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ANALYSIS OF FATAL TRAIN-PEDESTRIAN COLLISIONS IN METROPOLITAN CHICAGO 2004-2012

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ABSTRACT

This paper analyses the 338 pedestrian fatalities on railroads that occurred in the Chicago metropolitan area between 2004 and 2012. On average there was one such fatality every ten days, and they comprised the vast majority (84%) of all deaths on the railroad. Almost half (47%) of the pedestrian fatalities are apparent suicides. Non-suicidal fatalities at stations and crossings represent 21% of the total, while the remaining 32% are non-suicidal incidents at other places along the right of way.

The decedents are predominantly male (72%) and of working age (83% between the ages of 18 and 65). There are very few minors or senior citizens. Chicago has harsh winters, so incidents are much more common during the warmer months. There does not seem to be any pattern to how fatalities are distributed across the days of the week, but they are concentrated during peak travel times of day, with an additional spike late at night.

A spatial analysis shows that while there is a general randomness in incident location, there are some common patterns, and also some notable outliers or “hot spots.” The frequency of fatalities at stations and crossings and from trespassing in different municipalities within the region is strongly related to the density of public access points to the right of way. Consequently, grade separation is effective in reducing fatalities. But fatalities of these types do not increase with train volume suggesting that pedestrians may exercise more care around busier lines.

The distribution of apparent suicides is less strongly related to the density of public access points suggesting that those intending self-harm will seek out a point of access. Apparent suicides are also more prevalent where there is a higher train frequency and a greater proportion of passenger trains that run to a published schedule. They are also more prevalent in municipalities with higher incomes and lower population density. While most of the apparent suicides (70%) are not associated with any copycat activities, the dataset contains 20 clusters of suicides. These clusters contain incidents that are proximate in both time and space and are unlikely to have occurred randomly. There was also a highly-publicized suicide that led to a 95% increase in apparent suicides throughout the region in the 18 weeks following the incident.

INTRODUCTION

Pedestrians and other non-motorized members of the general public account for four out of every five deaths (79.3%) on railroads in the United States in 2012 and 2013.¹ The breakdown by category, based on data reported to the Federal Railroad Administration (FRA), is shown in table 1. Moreover, this proportion has been increased during the past 35 years. This is because annual non-motorized deaths have not changed much in recent decades whereas the count in other categories of death on the railroads has declined. The total number of trespasser deaths has been reasonably consistent within the range of 400 to 500 a year for decades. The same is true for the number of non-motorized fatalities at grade crossings that have fluctuated in the range of 60 to 90 a year. A time trend for

¹ The term “railroads” is used in this paper to indicate railroads regulated by the Federal Railroad Administration. This includes freight, intercity, regional and switching railroads, but excludes rapid transit rail systems. Non-motorized persons include pedestrians, wheel-chair users, pedal bicyclists and horse riders.

suicides is not available because prior to June 2011 railroads were not required to report suicidal acts to the federal government.

TABLE 1: ANNUAL RAILROAD FATALITIES IN UNITED STATES (AVERAGE OF 2012 AND 2013)

Primarily Non-Motorized Members of the General Public		Other Fatalities	
Trespassers at places other than grade crossings ²	459	Motorized highway users at highway-rail grade crossings	160
Confirmed suicides ³	234	On and off-duty employees and contractors working on the railroad	20
Pedestrians and non-motorized highway users at grade crossings	81	Other persons lawfully on the railroad, such as delivery drivers	15
		Passengers on trains	6
		Bystander not on railroad property	1
Total	774	Total	202

In contrast there has been a considerable reduction in employee fatalities. The number of employees is only half of what it was in 1976, and the fatality risk per employee hour has fallen by 70% (Savage, 2013). Even more astonishing is the decline in the number of motor vehicle occupant fatalities at grade crossings from 1,016 in 1976 to about 160 in recent years despite highway traffic doubling in volume. The improvement at grade crossings has been due to a combination of factors: railroad line abandonments, the closing of some crossings on lines that remained open, a federally-funded program to install warning lights and gates at crossings, and a public education campaign known as “Operation Lifesaver” (Mok and Savage, 2005; Savage, 2006).

While the total number of trespasser and non-motorized crossing user fatalities may not have changed, the risk rate has fallen because the population has increased. The rate of trespasser fatalities relative to the U.S. resident population is now about 25% less than what it was in the mid-1970s. In part this may be explained by line closures and changes in land-use patterns over time that result in people now living and working some distance from the nearest train tracks, whereas historically settlements were clustered around railroad lines. Trespassers also tend to be males in their 20s and 30s, and as the baby boom generation has aged a smaller proportion of the population is in that age group (Savage, 2007).

These divergent trends have had their effect on public policy. One of the most pressing safety issues facing the railroad industry in the 1970s was grade crossing collisions. In the early-1970s the number of fatalities at grade crossings exceeded trespassing fatalities elsewhere on the railroad by a ratio of three to one. Programs were put into place that reduced the risk. By 1997 the number of trespasser fatalities exceeded the number killed in collisions at grade crossings for the first time since 1941. The trend continued and by 2012-13 the number of crossing fatalities was only about half of the number of trespasser fatalities.

Tellingly, the FRA’s ten-year safety strategic plan in 1994 was entitled “Rail-Highway Crossing Safety Action Plan” with trespassing relegated to the final section, but in 2004 the title was changed to “Secretary’s Action Plan - Highway-Rail Crossing Safety and Trespass Prevention” (U.S. Department of Transportation, 1994, 2004). Moreover, workshops were held in 2008 and 2012 under the title “Right-of-Way Fatality and Trespass Prevention” which also included discussion of suicide prevention (Harrison and DaSilva, 2013). These workshops were jointly sponsored with the Federal Transit Administration because new light-rail transit systems have been introduced to many cities in the past two decades, and these systems run next to or in the middle of public streets and pose particular risks to both motorists and pedestrians.

² The FRA also uses the word “trespassers” to indicate person or vehicles who enter grade crossings when the warning devices are activated. This paper uses the word trespassers to mean persons on the right-of-way at locations other than grade crossings. There are a small number of motorized trespassers such as motor vehicles that leave an adjacent highway and end up on the tracks, and some snowmobile and all-terrain vehicle riders.

³ There are a handful of suicides involving motor vehicles stopped on grade crossings.

LITERATURE REVIEW

In the United States the literature began in the 1990s with a widely-cited Centers for Disease Control and Prevention (CDC) study that examined coroners' reports for all of the 138 trespasser deaths in North Carolina for the years 1990 to 1994 (Pelletier, 1997). This was followed by another CDC study that analyzed 132 fatalities and 156 injuries that occurred in Georgia between 1990 and 1996 (CDC, 1999). A subsequent consulting report to the FRA matched up 61% of the trespassing fatalities in the FRA national database for 2002, 2003 and 2004 with records held by local coroners and medical examiners (George, 2006). Recently, the FRA replicated the study with 2005 to 2010 data (FRA, 2013).

The FRA commissioned further analyses of those fatalities in the 2005 to 2010 study that were identified by coroners as suicides.⁴ Some basic descriptive statistics on 696 such deaths are reported in Martino, Gabree and Chase (2013). A subset of 55 suicides that occurred between 2007 and 2010 were examined in detail by conducted a “psychological autopsy” that involved interviewing friends and relatives of the deceased (Martino, Doucette, Chase and Gabree, 2013).

Botha, Elmasu and Leitzell (2010) present descriptive statistics and some geographical analysis of the 200 deaths that occurred along a 77-mile stretch of railroad near San Francisco, California between 1992 and 2010. A review article by Lobb (2006) presents an international overview of the relatively small literature that existed at the time and discusses potential interventions that have been undertaken to reduce the risks. Examples of countermeasures to reduce the risks and how they might be evaluated are discussed in Silla and Luoma (2011). In subsequent work, Silla and Luoma (2012) analyze 311 deaths in train-pedestrian collisions in Finland between 2005 and 2009.

In contrast to the somewhat sparse literature on unintentional deaths, suicides have engendered a comparatively large literature. Much of the literature deals with deaths on subway systems. Review articles include Mishara (2007), Ratnayake, Links and Eynan (2007) and Krysinska and De Leo (2008). A recent paper by Andriessen and Krysinska (2011) analyzed 1,092 suicides on Belgian mainline (which is to say non-rapid transit) railways between 1998 and 2009.

DATA

This analysis concerns fatalities resulting from collisions between non-motorized members of the general public and on-track rail equipment in the six counties in Northeastern Illinois that comprise the City of Chicago, its suburbs, exurbs, and some semi-rural areas.⁵ The area is home to 8.3 million people, and has a dense and busy rail network. Chicago is the largest rail hub in North America served by all six of the major Class I freight railroads. It has an extensive commuter passenger service operating on 12 routes, primarily marketed under the name “Metra,” and is the center of a network of intercity trains operated by Amtrak.

The data covers the nine-year period from 2004 to 2012. The data excludes the physically separated rail rapid transit system operated by the Chicago Transit Authority (CTA). However, the CTA provided some summary information for the years 2008 to 2012 to the “Chicago Tribune” (Hilkevitch, 2013), and the railroad and rapid transit data are combined and analyzed in an appendix to this paper.

Illinois is of particular interest as it ranks fourth among the states in the fatality rate per capita for the five-year period from 2006 to 2010 when the deaths of non-motorized users at grade crossings are added to those of trespassers. The rate is 75% above the national average. The only states with higher rates are the rural states of Montana and West Virginia, and also New Mexico which has a particular problem with illegal immigrants using the right of way. The extensive rail system in Illinois contributes to the higher risk as does the flat terrain which means that there is little natural grade separation with highways and surrounding land. Other large states with extensive rail systems such as California, Florida, New York, Ohio, Pennsylvania and Texas have much lower fatality rates than Illinois.

⁴ Note that, in theory, suicides should not have been reported to the FRA or included in the trespassing statistics prior to June 2011, but often coronial decisions take time and the railroad has already filed a report.

⁵ Counties of Cook, DuPage, Kane, Lake, Will and McHenry.

An unusual feature of this analysis is that it uses a dataset that is much wider in scope than that collected and disseminated by the FRA. The data is collected by the Illinois Commerce Commission (ICC), which is the state agency tasked with oversight of the railroad industry, and also coordinates the distribution of federal and state funds for upgrading highway-rail grade crossings. The ICC obtains its information from reports submitted to the FRA, the Federal National Response Center, and Illinois Emergency Management Agency, and by monitoring the news media. The ICC follows up to obtain additional details from railroads, municipal police departments, and local coroners and medical examiners.

The dataset contains 338 fatalities that occurred in 334 separate incidents.⁶ There are only four two-fatality events (albeit that another pedestrian may have suffered non-fatal injuries or escaped uninjured in the same incident). Nearly all of the fatalities are pedestrians (327 of 338), with the remainder pedal cyclists. Therefore the term “pedestrians” will be used interchangeably with “non-motorized persons.” There were no on-train fatalities in any of these incidents. There is no evidence of any time trend. Annual fatalities fluctuate in the range of 29 to 46 per year. The fatalities are classified into three groups:

- Apparent suicides (161 deaths, 47% of the total),
- Non-suicides at stations and crossings, which are locations where pedestrians have legal access (70 deaths comprising 20 at stations which includes any pedestrian walkways between platforms, and 50 at highway crossings, 21% of the total), and
- Non-suicides not at stations or crossings⁷, which will be termed “trespassers” because these are locations where pedestrians do not have legal access (107 deaths, 32% of the total).

Stations and crossings are considered as one group because the flat terrain and the low-level platforms used on all but one route mean that the access to and between platforms is usually accomplished by highway crossings adjacent to the platforms and walkways in the middle of the station.

There are two major differences between the data used in this study and the FRA dataset used in previous studies. The first is that suicides are included in the ICC dataset even though prior to June 2011 they were not reportable to the FRA.⁸ It should be noted that the ICC classifies a death as a suicide in a more permissive manner than does the FRA. The FRA classification is based on a determination by a coroner, medical examiner or a non-railroad police officer. The ICC also considers the content of police and media reports. Consequently the term “apparent suicides” will be used when referring to the Illinois data.

Of the 161 apparent suicides in the ICC database, 46 (29%) appear in the FRA data as a trespasser. This implies that 37% of the 125 trespasser deaths recorded by the FRA are likely apparent suicides. This proportion is in line with the findings of FRA (2013) who found that 28% of trespassing fatalities were actually determined to be a suicide by a coroner or medical examiner, and in a further 8% of cases the coroner explicitly indicated that it could not be determine whether or not the death was a suicide.

The second major difference between the ICC and the FRA datasets is that it would appear that some non-suicide incidents that the ICC finds out about are not reported to the FRA. The ICC database contains three fatalities (out of 70 in the database) that occurred at stations and crossings that were not reported to the FRA. In addition a quarter of the non-suicide trespassing deaths (28 out of 107) were not reported to the FRA as either a fatality or an injury.

Pedestrian fatalities represent 84% of total railroad fatalities in metropolitan Chicago, as shown in table 2. This is somewhat higher but not inconsistent with the 79.3% calculated in table 1 for the whole United States. Pedestrian deaths not only represent the vast majority of rail deaths in metropolitan Chicago, but also occur quite frequently with a pedestrian death every ten days on average.

⁶ There were 12 additional fatalities in the ICC database which are not included in this analysis. Two were found to be duplicate entries, one was incorrectly shown as occurring in the Chicago area, three were persons found dead on the right of way who had not been struck by a train, three were decedents of crashes on adjacent highways who were projected onto the railroad, two were motor vehicle users who drove onto the railroad at places other than a grade crossing, and one was a person found frozen to death in a freight car in a Chicago yard who had boarded outside the Chicago area. Where appropriate these fatalities do appear in the “Other Fatalities” column of table 2.

⁷ Albeit that a crossing or station platform may have been the point of original access to the right of way.

⁸ Even after June 2011 the FRA only publishes the total number of suicides and does not provide any details on individual incidents.

TABLE 2: RAILROAD FATALITIES IN METROPOLITAN CHICAGO 2004-2012

Non-Motorized Members of the General Public		Other Fatalities	
Apparent suicides	161	Motor vehicle occupants / riders	39
Trespassers at places other than grade crossings	107	Vehicular suicides	2
At stations and grade crossings	70	Railroad employees	6
		Railroad contractors	8
		Passengers on trains	4
		Miscellaneous others	5
Total	338	Total	64

When a comparison is made to the national data shown in table 1, there are some notable differences. At a national level confirmed suicides are 30% of the non-motorized total whereas in Chicago the proportion represented by apparent suicides is 47%.⁹ While this may be due in part to the wider classification of a suicide by the ICC, other evidence points to the greater prevalence of trains as a method of suicide in Chicago. A study of coroner's records from 2005 to 2008 for four of the six countries in this study found that 4.1% of all suicides were by train (Children's Memorial Hospital of Chicago Research Center, 2011). This would include suicides on the rapid transit rail system. This is considerably higher than the proportion in the nation as a whole where suicides by train are less than 1% of total suicides.¹⁰ While high by national standards, the 4.1% ratio is not inconsistent with that seen in other countries with a dense rail network (Krysinska and De Leo, 2008). In explaining the difference between the Chicago region and the nation as a whole, it is notable that slightly more than 50% of all suicides nationally involve firearms, whereas the Chicago study found that firearms were involved in 33% of suicides. The State of Illinois had, at the time covered by this analysis, one of the most restrictive gun ownership and use restrictions in the nation. Martino, Doucette, Chase, and Gabree (2013) found by interviewing friends and relatives of decedents that proximity to rail tracks and a lack of access to firearms were likely contributing factors to decedents choosing train as a method of suicide.

Another difference is that non-motorized stations and crossings users form a higher proportion of non-motorized fatalities (21%) in Chicago, whereas nationally 10% of non-motorized fatalities occur at crossings, including pedestrian crossings at stations. The Chicago region has a well-patronized commuter rail service, and many of the suburban towns are centered on the railroad station, so there is considerable foot traffic across the railroad. As a consequence trespassers are only 32% of the non-motorized total in Chicago but comprise 60% of the non-motorized deaths nationally.

DEMOGRAPHIC ANALYSIS

Analysis by Gender

The distribution of fatalities by gender is shown in table 3. The gender of the decedent is known in 90% of cases. For those cases in which gender is known, males are 57% of the stations and crossings deaths, 80% of the trespassing deaths, and 73% of the apparent suicides. The FRA does not have a field on their report form for gender, so there is not any definitive national comparison. But the Chicago data is consistent with the subset of the national database that was matched up with coroners' records. FRA (2013) found that 82% of the trespassing decedents were male, and Martino, Gabree and Chase (2013) found that 72% of suicide decedents were male. There is evidence that suicide by train is a somewhat more prevalent method of suicide for females. Females are 27% of apparent suicide decedents in this study whereas national data indicates that females represent 22% of decedents by all methods of suicide (Murphy, Xu and Kochanek, 2013).

⁹ The Chicago region has an overall annual completed suicide rate by all methods of 80 per million, based on data from the State of Illinois Department of Public Health. This would place the Chicago region below the average for the United States. By worldwide standards the suicide rate in the United States is in the middle of the rankings according to World Health Organization.

¹⁰ In general there are about 300 confirmed suicides a year by train (about 250 reported by the FRA and 50 occurring on rapid transit systems that are reported to state authorities and relayed to the Federal Transit Administration), and the total number of suicides is in the middle 30,000s (the number has been increasing during the past decade).

TABLE 3: FATALITIES BY GENDER

Gender	At Stations & Crossings	Trespassers	Apparent Suicides
Male	37	69	110
Female	28	17	41
Not Reported	5	21	10
Total	70	107	161

Analysis by Age

Data on age was reported for 84% of the decedents. The distribution by age group for those whose age is known is shown in table 4. Deaths involving persons aged younger than 20 (especially non-suicidal deaths) are surprising few, and deaths of those younger than ten are rare. Indeed the sole stations and crossings death by a person younger than ten in the Chicago dataset involved an infant being held by an adult who was also killed.

TABLE 4: COMPARISON OF CHICAGO AND NATIONAL DISTRIBUTIONS BY AGE WHERE AGE IS KNOWN

Age Group	At Stations and Crossings		Trespassers		Apparent Suicide
	Chicago Data (2004-2012)	FRA National Data (2012)	Chicago Data (2004-2012)	FRA National Data (2012)	Chicago Data (2004-2012)
0-9	1.5%	1.6%	1.2%	0.7%	*
10-19	12.1%	9.5%	10.6%	11.4%	18.2%*
20-29	22.7%	12.7%	15.3%	22.8%	17.4%
30-39	16.7%	20.6%	23.5%	17.8%	14.4%
40-49	18.2%	17.5%	27.1%	16.9%	21.2%
50-59	12.1%	14.3%	14.1%	17.1%	15.9%
60-69	6.1%	12.7%	4.7%	8.3%	9.8%
70-79	6.1%	7.9%	3.5%	2.9%	3.0%
80+	4.5%	3.2%	0%	2.1%	0%

* The youngest apparent suicide in the database is 13 years old

For stations and crossings, and trespasser deaths a comparison is made with national data for 2012. Stations and crossings decedents seem to be somewhat younger in Chicago compared with the nation as a whole, whereas trespassers tend to be somewhat older with a greater proportion in the 30-49 age group and a lower proportion in the 20-29 age group.

TABLE 5: ANNUAL FATALITY RISK PER MILLION BY AGE GROUP

Age Group	At Stations & Crossings	Trespassers	Apparent Suicides	Total
0-9	0.1	0.1	-	0.2
10-19	0.8	1.1	3.9*	4.6
20-29	1.5	1.5	2.7	5.7
30-39	1.1	2.4	2.2	5.7
40-49	1.2	2.7	3.2	7.0
50-59	0.9	1.5	2.6	4.9
60-69	0.7	0.8	2.5	4.0
70-79	1.2	1.1	1.4	3.8
80+	1.3	0	0	1.3
Overall	0.9	1.4	2.2	4.5

* The apparent suicide rate for this age group is based on the population in age range 13-19

Table 5 shows the annual risk per million in the Chicago area by category and age group. These rates are based on the assumption that the ages of decedents whose age was not reported follow the same age distribution as those whose age is known. Perhaps surprisingly it shows that people in their 40s are at the greatest overall risk. They have a high risk in all categories, and a particularly high risk of apparent suicide. This is consistent with national

data that shows that those in the 45-54 age group have the highest rate of completed suicides by all methods (Murphy, Xu and Kochanek, 2013).

While retired people generally have lower risks, there does appear to be some increase in risk for those above the age of 70 when using highway or station crossings. Perhaps this is due to slower reaction times, diminished hearing and sight, and a slower pace which lengthens crossing times. In contrast the apparent suicide rate by train falls dramatically for those above the age of 70 which is in contrast to increasing suicide rates for older Americans when suicides by all methods are included (Murphy, Xu and Kochanek, 2013).

TABLE 6: INDICES OF THE SUICIDE RATES PER CAPITA BY AGE GROUP RELATIVE TO THE AVERAGE RATE FOR THE ENTIRE POPULATION AGED 15 OR OLDER

Age Group	All Methods of Confirmed Suicides USA (2010)	Apparent Suicides on Railroads Chicago (2004-2012)
15-24	69	143
25-34	91	72
35-44	104	123
45-54	127	106
55-64	114	106
65-74	89	71
75-84	102	17
85+	115	0
All Persons aged 15+	100	100

Table 6 provides further insights into suicide rates by age. It shows an index of the per capita rate in that age group to the overall rate for all persons aged 15 or older. The middle column shows the 2010 data on suicides for the entire United States by all methods (Murphy, Xu and Kochanek, 2013). The right-hand column shows the data from this study. It is immediately apparent that suicide by train is a method of suicide chosen by a younger demographic. Those in the 15-24 age group have a 40% higher than average rate for rail suicides in Chicago, whereas nationally people in this age group have a 30% lower than average suicide rate when all methods of suicide are considered. Trains become a less favored method of suicide for those aged 45 and older, and the decline in rail suicides is particularly noticeable for those aged older than 65.

TEMPORAL ANALYSIS

Analysis by Time of Year

The distribution of fatalities across the year, classified by the seasons, is shown in table 7. Not surprisingly, fatalities are higher during the warmer months of the year. Trespassing deaths peak between April to July, and again in November. Interestingly 27% of stations and crossings deaths occurred in the month of June, for reasons that are not readily explainable. One might have imagined that the risk would be higher in winter as people wear headgear that might restricting their field of vision, and visibility is limited by more hours of darkness and falling snow. However, this does not appear to be the case. The peak months for apparent suicides are March to October, with the colder months of November through February having lower counts.

TABLE 7: DISTRIBUTION OF FATALITIES BY MONTH OF THE YEAR

Months	At Stations & Crossings	Trespassers	Apparent Suicides
December-February	23%	13%	17%
March-May	14%	30%	34%
June-August	37%	28%	25%
September-November	26%	29%	25%

Analysis by Day of Week

The distribution of fatalities by day of the week is shown in table 8. There is a surprising consistency across the week. Compared with national data and previous research which indicates higher risks on Friday and Saturday

evenings (Savage, 2007), trespassing fatalities do not seem to increase on the weekend (albeit, of course, that there are fewer commuter trains in service on the weekend). There is some evidence of an increase in apparent suicides on Fridays.

TABLE 8: DISTRIBUTION OF FATALITIES BY DAY OF WEEK

Day of Week	At Stations & Crossings	Trespassers	Apparent Suicides
Monday	16%	7%	13%
Tuesday	14%	17%	12%
Wednesday	10%	20%	16%
Thursday	21%	12%	12%
Friday	20%	15%	20%
Saturday	10%	15%	11%
Sunday	9%	15%	16%

Analysis by Time of Day

The distribution of fatalities by time of day, listed by hour and also summarized into three-hour windows, is shown in table 9. Not surprisingly, 56% of the fatalities at stations and crossings occur in the prime commuting hours of 7am-9am and 3pm-7pm when there are a large number of pedestrians and trains about. Trespassing fatalities appear to be equally spread across all hours of day and night. While apparent suicides are distributed across the day, there are hotspots in the 7am, noon, 5pm and 6pm hours when there are a large number of people and trains about, and there is also a spike in the early hours of the morning in the 1am hour, which is about the time that most bars close.

TABLE 9: DISTRIBUTION OF FATALITIES BY TIME OF DAY

Time of Day	At Stations & Crossings	Trespassers	Apparent Suicides
Midnight	2.9%	9.3%	3.7%
1am	1.4%	2.8%	6.2%
2am	0.0%	2.8%	2.5%
3am	2.9%	0.9%	1.9%
4am	7.1%	4.7%	1.2%
5am	2.9%	1.9%	2.5%
6am	2.9%	6.5%	5.0%
7am	12.9%	3.7%	6.2%
8am	7.1%	4.7%	3.7%
9am	1.4%	1.9%	3.1%
10am	0.0%	7.5%	3.7%
11am	1.4%	1.9%	3.7%
Noon	0.0%	5.6%	5.6%
1pm	4.3%	0.9%	4.3%
2pm	2.9%	5.6%	2.5%
3pm	8.6%	1.9%	5.0%
4pm	5.7%	3.7%	5.0%
5pm	8.6%	9.3%	7.5%
6pm	12.9%	2.8%	7.5%
7pm	7.1%	1.9%	3.1%
8pm	4.3%	5.6%	3.7%
9pm	0.0%	8.4%	4.3%
10pm	1.4%	0.9%	3.1%
11pm	1.4%	4.7%	5.0%

CLUSTERING OF APPARENT SUICIDES

In the suicide literature there is a discussion as to whether suicides cluster together due to copycat action. A frequently-cited study indicates that suicides on the Vienna, Austria subway increased during a period when the media provided extensive coverage of these incidents (Sonneck, Etzersdorfer and Nagel-Kuess, 1994). A recent paper by Kunrath, Baumert and Ladwig (2011) found that suicidal acts on German mainline railroads were 44% higher than would be expected in the two-month period following a highly publicized incident in December 2006.¹¹

There was a widely-publicized rail suicide in Chicago on May 7, 2010. The decedent was the longtime head of the commuter rail agency. He was on his way to a board meeting of the agency at which he was likely to be dismissed due to financial improprieties that had already been widely discussed in the media. Table 10 shows the count of apparent suicides for the 18 weeks prior to and after May 7 for each of the nine years in the dataset (the death that occurred on May 7 is not included in this table).

TABLE 10: COUNT OF APPARENT SUICIDES IN 18 WEEKS PRIOR TO AND AFTER MAY 7

Year	January 1 to May 6	May 8 to September 10
2004	4	8
2005	6	5
2006	8	5
2007	4	6
2008	6	8
2009	11	2
2010	5	13
2011	5	4
2012	8	9

The mean number of apparent suicides in the May to September period is 6.67, whereas the actual number in 2010 was 13. The Poisson probability that there would be 13 *or more* apparent suicides in the period is 0.0192, or approximately once in every 50 years, suggesting that the extensive public interest in the incident did lead to additional apparent suicides that year. (As a side note, it is interesting that there was a much larger than normal number of apparent suicides in the early months of 2009 as the nation plunged into a serious financial downturn, albeit that the number of apparent suicides later in that year was much lower than normal.)

The suicide that has just been discussed was publicized throughout the Chicago region, and the subsequent additional apparent suicides occurred in all parts of the region. In general the region-wide media outlets in Chicago are very restrained in reporting on rail deaths when it becomes known that suicide was the likely explanation. However, news of a suicide may spread through localized social circles and social and public media. The dataset was searched for possible localized clustering. The criteria used was that there had to be two or more apparent suicide fatalities occurring in the same municipality, or an adjacent municipality along the same rail line, with less than four calendar months between incidents.¹² This is a quite strict standard. Table 5 shows that the overall rate of apparent suicides is 2.2 per year per million. A typical suburban municipality in Chicago has a population of 22,000 which implies that even a single rail apparent suicide in a given year is a low probability event, so two or more apparent suicides in a short period of time would be very unusual.

Seventy percent (113 of 161) of apparent suicides were “single events” and not part of a cluster. However, one in eight apparent suicides seems to trigger a cluster. There were twenty clusters of multiple fatalities. Fifteen of the clusters comprised two fatalities, three had three fatalities, one had four fatalities and one had five fatalities. Presuming that the initial fatality is random, these clusters contain 28 subsequent fatalities, which represent 17.5% of the total.

Table 11 lists the clusters in chronological order. Of course the randomness associated with the Poisson process may result in two or more apparent suicides occurring close together. A calculation is made of the probability of such a

¹¹ The initial presumed suicide was not the motivation for the widespread media attention. The deaths of three of the investigative team who were struck by a subsequent train led to the media coverage.

¹² There were no cases where there were multiple apparent suicide decedents in any one incident. Railroad suicides in the City of Chicago are rare, and there were no occasions when two apparent suicides occurred in the same area of the City within a four-month period.

random occurrence. To do this, it is presumed that the initial fatality is purely random, and that the expected number of subsequent fatalities can be calculated by using the known daily rate of apparent suicides per person in the county in which the municipality is located¹³, the duration of the cluster in days from the first to the last fatality, and the population of the municipality or municipalities. Using cluster 8 as an example, there is one initial fatality and two subsequent fatalities in a span of 55 days. The expected number of subsequent fatalities is 0.048 rather than the two that actually occurred. The Poisson probability of two *or more* subsequent fatalities is 0.00112 or approximately 1 in 900. This is a conservative estimate in that the probability of two *or more* subsequent fatalities, and not just exactly two subsequent fatalities, is calculated.

TABLE 11: CLUSTERS OF APPARENT SUICIDES

Cluster	Municipality	Number of Fatalities (X)	Duration (Days)	Population	County	Expected Number of Subsequent Fatalities	Probability that Subsequent Fatalities \geq X-1
1	Northbrook / Deerfield	2	105	51,395	Cook/Lake	0.041	0.03971
2	Glen Ellyn / Lombard	2	58	70,615	DuPage	0.061	0.05935
3	Roselle	2	87	22,763	DuPage	0.030	0.02915
4	Barrington	2	68	10,327	Cook/DuPage	0.006	0.00593
5	Round Lake	2	33	18,289	Lake	0.008	0.00755
6	Wheaton	2	64	52,894	DuPage	0.051	0.04932
7	Lisle	2	73	22,390	DuPage	0.024	0.02412
8	Palatine / Arlington Heights	3	55	143,658	Cook	0.048	0.00112
9	Naperville	2	16	141,853	DuPage	0.034	0.03334
10	River Grove / Franklin Park	2	28	28,560	Cook	0.005	0.00486
11	Lombard / Villa Park	2	64	65,069	DuPage	0.062	0.06032
12	Crystal Lake	2	21	40,743	McHenry	0.008	0.00758
13	Barrington	2	38	10,327	Cook/Lake	0.003	0.00294
14	Lombard / Villa Park	3	97	65,069	DuPage	0.094	0.00418
15	Wilmette	2	16	27,087	Cook	0.003	0.00264
16	Blue Island	2	34	23,706	Cook	0.005	0.00490
17	Naperville	5	159	141,853	DuPage	0.337	0.00041
18	Lake Forest	3	77	19,375	Lake	0.019	0.00017
19	Glen Ellyn / Lombard / Villa Park	4	56	92,519	DuPage	0.077	0.00007
20	Cary / Crystal Lake	2	21	59,014	McHenry	0.011	0.01095

The probability that the subsequent apparent suicides might occur due to random variation around the mean is small for all of the clusters, with a probability ranging from 0.00007 (1 in 13,710) to 0.06 (1 in 17). For twelve of the clusters the probability is less likely than 1 in 100. The two clusters that are the least unlikely (numbers 2 and 11) are notable in that they overlap geographically, and that there are two other clusters (numbers 14 and 19) in the same geographic area. The three adjacent municipalities that comprise these four clusters recorded 15 apparent suicides between 2004 and 2012 (11 in clusters and 4 in single events). With a combined population of 92,000, the annual apparent suicide rate in these three municipalities is eight times the overall rate for the metropolitan Chicago region.

¹³ Later it will be shown that the underlying risk of apparent suicides varies between counties.

There is evidence to support the contention that young people are particularly susceptible to copycat behavior. Eleven of the 25 subsequent decedents (four female, seven male) for whom their age is known were 21 or younger. In five of these 11 cases the initial decedent in the cluster was also aged 21 or younger. After the highly publicized May 7, 2010 suicide, four of the 13 subsequent decedents (all male) were 21 or younger.

ANALYSIS BY TYPE OF RAIL LINE AND TRAIN TYPE

Table 12 presents data on the distribution of fatalities by type of rail line and the type of train involved. This table cannot be interpreted as a fatality rate because information on train miles on different routes and by different types of trains is not available at a region-wide level. However, later in the paper information on train volume and type is available when the risk in individual municipalities is analyzed. Despite the lack of exposure data, some general observations can be made. The first is that greater than 80% of the fatalities occur on routes where there is commuter rail service and 60% of the fatalities involve commuter trains. In particular, apparent suicides appear to be more attracted to commuter passenger trains (67% versus 60% of the deaths at stations and crossings, and 48% of the trespassers) perhaps because commuter trains run to a published schedule.

TABLE 12: DISTRIBUTION OF FATALITIES BY CATEGORY OF TRAIN LINE AND TRAIN TYPE 2004-2012

Train Line Type / Train Type	At Stations/ Crossings	Trespassers	Apparent Suicides	Total
Commuter Railroad Routes				
Commuter Train	60%	48%	67%	59%
Inter-City (Amtrak) Train	11%	8%	4%	7%
Freight Train	13%	17%	17%	16%
<i>Sub-Total</i>	<i>84%</i>	<i>73%</i>	<i>88%</i>	<i>82%</i>
Non-Commuter Railroad Routes				
Inter-City (Amtrak) Train	3%	5%	1%	2%
Freight Train	13%	22%	12%	15%
<i>Sub-Total</i>	<i>16%</i>	<i>27%</i>	<i>12%</i>	<i>18%</i>

The second general observation is that 27% of trespasser fatalities occur on non-commuter rail routes, compared with 16% of stations and crossings fatalities and 12% of apparent suicides. This suggests that the inherently irregular scheduling of freight trains poses more of a risk to trespassers, who are caught unawares by an unexpected train.

SPATIAL ANALYSIS BY COUNTY

Chicago is situated at the southwestern corner of Lake Michigan. It extends north along the shoreline, and to the west and south. Areas to the southeast are in the neighboring state of Indiana. Cook County is the center of the region and contains the City of Chicago and the inner ring of suburbs. Cook County is separated into its City and suburban components in the following analysis. The far northern and western suburbs lie in Lake and DuPage Counties, respectively. Finally there are three counties – Kane, McHenry and Will - that comprise some satellite towns, exurbs, and semi-rural areas.

The fatality risks are shown in Table 13 in descending order of per capita risk. The generally low rates in the City of Chicago are due to two factors. The first is that rapid transit rail lines are also an option for those intending self-harm by train. In the appendix, data on rapid transit deaths are included, and as a result the suicide by train rate in the City of Chicago exceeds that in the inner suburbs, but is still considerably below that in DuPage and Lake Counties. The second is that the risk at stations and crossings is below that in the inner ring of suburbs. The City of Chicago passed a series of ordinances between 1893 and 1908 that required steam railroads to grade separate their mainlines. The only grade crossings that remain within the City are on branch lines, secondary freight lines, and in some outlying areas that had not been annexed to the City at the time the ordinances were passed.¹⁴ A few, but not many, suburbs followed suit in requiring grade separation at various times between 1900 and the 1960s.

¹⁴ One should not get the impression that grade crossings have been totally eliminated within City limits. There are still 340 public highway and pedestrian crossings, and one well-used part of the commuter rail system runs down the center of the street.

TABLE 13: ANNUAL RAILROAD FATALITY RISK PER MILLION 2004-2012

County	At Stations & Crossings	Trespassers	Apparent Suicides	Total
DuPage – far western suburbs	0.6	1.7	5.5	7.8
Lake – far northern suburbs	0.9	1.3	4.6	6.8
Suburban Cook – inner ring of suburbs	1.5	1.5	2.2	5.2
McHenry –northwest exurbs	1.1	0.7	3.2	5.0
City of Chicago*	0.8	1.4	0.6	2.8
Will – south and southwestern exurbs	0.0	0.8	1.5	2.3
Kane – western exurbs	0.4	0.9	0.9	2.2
Region Overall	0.9	1.4	2.2	4.5

* The City of Chicago and to a limited extent suburban Cook County is also served by a rapid transit rail system whose fatalities are not included in this table

The highest risks are in the far suburbs in DuPage and Lake Counties. The higher risk is primarily due to the much higher risk of apparent suicides. The higher apparent suicide risk more than outweighs the reduced risk of stations and crossings fatalities in these far suburban areas where land use patterns result in less pedestrian traffic than is the case in the inner ring of suburbs. In part the higher rail suicide rate is explained by a higher rate of suicide in general. Using data for 2008 to 2010 from death certificates submitted to the State of Illinois Department of Public Health, DuPage County has a suicide rate by all methods 5% above the region average, and Lake County a rate that is 21% above the region average. In contrast the suicide rate in the City of Chicago was 16% below the region average.

DuPage County has a rate of apparent suicides by train that is about twice as high as the region average when suicides on rapid transit are included (see appendix). It has only a marginally higher-than-average rate of suicides by all methods. Consequently the proportion of rail suicides to total suicides in that County would be much higher than the 4.1% found for the region by Children's Memorial Hospital of Chicago Research Center (2011), and closer to the top of the range found among the countries of Western Europe.¹⁵

SPATIAL ANALYSIS BY SUBURBAN MUNICIPALITY

Data

Of the 338 fatalities in the dataset, 269 (80%) occur outside the City of Chicago. These suburban areas have 70% of the region's population. The Chicago suburbs are composed of 270 municipalities of which 216 have railroad lines passing through them.¹⁶ The rail-served suburban municipalities range in size from 200 residents to 200,000 residents, but most are quite small. The average population is 22,000, and the median is 15,000. The large number of suburban municipalities provides the opportunity for statistical analysis because there is considerable variation in the fatality experience and the characteristics of rail service.

Table 14 provides descriptive statistics for each of the variables that will be used in the analysis. The first three lines of the table represent the three dependent variables that will be used. These are the total count of fatalities from 2004 to 2012 that occur within the municipal boundaries for the three categories of non-motorized persons. Because most municipalities are small the modal value for each of these counts is zero, and the mean number of fatalities in all three categories combined is 1.2.

The extent of rail service in each municipality is measured by a variable that combines together the number of lines that traverse the municipality, the length of traverse, and most importantly whether the lines go through areas where roads intersect the rail lines, and if they do whether there is grade separation. The measure is the total number of public access points, measured by the sum of the public highway and pedestrian crossings and the number of passenger stations, per square mile. In 21 municipalities there are no stations and no crossings (indicating total

¹⁵ Krysiniska and De Leo (2008) and Andriessen and Krysiniska (2012) report that the proportion is 6% in Sweden, 7% in Germany, 10% in Belgium, and 12% in Spain and the Netherlands.

¹⁶ Rapid transit rail service extends into five suburban municipalities. Data on rapid transit fatalities and service provision is excluded from this analysis.

grade separation or no intersecting highways or footpaths). On average there are 1.2 public access points per square mile. Seventeen municipalities have three or more access points per square mile with a maximum of 9.8 per square mile.

TABLE 14: DESCRIPTIVE STATISTICS ON 216 SUBURBAN RAIL-SERVED MUNICIPALITIES

	Minimum	Mean	Maximum
Fatalities at stations and crossings 2004-12	0	0.23	5
Trespasser fatalities 2004-12	0	0.30	4
Apparent suicide fatalities 2004-12	0	0.68	8
Population – 2010 census	228	21,869	197,889
Public crossings and stations per square mile	0	1.22	9.83
Daily trains	2	68	233
Proportion of freight trains to total trains	0.04	0.56	1.00
Maximum number of tracks	1	2.16	6
Maximum line speed – miles per hour	10	63	79
Population per square mile – 2010 census	86	3,281	14,509
Median household income – 2010 census	\$22,049	\$76,629	\$247,000

The volume of rail service is measured by the number of trains passing through the municipality each day. The data were obtained by filings from the railroads to the FRA as part of the inventory of highway-rail grade crossings, and are available on the FRA’s website.¹⁷ On average there are 70 trains a day indicating that the Chicago region is a busy hub for rail service.

The nature of rail service is represented by three variables. The first is the proportion of the daily trains that are freight trains. These data are obtained from the FRA crossing inventory database, supplemented by commuter rail and Amtrak timetables. The second and third variables measure the number of tracks and the line speed. These are also from the FRA crossing inventory. When more than one line passes through a municipality, the variables represent the line with the most number of tracks, and the line with the highest speed.

The final two variables are characteristics of the municipality: the population density which would indicate land use, and the median household income. Both were obtained from the 2010 United States census. There is considerable variation in both, and there is a negative correlation between them with a correlation coefficient of -0.34.

Analytical Technique

The regression technique used is the negative binomial regression with the count of fatalities as the dependent variable, population as the exposure variable, and most of the other explanatory variables expressed in logarithms. The negative binomial regression is a more generalized version of the Poisson regression. It assumes that the mean, $E(Y)$, and variance, $Var(Y)$, of the count of casualties for a group of years with identical values of the explanatory variables have the following relationship:

$$Var(Y) = E(Y) + \alpha E(Y)^2$$

The negative binomial equation can be usefully visualized as having the form:

$$\text{count of fatalities} = \text{population} * e^{(\alpha + \sum \beta \ln(X_i))} + \varepsilon$$

or

$$\text{count of casualties/population} = e^{(\alpha + \sum \beta \ln(X_i))} + \varepsilon$$

¹⁷ If more than one railroad line passes through a municipality, this measure is the sum of the trains on each route. In the event that there are no grade crossings on a particular line within the municipality, the train count is derived from data on the most proximate crossing on that line.

where X_i is the set of explanatory variables other than population. This particular functional form means that because all but one of the non-population explanatory variables is expressed in logarithms, their coefficients can be interpreted as elasticities.

Regression Results

The regression results are shown in Table 15. The regressions have alpha values significantly larger than zero at the 1% level for trespassing and apparent suicides, and at the 10% level for stations and crossings, thereby rejecting the Poisson model. As the estimated value of α is positive, the data are referred to as overdispersed.

In general, the pseudo R^2 statistics are quite poor at 0.07 for trespassing, 0.085 for stations and crossings, and 0.1125 for apparent suicides. The pseudo R^2 is a measure, using the estimated log-likelihoods, of the explanatory power of the full regression compared with a regression with a constant as the sole explanatory variable. The low pseudo R^2 would support a hypothesis that pedestrian fatalities occur quite randomly in terms of geography. To some extent this is not unexpected as the suburban dataset contains 269 fatalities (50 stations and crossings fatalities, 73 trespassers and 146 apparent suicides) and 216 potential municipalities that these fatalities could occur in. However, there are some factors that explain the higher risk of fatalities in some municipalities.

TABLE 15: NEGATIVE BINOMIAL REGRESSION RESULTS

Dependent Variable. Count of fatalities 2004-12	At Stations and Crossings		Trespassers		Apparent Suicides	
	Coefficient	t	Coefficient	t	Coefficient	t
Constant	-19.9459	2.24	-15.2497	1.78	-23.1304	3.79
Ln of population (exposure variable)	1.0000	-	1.0000	-	1.0000	-
Public crossings and stations per square mile	0.4119	3.38	0.4109	2.92	0.1588	1.85
Ln of daily trains	-0.0127	0.04	0.3715	1.04	0.5952	2.30
Ln of proportion of freight trains	-0.1087	0.51	-0.0224	0.10	-0.2584	1.96
Ln of maximum number of tracks	0.8228	1.35	-0.0849	0.13	-0.0533	0.13
Ln of maximum line speed	0.7708	0.70	1.9283	1.64	0.9010	1.06
Ln of population per square mile	-0.1583	0.47	-0.3618	1.17	-0.4346	2.11
Ln of median household income	0.4771	0.83	-0.2705	0.46	0.8500	2.23
Alpha	0.9019	1.76	1.7753	2.61	0.5871	2.82
Pseudo R^2	0.0845		0.0703		0.1125	
Observations	216		216		216	

The Extent of Rail Service Of course one would expect that the extent of the rail network in a municipality and its grade separation will have a major effect on the number of fatalities. This variable could not be expressed in logarithms as some municipalities have no public access points to the rail network, and the logarithm of zero is undefined. The effect of this variable is shown in table 16. The relationship between the explanatory variables in a negative binomial regression is inherently multiplicative. For example in the stations and crossings equation the coefficient is 0.4119. The effect of access density on the predicted fatality count is to multiply the prediction of the other variables by the natural exponential function of 0.4119 of the density of public access. When there are no public crossings or stations the value of the exponential function is 1.0, implying that the variable has no effect on the risk.

The estimated coefficients in both the stations and crossings and trespassing regressions are almost identical, so they will be discussed together. A municipality that has a public access density of 0.41 per square mile, which is at the lower quartile of the dataset, would have a count that is 18% higher than an otherwise similar municipality with no public access. In the median municipality where the access density is 0.78 per square mile the predicted count is 38% higher than municipalities with no public access. At the upper quartile with 1.44 public access points per square mile the predicted count is 81% higher than municipalities with no public access. Because of the functional form, the predicted counts rise quite rapidly for those few municipalities with very high public access densities. The result certainly shows that grade separation is an effective, if costly, way to reduce not only fatalities that might occur at stations and crossings, but also non-suicide fatalities at other places along the right of way.

**TABLE 16: EFFECT OF THE PUBLIC CROSSINGS AND STATIONS PER SQUARE MILE
VARIABLE ON THE COUNT OF FATALITIES**

Value	At Stations & Crossings	Trespassers	Apparent Suicides
Minimum (0.0)	1.00	1.00	1.00
Lower Quartile (0.41)	1.18	1.18	1.07
Median (0.78)	1.38	1.38	1.13
Upper Quartile (1.44)	1.81	1.81	1.26
90 th percentile (2.56)	2.87	2.86	1.50
95 th percentile (4.87)	7.42	7.39	2.17
Maximum (9.83)	57.24	56.70	4.76

In contrast the estimated coefficient of the access density variable on apparent suicides is much smaller. While it is statistically significant at the 10% level, it is not at the 5% level. The effect of this smaller coefficient can be seen in the final column of table 16. The predicted count in a municipality in the 95th percentile of public access is only double that in a municipality with no public access. It is clear that suicidal persons seek out points of access, and do not seem to be greatly deterred by a lower density of public access points.

The Volume and Nature of the Rail Service In the stations and crossings and trespasser regressions, only one of the rail-service variables is statistically related to the fatality count. That is the train speed variable in the trespassers regression. While only significant at the 10% level, the magnitude of the elasticity is large at 1.9 indicating that fatalities increase twice as fast as any increase in train speed. This is perhaps not surprising as faster trains leave trespassers with less time to move off of the tracks. The essentially zero coefficient on the freight train proportion variable indicates that trespassers are equally susceptible to fast freight and passenger trains. The insignificant coefficient for the number of tracks is somewhat surprising, as one would have imagined that three-track main lines are more risky to people using crossings or walking on the tracks than single or double track lines.

Surprisingly, there is not a statistically-significant relationship between train volume and stations and crossings or trespasser fatalities. Indeed in the case of stations and crossings the estimated coefficient is close to zero. Perhaps there are conflicting forces at work. While an increased number of trains should increase the chance of a collision with a pedestrian, the higher train volume may engender pedestrians to take more care.¹⁸ This would be consistent with the general theory of risk compensation (see Hedlund, 2000, for a review of the literature).

For apparent suicides, there is a statistically-significant positive relationship with train volume. Albeit that the estimated elasticity is 0.5 indicating the increase in fatalities increases less than proportionately with train volume. While the number of tracks and the line speed are not statistically related to the fatality count, the proportion of freight trains is negatively related. That is to say apparent suicides are more likely on lines where passenger trains are present. This is consistent with the analysis of the location of apparent suicides versus other types of fatalities shown in table 12. This would also be consistent with the hypothesis that those seeking deliberate self-harm are attracted to lines on which the trains run frequently and to a published schedule.

Municipality Characteristics In the stations and crossings and trespassers regressions there are no statistically-significant relationships between population density or median household income and fatalities. In contrast for apparent suicides there are strong statistical findings that fatalities decrease with population density (with an elasticity of -0.43) and increase with median household income (with an elasticity of 0.85). The reader is cautioned that the data represent the municipality in which the fatality occurs. The decedent may reside in another municipality, and the person's own household income is not known. It has already been noted in table 13 that apparent suicide rates are much higher in the far suburbs which generally have high household incomes. The two municipalities with the highest rates of apparent suicide (Barrington and Lake Forest) are among the wealthiest municipalities in the Chicago area. However, it would be incorrect to give the impression that apparent suicides are

¹⁸ Metaxatos and Sriraj (2013) interviewed pedestrians at ten crossings in Northeastern Illinois and found that people stated that they would be less likely to disregard activated flashing lights and gates at crossings with higher train volumes. The current analysis would suggest that the increased care offsets the increased risks inherent from a greater frequency of trains.

exclusively in wealthy areas. The municipalities with the next highest rates (Villa Park and Round Lake) have much more modest median household incomes.

The Effectiveness of Operation Lifesaver

An analysis was undertaken to try to determine the effectiveness of Operation Lifesaver, the campaign that educates the public on safe conduct around railroads. Activities undertaken under the Operation Lifesaver banner include lectures to schools and community groups, displays, police-supported enforcement and education campaigns at or near commuter rail stations, and training given to specific groups such as school bus drivers. The state coordinator for Illinois is the ICC who provided a log of all activities from 2004 to 2012. The data include a count of the number of audience members at each event or activity. The level of activity in each municipality was calculated by dividing the total audience members between 2004 and 2012 by nine to produce an average per year. This average was expressed as a rate per 10,000 residents. There is considerable variation across municipalities. Among the 216 rail-served suburban municipalities, 25 did not see any Operation Lifesaver activities. The median annual audience was 150 per 10,000 residents, and just nine municipalities had more than 1,000 per 10,000 residents.

Initially this variable (which could not be expressed in logarithms) was included in the regressions. Operation Lifesaver activity was found to be unrelated to the count of trespassing deaths, but positively related to the count of stations and crossings fatalities (at the 10% level of significance). On one hand the latter result is satisfying in that educational activities are clearly concentrated in municipalities in which there is a known safety problem at stations or crossings. On the other hand, one would hope to find that educational activities would lead to a decrease in fatalities. The lack of a relationship between Operation Lifesaver activities and trespassing fatalities might reflect poorly on the resource allocation decisions by Operation Lifesaver.

Interestingly, Operation Lifesaver activity was also strongly related to the count of apparent suicides, and the relationship was statistically significant at the 1% level. This is somewhat surprising as Operation Lifesaver does not deal with the prevention of suicides. Indeed its basic message that trains are fast, cannot stop quickly and any collision is likely to be fatal is perhaps counterproductive in deterring a person considering suicide by train.

Because of these counterintuitive relationships, the Operation Lifesaver variable was not included in the final regressions, and alternative methodologies were sought out to test whether Operation Lifesaver is effective in reducing risk. The method chosen was to split the time period into two parts. The first period was the four years from 2004 to 2007, and the second was the five years from 2008 to 2012. The average annual audience in Operation Lifesaver events per 10,000 residents was calculated for the first period. The annual fatality rate per 10,000 residents was calculated for both time periods, and the change in the fatality rate from the first to the second period was tested to see if it was related to higher Operation Lifesaver activity in the first period. The investigations were fruitless. It has already been observed that Operation Lifesaver activities and trespassing fatalities seem to be unrelated, and that Operation Lifesaver does not deal with suicide prevention. This just leaves fatalities at stations and crossings. As there were just 25 such fatalities in the 216 suburban municipalities in the 2004-2007 period and 25 in the 2008-2012 period, nearly all changes were from zero fatalities to one fatality or vice-versa. It is impossible to untangle any effects of Operation Lifesaver from the random patterns inherent in a Poisson process.

This is not to say that Operation Lifesaver should be totally dismissed. The City of Elmhurst in the western suburbs with a population of 44,000 has been very aggressive in education and police enforcement. The annual audience is in the 95th percentile at 980 audience members per year per 10,000 residents. It recorded zero fatalities between 2004 and 2012 despite neighboring municipalities having some of the highest rates of fatalities in the region. If Elmhurst had experienced the same rates as neighboring municipalities¹⁹ it would have expected to have had 5.4 fatalities during the period (1.3 stations and crossings fatalities, 1.2 trespassers and 2.9 apparent suicides).

Outliers

The poor performance of many of the explanatory variables, and the low pseudo R^2 of the regressions should not be interpreted as meaning that fatalities are totally random occurrences. The paper has already identified that 30% of the apparent suicides appear to be clustered in time and space. There are also municipalities where the actual fatality counts are far higher than would be expected. These are typically referred to as “hot spots.” In some cases the

¹⁹ The twenty municipalities that lie along the BNSF Railway line from Berwyn to Lisle and along the Union Pacific Railroad's west line from Maywood to Wheaton.

higher occurrence can be explained by local factors such as curves in the rail line reducing the visibility of oncoming trains, poor geometry of individual grade crossings, and land use factors such as locating a school near the railroad but far away from the nearest legal rail crossing.

Mishara (2007) in his review of the literature identifies a higher occurrence of rail suicides near residential mental health facilities. This is not the case in Chicago. Of the three major State of Illinois psychiatric hospitals in the Chicago area, one is located in the City of Chicago far from a rail line, and there were no rail apparent suicides close to the other two which are located in suburban areas.

The regression models in table 15 were used to estimate the expected number of fatalities of each type for each municipality. The probability that fatalities could be equal to *or more* than the actual count due to random variation around the mean was calculated.²⁰ A negative binomial distribution was used to make this calculation with the predicted value as the mean, and utilizing the appropriate alpha value from table 15 (Hilbe, 2011, chapter 8). The most extreme outliers are shown in table 17, all of which had two or more fatalities of that type and a probability that the fatality count would occur due to random variation of smaller than 0.05.

TABLE 17: MUNICIPALITIES THAT ARE POSITIVE OUTLIERS WITH TWO OR MORE FATALITIES AND A NEGATIVE BINOMIAL PROBABILITY OF RANDOM OCCURRENCE OF LESS THAN 0.05

Municipality	Type	Actual (X)	Predicted by Regression Model	Negative Binomial Probability $\geq X$
Barrington	Apparent suicide	6	0.65	0.002
Lombard	Apparent suicide	8	1.33	0.005
Hometown	Trespasser	2	0.08	0.008
Villa Park	Apparent suicide	5	0.74	0.008
Crete	Trespasser	2	0.10	0.011
Round Lake	Apparent suicide	4	0.65	0.016
Burnham	Trespasser	2	0.15	0.021
Lansing	Stations and Crossings	2	0.17	0.021
Berwyn	Stations and Crossings	5	0.91	0.023
Winfield	Trespasser	2	0.18	0.027
Clarendon Hills	Trespasser	2	0.18	0.028
Round Lake	Trespasser	2	0.20	0.032
Tinley Park	Stations and Crossings	3	0.49	0.034
Roselle	Apparent suicide	4	0.96	0.044
Villa Park	Trespasser	3	0.49	0.046

Fifteen outliers meet the criteria. Seven related to trespassing, five related to apparent suicides, and three to stations and crossings. Two municipalities (Round Lake and Villa Park) appear in both the trespassing and apparent suicide categories. Results from an analysis like this could help focus public policy attention in deciding where to install additional fencing, redesign crossings, concentrate Operation Lifesaver activities, or deploy mental health services. Indeed there is evidence that a reallocation of Operation Lifesaver activities may be warranted. Of the ten municipalities that are outliers for fatalities in the stations and crossing or trespassers categories, only three are among the top quintile when municipalities are ranked in descending order of the annual audience per capita at Operation Lifesaver events.

CONCLUSIONS

The vast majority (84%) of the fatalities on railroads in the metropolitan Chicago region between 2004 and 2012 were pedestrians, or in a small number of cases pedal cyclists. On average there is one pedestrian fatality every ten days. Almost half (47%) of the pedestrian fatalities were apparent suicides. Non-suicidal fatalities at stations and

²⁰ There were three instances in suburban areas where two fatalities occurred in the same incident. These have been treated these as if there was just a single fatality for the purposes of discerning the extreme outliers.

crossings represented 21% of the total, while the remaining 32% were “trespassers” which is to say non-suicidal incidents at other places along the right of way.

Gender of the decedent is known in 90% of cases. For the cases where gender is known, males represent 57% of the stations and crossings deaths, 73% of the apparent suicides, and 80% of the trespassing deaths. The proportion of males among apparent suicide and trespasser deaths would appear to be consistent with national studies. There is evidence that suicide by train is a somewhat more prevalent method of suicide for females. Females are 27% of apparent suicide decedents in this study whereas national data indicates that females represent 22% of decedents by all methods of suicide.

The vast majority of decedents are adults with very few minors or seniors. Perhaps surprisingly the age group at the greatest risk is those aged 40-49. They have a high risk in all categories. Relative to national data that points to persons in their 20s and 30s as most at risk from trespassing, Chicago has a somewhat older demographic with the peak risks for those in their 30s and 40s. Persons in the 40-49 age group have a particularly high risk of apparent suicide. This is consistent with national data that shows that the rate of completed suicides by all methods peaks in the 45-54 age group.

In the Chicago dataset, teenagers have the highest rate of apparent suicide. Trains appear to be a particular favored method of suicide for those in the 15-24 age group. This group has a 40% higher than average rate of rail apparent suicides in Chicago, whereas nationally people in this age group have a 30% lower than average suicide rate when all methods of suicide are considered. In general, retired people have low risks around the railroad, although there does appear to be some increase in risk for those older than 70 when using crossings.

Fatalities are more common in the warmer months, which is not surprising for a region with severe winters. Fatalities are spread out across the days of the week and are concentrated during peak travel times of day. In general this study is not consistent with national data that suggests increased risk in the evenings on the weekends. However, there is some suggestion of an increased frequency of apparent suicides on Fridays, and there is a spike in apparent suicides late at night in the 1am hour.

There is some evidence of copycat behavior in apparent suicides. A highly publicized rail suicide in 2010 resulted in a statistically-significant 95% increase in the number of apparent suicides in the following four months compared with the average number at that time of year. There are also some localized clusters of suicides, defined as multiple apparent suicides in the same or an adjacent municipality within a four-month period. Because apparent suicides in general are relatively rare, and the typical municipality in Chicago is small, these clusters are highly unlikely to occur due to random variation. However, it should be noted that the majority (70%) of apparent suicides are single events. But one in every eight apparent suicides seems to trigger a cluster, and these clusters are associated with 28 subsequent apparent suicides in this dataset, which represent 17.5% of the total number of apparent suicides.

The spatial dispersion of incidents was investigated by fitting negative binomial models to explain the incidence of fatalities in 216 suburban rail-served municipalities.²¹ Fatalities at stations and crossings and among trespassers are found to increase with the density of public access points to the railroad within a municipality. Public access density is defined as the number of public crossings and stations per square mile, and therefore measure a combination of the length of railroads traversing the municipality and the amount of grade separation. Grade separation is clearly an effective, if expensive, way to reduce these types of pedestrian deaths. In contrast to the other two categories, there is a much less strong, albeit still positive, relationship between the density of access points and apparent suicides. It is clear that persons intending self-harm seek out a point of access.

Increased train speeds are associated with increased risks to trespassers, but the frequency of trains is not found to explain either stations and crossings or trespassing fatalities. It is likely that while busy routes may pose more of a risk in that there are more trains about, pedestrians who are not seeking self-harm exercise more care when around these lines. Conversely, apparent suicides are higher in municipalities with higher train volumes and a greater proportion of passenger trains. This would also be consistent with the hypothesis that those intending self-harm are attracted to lines on which frequent trains run to a published schedule.

²¹ There is a low frequency of incidents in large parts of the City of Chicago itself. This is primarily due to municipal ordinances dating back to the 1890s that required the grade separation of main lines.

While suicides appear to be more prevalent on busier routes with scheduled passenger service, trespassing fatalities are disproportionately greater on freight-only routes, or routes with freight and occasional Amtrak service. Such routes account for 27% of trespasser fatalities compared with 16% of stations and crossings fatalities and 12% of apparent suicides. This suggests that the inherently irregular scheduling of freight trains poses more of a risk to trespassers who are caught unawares by an unexpected train.

There is no evidence that population density or median household income of a municipality is related to the probability of occurrence of stations and crossings or trespassing fatalities. However, apparent suicides occur more frequently in municipalities with lower population densities and higher median household incomes.

Despite the high degree of randomness, as measured by the low pseudo R^2 of the regressions and the generally poor performance of many of the explanatory variables especially in the stations and crossing and trespassing regressions, there are notable outliers that would constitute “hot spots.” The clustering of some apparent suicides has already been discussed. There are also municipalities that have a much higher incidence of fatalities from trespassing or from collisions at stations and crossings. These outliers warrant particular attention when priorities are set for remedial actions such as engineering solutions, increased police enforcement, or public education activities.

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**APPENDIX A
COMBINED DATA ON RAILROAD AND RAPID TRANSIT RAIL FATALITIES**

There is also an extensive rapid transit rail system in Chicago operated by the Chicago Transit Authority (CTA). The CTA is not regulated by the FRA, and data on fatalities is not publically available from government sources. However, data on pedestrian fatalities from 2008 to 2012 were provided to the “Chicago Tribune” (Hilkevitch, 2013). These are shown in the right-hand columns of table A1. The railroad data for the same five years is shown on the left-hand columns. The railroads had four times as many pedestrian fatalities, yet the commuter rail system had only two-fifths as many passengers as the rapid transit system.

**TABLE A1: RAILROAD VERSUS RAPID TRANSIT RAIL PEDESTRIAN FATALITIES
IN METROPOLITAN CHICAGO 2008-2012**

Railroads		Chicago Transit Authority Rail	
Stations and crossings	38 (19%)	Non-suicides	15 (33%)
Trespassers	67 (34%)	Apparent suicides	30 (67%)
Apparent suicides	94 (47%)		
Total	199	Total	45

Of course, much of the apparent lower risk on rapid transit is explained because the system is primarily grade separated from the street. However, the CTA does pose its own unique dangers in that it is powered by electricity delivered by a third rail (electrocution was the cause of death in 20% of the fatalities) and has high-level platforms which means that people who fall from platforms have trouble moving away from an approaching train. Nearly all transit fatalities occurred at stations or crossings, with only two fatalities occurring at other locations (the CTA did not specify if these were apparent suicides or not). Apparent suicides form a higher proportion of pedestrian fatalities on the CTA, which is perhaps not too surprising as the grade separation reduces the risks to those not intending self-harm.²²

**TABLE A2: ANNUAL COMBINED RAILROAD AND RAPID TRANSIT RAIL FATALITY RISK
PER MILLION POPULATION 2008-2012**

County	Non-Suicides	Apparent Suicides	Total
DuPage – far western suburbs	2.6	6.3	8.9
Lake – far northern suburbs	2.8	4.3	7.1
City of Chicago	3.4	2.9	6.3
Suburban Cook – inner ring of suburbs	3.1	2.4	5.5
McHenry –northwest exurbs	1.3	3.2	4.5
Will – south and southwestern exurbs	1.5	1.2	2.7
Kane – western exurbs	1.2	0.8	1.9
Region Overall	2.9	3.0	5.9

²² Lin and Gill (2009) provide additional insights on rapid-transit fatalities by analyzing the 211 deaths on the New York City subway system from 2003 to 2007.

The rapid transit system is primarily within the City of Chicago but it does extend into parts of suburban Cook County, and four fatalities occurred in these suburban areas. The combined railroad and rapid transit rail annual risk rate per million population for the different parts of the Chicago region is shown in table A2. The stations and crossings and trespasser categories have been combined into a single “non-suicide” category. Compared with table 13, which deals with just railroads, the main effect is to inflate the risk within the City of Chicago. The overall risk in Chicago is now greater than the risk in suburban Cook County, but is still considerably below the risks in the far suburban DuPage and Lake Counties.