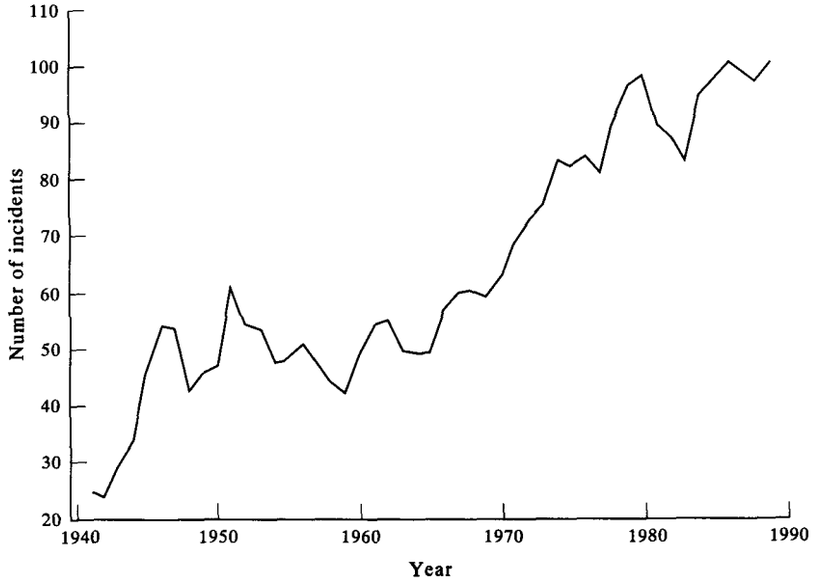


Fig. 1. Suicidal acts on the London Underground. Three-year moving average.

Table 2. Distribution of incidents by month

Month	Number	Estimated expected number	Residual
January	237	275.2	−38.2
February	259	248.5	10.5
March	336	275.2	60.8
April	253	266.3	−13.3
May	309	275.2	33.8
June	282	266.3	15.7
July	278	275.2	2.8
August	232	275.2	−43.2
September	274	266.3	7.7
October	249	275.2	−26.2
November	285	266.3	18.7
December	246	275.2	−29.2
Total	3240		

$\chi^2 = 38.94$, 11 *df*, $P < 0.001$.

seasons. Seasons were defined as 3-monthly periods, winter including December, January and February and so on.

The average rate of suicides per day was calculated for each season as follows: winter = 0.162; spring = 0.191; summer = 0.169; autumn = 0.174. The data were reanalysed according to a model which assumed constant rates within seasons [9]. It was concluded that the suicide rate on the London Underground system was highest in spring but that suicide rates were not constant within seasons ($\chi^2 = 25.5$, 8 *df*, $P < 0.001$).

Day of week. Absolute daily numbers of incidents and daily rates are shown in Table 3. The suicide rate for each day of the week was calculated by dividing the total number of incidents observed on this day by the number of such days in the study period. Since the study period was 51 yr the denominator for each daily rate was 2652 (51 × 52).

It was assumed that daily rates were generated according to a Poisson process. These rates were compared. The Sunday rate differed significantly from the rates on all days ($P < 0.001$). There were no statistically significant differences between the rates on other days.

Table 3. Distribution of incidents by day of week

	No. of incidents 1940–1990	Daily rate
Monday	517	0.19
Tuesday	487	0.18
Wednesday	484	0.18
Thursday	460	0.17
Friday	497	0.19
Saturday	469	0.18
Sunday	326	0.12

Time of day. Suicide on the London Underground was not a rush-hour phenomenon. The hourly distribution of incidents is shown in Fig. 2. The peak hour was 11.00 and 41% incidents occurred between 10.00 and 16.00. The figures for incidents between 02.00–05.00 when there is no scheduled service refer to bodies found on the tracks by night maintenance workers.

The number of incidents involving men was fairly constant throughout the day. However, for women there was a clear peak between 10.00 and 13.00 after which time the hourly numbers dropped steadily. 45% of all incidents between 10.00–13.00 involved women. This proportion declined to 17% for incidents which occurred after 22.00.

Sex differences. Between 1950 and 1990, 1821 incidents involved males (64%) and 1026 females (36%). (These data were not available for the period 1940–1949.) The ratio of men to women was 1.8:1. The age distributions were similar for both sexes, the peak age-band being 25–34 yr, and the numbers in each age group falling sharply with increasing age. Over 40% of both men and women were aged between 15 and 34 yr at the time of the incident and some 75% of incidents involved persons under 55 yr of age. The mean age for men was 40.7 yr (SD = 17.18) and for women 41.3 yr (SD = 17.04).

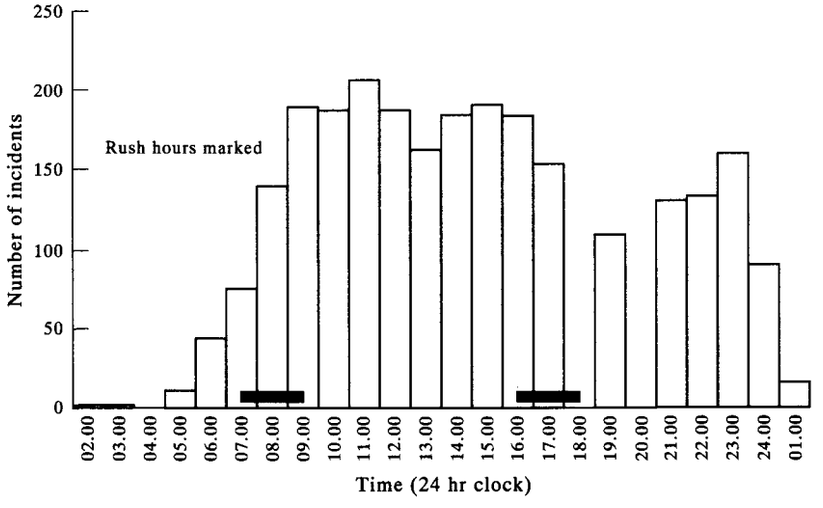


Fig. 2. Incidents involving persons under London Underground trains (1950–90). Time of day.

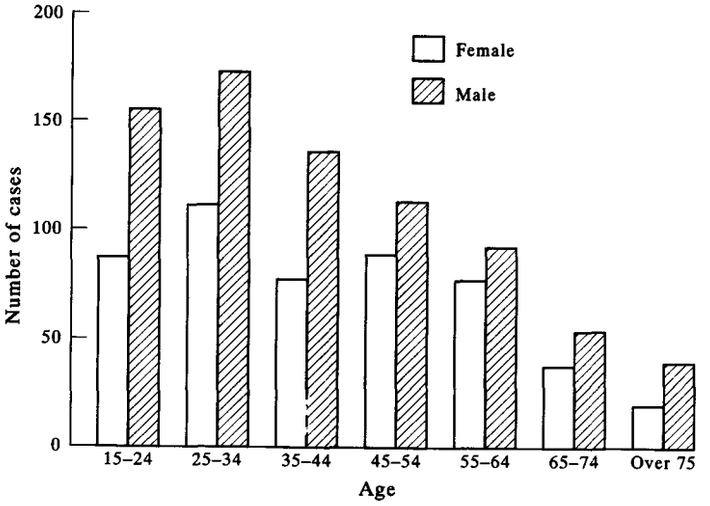


Fig. 3. Incidents involving persons under London Underground trains (1975–90). Cases by age and sex.

The distribution of cases by age and sex is shown in Fig. 3.

2. Place

Geographical clusters. The suicide problem on the London Underground was unevenly distributed around the system. Table 4 lists stations which experienced on average more than one incident each year between 1981 and 1990. These constituted 5% of the total number of stations yet accounted for 24% of the total number of incidents.

The geographical locations of the stations identified by Table 4 are illustrated by Map 1 which indicates the position of LUL tracks in the Greater London area. Psychiatric hospitals which are adjacent to stations and from which suicides at these stations were drawn, are indicated.

In order to adjust for the variations in passenger flow the expected number of incidents for each station was computed on the basis that the number of incidents would be directly proportional to the number of passengers passing through the station.

Table 4. Incidents involving persons under London Underground trains (1981–1990). Stations experiencing most incidents

	Number
King's Cross	34
Mile End	22
Victoria	22
Euston	17
Tooting Bec	16
Archway	15
Oxford Circus	15
Finsbury Park	14
Hammersmith	13
South Kensington	12
Embankment	11
Belsize Park	11
Waterloo	11
Piccadilly Circus	11

Stations listed experienced on average more than one incident each year.

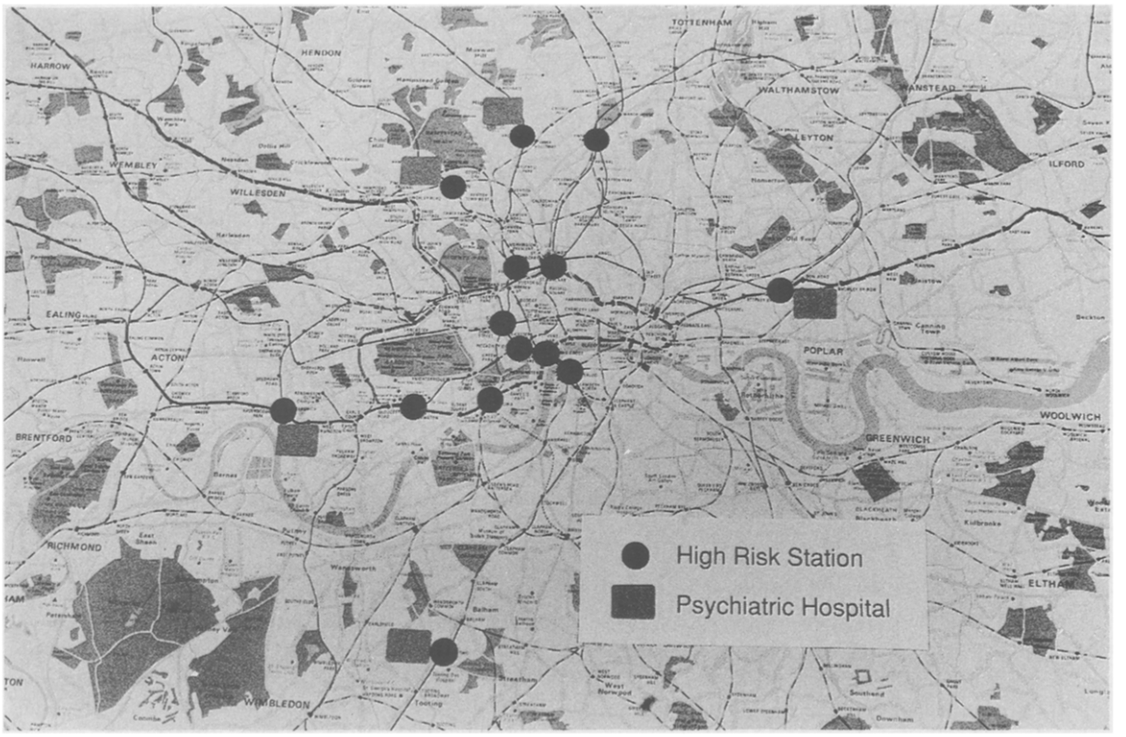
Table 5 lists those stations which experienced a statistically significant excess of incidents ($P < 0.01$) after controlling for passenger traffic. These are the high adjusted risk stations (some are also at high absolute risk). Most of these stations are near a psychiatric hospital and many of the victims at these stations were in-patients at that hospital at the time of the incident. Out-patient and day-patient data were not available. Map 2 illustrates this relationship.

3. Factors affecting outcome

'Suicide pit'. Fatality rates differed considerably between lines. Figure 4 illustrates the relationship between the percentage of non-fatal incidents per line and the percentage of stations on each line which were equipped with a 'suicide pit'. The suicide pit is a channel several feet deep between the rails which is a feature of some stations on some lines only. It is not absolutely clear why these channels were built but they have become known as 'suicide pits' because they increase the clearance between train mechanisms and the body on the track and thus increase the likelihood of survival. It is clear that, in general terms, lines with a greater proportion of these pits experience a higher survival rate.

Between 1973 and 1990 overall case fatality was 55% (this information is unavailable before this date). However 66% of incidents at stations without pits were fatal (506/764) while this was true for only 45% of incidents at stations equipped with pits (380/842). This difference was statistically significant ($\chi^2 = 72.1$, 1 *df*, $P < 0.001$).

Location of incident. Incidents tended to be platform-based (87.4%) with a small number involving persons who had entered the tunnel (9.1%) and very few involving persons who had accessed open air stretches of track (3.4%). 40% of all platform



Map 1. LUL stations most affected by incidents of suicide and attempted suicide.

incidents occurred within 50 ft (one carriage length) of where the train entered the platform.

Outcome was also influenced by the point on the platform from which the jump was made. 68% of jumps from the first third of the platform resulted in death. This was true for 48% of jumps from the middle third and 27% from the final third, where the train was travelling more slowly and braking to a halt.

Age. Another factor associated with survival was age. 46% of incidents involving those aged 20–30 yr survived. This was true for only 32% of those aged over 70 yr.

Certification of LUL deaths. It is required by law that railway deaths be investigated by one of H.M. Coroners sitting with a jury. The jury returns a verdict for each case. Possible verdicts for railway deaths are took own life, accident/misadventure, open or unlawful killing.

Figure 5 illustrates the distribution of verdicts by sex between 1950–1965 and 1975–1990. Data for the period 1966–74 are unavailable. There were no

Table 5. Incidents involving persons under London Underground trains (1981–1990)

	Observed	Expected	Chi-square	% In-patients
Mile End	22	4.18	75.97	22.22
Tooting Bec	16	3.10	53.68	56.25
Archway	15	3.02	47.52	53.33
Ravenscourt Park	8	1.35	32.76	0.00
Belsize Park	11	2.46	29.65	55.56
Clapham North	9	1.96	25.29	16.67
Oval	10	2.70	19.74	33.33
Chalk Farm	7	1.82	14.74	14.27
Hounslow West	6	1.58	12.36	16.67
Plaistow	9	2.96	12.32	0.00
Tufnell Park	6	1.62	11.84	33.33
Hampstead	7	2.11	11.33	16.67
Northwick Park	5	1.31	10.39	60.00
Clapham Common	9	3.43	9.05	14.29
Fulham Broadway	8	2.93	8.77	0.00
Barons Court	9	3.48	8.76	12.50
Colliers Wood	5	1.54	7.77	0.00
Stockwell	10	4.42	7.04	0.00

Stations with significant excess of incidents after adjustment for number of passengers ($P < 0.01$).

Map 2. LUL stations with greater than expected numbers of suicides and attempted suicides, after adjusting for the volume of passenger throughput.

verdicts of unlawful killing. A greater proportion of female deaths were certified as suicides for all age groups. This difference was most pronounced for the 35–44 yr olds where 80% of female deaths and 46% of male deaths were certified as suicides.

Between 1975 and 1989, 2747 deaths on railways in England and Wales were officially recorded as suicides. This constituted 4.5% of all suicide verdicts returned during this period. In Greater London over the same 15 yr, 4.6% of all suicide verdicts concerned deaths on the London Underground. The numbers of suicides in Greater London over this period which took place on British Rail tracks is unknown.

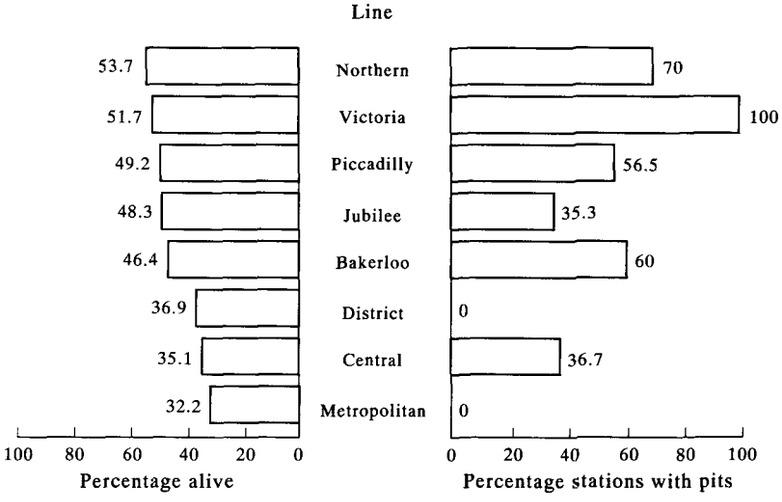


Fig. 4. Incidents involving persons under London Underground trains (1973–1990). Survival according to line and presence of pits.

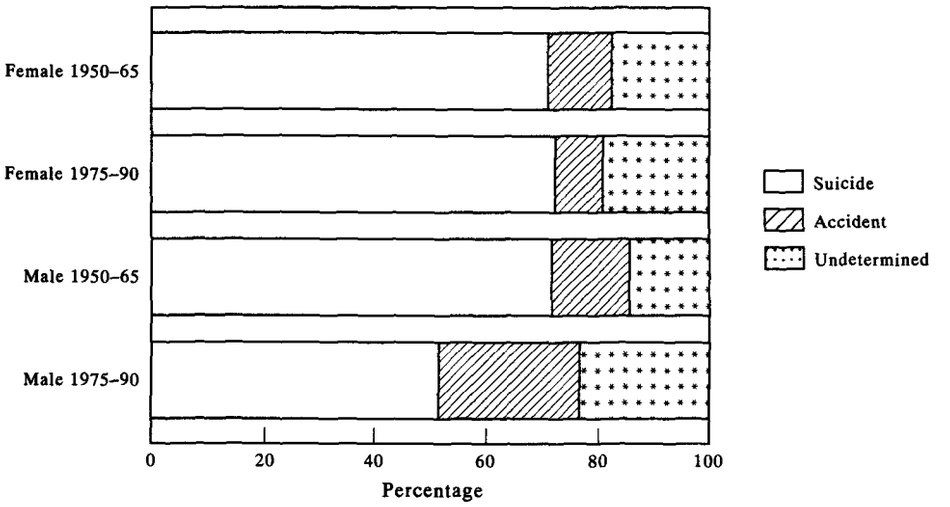


Fig. 5. Deaths under London Underground trains. Verdicts returned by Coroners' juries.

DISCUSSION

Main findings

Interesting clusters of incidents of suicidal behaviour were observed at some LUL stations. These stations fell into two groups. The first comprised busy central London stations such as King's Cross St Pancras, Victoria and Oxford Circus. When passenger usage was taken into account there was little difference in the ratio of observed to expected numbers of incidents at these busy stations (e.g. observed/expected for King's Cross was 0.91, for Hammersmith it was 0.98, for South Kensington it was 1.06). Of the central stations at high absolute risk listed in Table 4, only the number of incidents observed at Oxford Circus differed significantly from chance ($P < 0.05$) with fewer than expected.

The second group of stations which were at absolutely high risk were more peripheral stations used by few passengers. Passenger throughput was a poor explanatory variable in these cases. Their risk status appeared to be explained rather by proximity to a psychiatric hospital. Indeed, when an adjustment was made for passenger flow another group of high risk stations emerged. Again these stations tended to be proximate to psychiatric hospitals and persons involved in incidents at these stations were often receiving in-patient treatment at these hospitals. Thus, it is possible that in some cases ease of accessibility of London Underground stations may be a determinant of suicide.

The temporal distribution of incidents of suicidal behaviour on the London Underground system is worthy of note. A reduced rate of suicidal behaviour was observed on Sundays. This may be partially explained by the reduction in the number of trains which run on this day (approx. 55% of the normal weekday service). However, on Saturdays a 66% service operates and there is no significant decrease in the number of incidents. It may therefore be the case that there are some characteristics associated with Sundays in particular which serve to reduce the number of railway suicides. These may include factors external to LUL. Also there was a clear seasonal effect with a peak in the spring. A spring peak in suicide rates has been regularly reported by suicidologists [10, 11]. The factors affecting seasonality in suicidal behaviour however are unclear.

Persons involved in suicide and attempted suicide on the London Underground system were young and predominantly male. A significant number were receiving treatment as psychiatric in-patients at the time of their death. These findings are similar to those reported in a recent international survey of suicidal behaviour on metro systems [6].

In England and Wales unnatural or violent deaths are investigated by one of H.M. Coroners. Most inquests are heard by a Coroner sitting alone. However, in some cases such as when notice of a death is required to be reported to a Government department, inquests must be heard before a Coroner sitting with a jury. Railway deaths fall into this category. It is the function of the inquest to ascertain the identity of the deceased and to establish when, where and how the death occurred.

In English law the presumption is against suicide. In order for such a verdict to be returned the jury must be convinced beyond reasonable doubt that the deceased initiated the actions which led to his death and that he intended the consequences of these actions. In many cases of 'probable suicide' this high standard of proof is not reached and an alternative verdict must be returned. Verdicts of accidental death or open verdicts can be returned if the jury is satisfied 'on the balance of probabilities'. The number of certified suicides is therefore an underestimation of the true rate.

Suicide verdicts were returned for a greater proportion of females than males at all ages. Overall,

70% of inquests for women killed by London Underground trains resulted in verdicts on suicide. This proportion has remained constant since 1950. However the proportion of suicide verdicts for men dropped from 72% between 1950 and 1965 to 51% between 1975 and 1990. There is no obvious explanation for this dramatic shift.

Implications for suicide prevention

Approaches to the prevention of railway suicide have usually focused upon modifications to the station environment and rolling stock. Myers [12] suggested the following measures aimed directly at the railways: filling the suicide pit with water ("to reproduce the effect of the Bottomless Pit"!); a spotlight on the front of the train which the driver could direct at anyone who appeared to be behaving suspiciously in order to distract them from their purpose; tighter controls over speed limits for trains; advertising the fact that there was a high probability of survival and mutilation, that death under a train was by no means quick, clean or certain.

Other suggestions have been to post trained inspectors as spotters on platforms at high risk times [13]; to adapt the front of the train so that bodies on the tracks are prevented from going under the locomotive's wheels where the most serious injuries are caused [7]; to restrict media coverage of railway suicides in order to minimise the possibility that publicity may generate imitative suicides [14, 15]. Even a study which considered prophylaxis to be "more a question of mental hygiene than a problem to be solved by Danish rail" [16] did not rule out the possible value of more direct measures and suggested erecting suicide barriers at specific locations to make access to tracks impossible.

With respect to the London Underground system in particular, an examination of the factors affecting mortality rates indicated several approaches to reducing both the numbers of incidents and the proportion of fatalities.

If all stations which experienced incidents between 1973 and 1990 had been equipped with suicide pits the expected number of deaths would have been 725 [(380/842) × 1606]. The observed number of deaths was 886. In other words there may have been 161 fewer deaths over this 18 yr observation period, had suicide pits been a feature of all stations. This constitutes a reduction of almost 20% in the total number of fatalities. It is clear therefore that environmental modifications, such as digging more pits, may have a major role to play in the prevention of railway suicide.

The great majority of incidents (almost 90%) took place at platforms so it is at this part of the system that interventions should be targeted. 40% of all platform incidents occurred within 50 ft (one carriage length) of where the train entered the platform. As these early jumpers were more likely to be killed, strategic barriers, even if they simply displaced jumpers further along the platform would reduce fatality rates. A barrier along part of the platform therefore has clear life-saving potential. As well as reducing fatality rates, such environmental modifications may have financial benefits. For example, it has been shown that delays to the service are less severe at stations with suicide pits and in non-fatal cases [17].

Finally, it is not necessarily the case that the prevention of railway suicides would automatically lead to the substitution of alternative methods of self-destruction. Suicide is often an impulsive action carried out if an acceptable means is available [18, 19]. Investigations of the relationship between the availability of particular lethal agents and the incidence of suicide indicate that removing the means of death during a time of crisis may lead to a genuine reduction in overall suicide rates, rather than simply a different pattern of suicide mortality caused by changing methods [20, 21].

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