Is Suicide at MIT a Poisson Process?

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Every time there is a suicide at MIT, there are calls from numerous parts of the community for action by the Administration. If suicides are in fact a random process then such calls are unwarranted as a consequence of a particular suicide or suicides (although in the long run, it still might be worth taking action to reduce the overall rate). We analyze data over a 28 year period, from 1964 through 1991, in an attempt to determine whether suicides may be modelled as a Poisson process.

Data Collection

Although MIT maintains no health statistics on the student, staff or faculty populations, suicide is such an exceptional event that we were able to obtain data from the Office of the Dean for Student Affairs. Dean Robert M. Randolph supplied us with the dates and methods of student suicides since 1964. Some of the data are incomplete to the extent that only the month and year were given; for these data, we have assumed that the suicide occurred on the 15th of the month. Table I shows the data following our regularization.

10/8/64	7/26/74	10/20/86
11/15/64	7/27/75	10/2/87
10/17/65	12/12/75	10/3/87
3/17/66	2/2/76	10/22/87
6/4/67	10/16/77	4/8/88
10/19/69	4/3/78	4/15/88
7/15/70	2/8/83	6/15/88
3/19/73	11/30/83	6/15/88
4/15/73	6/21/84	10/15/90
5/15/73	5/18/86	6/15/91
5/24/73	10/4/86	6/15/91

***Table I**: Dates of Suicides where the 15th of the month has been assumed when only the month and year are known.*

Hypotheses Postulated

We agreed upon the following plausible hypotheses:

• that suicides are a Poisson process, i.e. that one suicide has no effect on any other and that the expected time until the next suicide is independent of the elapsed time since the last one. This was the original hypothesis for the research.

• that the first suicide after a quiet period can be modelled as a Poisson event, but that subsequent suicides within three months are caused in some sense by the first. This hypothesis was considered after observing "clumps" in the data.

• that living under the presidencies of Ronald Reagan and Richard Nixon causes suicide. This hypothesis was considered after noting the large number of suicides in the periods 1981-1989 and 1969-1974.

• that mid-terms and final exams cause suicide. This hypothesis was postulated based on personal experience.

• that suicides are Poisson, but that the rate has been increasing with time. This hypothesis was postulated based on the observations that there are a large number in the 1980s and that the career prospects for MIT graduates have been dimming over the years 1964-1991.

• that recreational drugs and Hippie mentality prevent suicide. This hypothesis was based on the low number of suicides in the period 1967—1972, which was otherwise marked by extreme pessimism among students nationwide, and the high number during the "Just Say No" Reagan years, a time of optimism.

Testing the Basic Poisson Hypothesis

In order to test the basic original Poisson hypothesis, we tried to determine whether the interarrival times were exponentially distributed and also whether the number of arrivals in fixed periods matched a Poisson PMF.

In testing for exponential distribution of interarrival times, we first calculated the empirical interarrival times, giving 32 numbers from the 33 suicides. We then organized these into 3-month bins, i.e. 0-3 months, 3-6 months, ..., 21-24 months, >24 months. Because of the miniscule area under any fixed portion of the extreme tail of the exponential, we lumped all the periods longer than two years into one bin.

For each bin, we calculated the area under corresponding portion of the exponential first order interarrival time PDF for a Poisson process with constant λ. Since the experimental arrivals divided by the time period is an unbiased maximum likelihood estimator for λ, we simply performed that calculation (32 divided by roughly 28 years — note that we do not count the first suicide since that simply starts the clock). We multiplied the raw area for a single trial by 32, the total number of suicides, to get the total expected number of suicides per bin, had the suicides been generated by a Poisson process.

Interval Length	Empirical	Expected (Poisson)	Chi-Square Summand
0-3	12	8.29	1.66
3-6	5	6.14	0.21
6-9	3	4.55	0.53
9-12	3	3.37	0.04
12-15	3	2.50	0.10
15-18	0	1.85	1.85
18-21	1	1.37	0.10
21-24	1	1.02	0.00
>24	4	2.91	0.41
totals	32	32.00	4.91

***Table II**: Comparison of actual and expected distribution of suicide interarrival times. The Chi-Square Summand column shows each term of the summation* $\chi^2 = \sum_{i=1}^{n} (O_i - T_i)^2 / T_i$ *where* O_i *is the observed value and* T_i *is the theoretical or expected value.*

Table II shows both the actual and expected distribution of suicide interarrival times. Chart I presents the same data graphically.

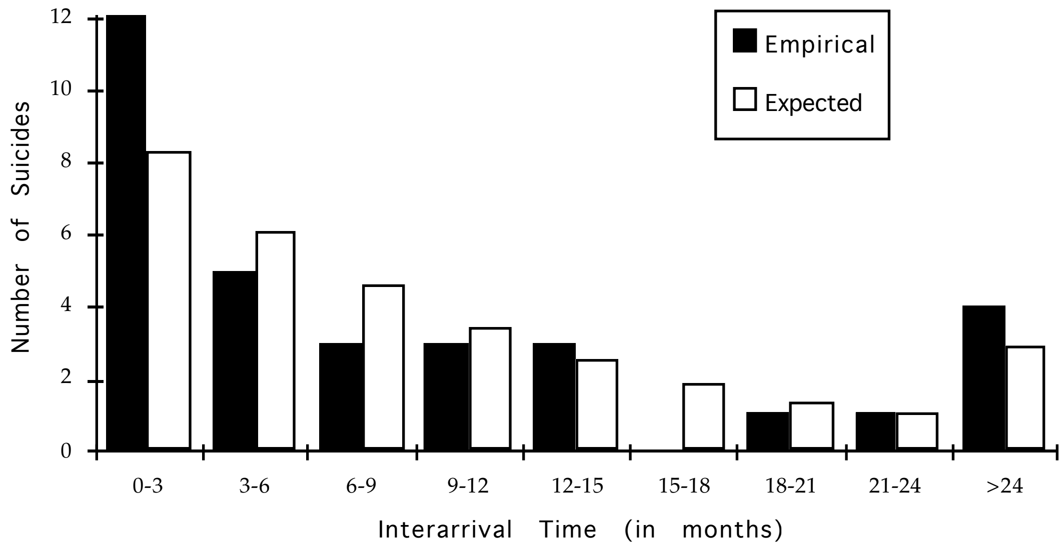

***Chart I**: Comparison of actual and expected distribution of suicide interarrival times.*

We conducted the following significance test:

H_0: That suicide interarrival times at MIT are exponentially distributed

Level of significance: $\alpha = 0.05$

With 8 degrees of freedom from 9 bins, we reject H_0 if $\chi^2 > 15.51$

Calculations in Table II show that $\chi^2 = 4.91$

$\therefore$ Accept H_0

A similar test with 6 month bins yielded a similar fit. We conducted another Chi-Square test to see if the number of observed suicides in fixed four year periods fit a Poisson PMF with constant λ (calculated by simply dividing 33 by 28, this time including the first suicide since the clock was arbitrarily started in 1964).

4 year period	Empirical	Expected (Poisson)	Chi-Square Summand
64-67	5	4.71	0.02
68-71	2	4.71	1.56
72-75	7	4.71	1.11
76-79	3	4.71	0.62
80-83	2	4.71	1.56
84-87	7	4.71	1.11
88-91	7	4.71	1.11
Total	33	33.00	7.09

Table III: *Comparison of observed suicides in 4 year periods to expected number from Poisson PMF*

Table III shows the results of this comparison: the Chi-Square goodness of fit is better than the 12.59 variance necessary to reject the Poisson process hypothesis. We did this for seven-year periods as well, and got a Chi-Square sum of 5.38, below the 7.82 value necessary to reject the Poisson hypothesis.

The Chi-Square test rests on the Central Limit Theorem and therefore is only reliable when there are a lot of values in each bin (at least five according to some practitioners). Because of the Chi-Square test's unreliability with such thin data, we decided to test alternative hypotheses.

Does One Suicide Trigger Others?

Noting that some of the data are clumped together, we considered the possibility that suicides occuring within three months of each other are dependent. If this were so, we should be able to get a better fit to an exponential distribution by considering only "first suicides", i.e. those that occur after a quiet spell of longer than three months. We found 21 such suicides, and performed a interarrival time binning test. Since our data selection method precluded interarrival times shorter than three months, we reduced the number of bins by 1 and scaled up the expected probability of the remaining portion of the exponential distribution by $e^{3\lambda}$ (so that the total probability would still be 1 under the possible portion of the distribution). We found that $\chi^2 = 3.84$, well below the significance test value for 7 degrees of freedom (for $\alpha = 0.05$, one must have $\chi^2 < 14.07$).

The Chi-Square goodness-of-fit for this hypothesis is about the same as for the raw Poisson process hypothesis, contradicting our first impression of the clumps.

Do Exams Cause Suicide?

Based on personal experience, we singled out the periods around examinations as likely times for suicides. Before looking at the data carefully (i.e. we wanted to be careful not to readjust our intervals to catch enough suicides to support any particular conclusion), we selected one month intervals around midterms and finals. We estimated the following midterm periods: October 16—November 15 and March 16—April 15. For finals periods, we obtained the actual MIT calendars for the years 1958 to the present. For each exam period, we started the interval seven days before the first exam date and extended it for a total of 30 days. When only a month and year were available for a suicide, we added a fractional number corresponding to the portion of the month that fell into an interval. Thus, for example, a suicide in June 1988 was given a proportion of $\frac{8}{30}$ since the interval extended from May 9 through June 8.

We found that 16.12 suicides[1] occurred during this period, against an expected number of 11 had the data been generated by a Poisson process (there were 33 suicides total and our intervals cover one third of each year). We conducted a significance test based on the assumption that there were enough data to apply the Central Limit Theorem. Thus we assume that variations from the expected number of Poisson arrivals in an interval are normally distributed.

[1] The fractions from the undetermined dates did not add to a whole number.

H_0: That suicides at MIT are distributed according to a Poisson PMF
H_1: That suicides are MIT are more prevalent during exam periods

Level of significance: $\alpha = 0.05$

Considering only the right-hand tail of a normal distribution with mean 11 and variance 11 (implying a standard deviation of $\sqrt{11}$ or 3.32), we reject H_0 if the empirical value is more than 1.65 standard deviations from the mean, i.e. if we observe more than 16.5 suicides.

The data show 16.12 suicides in the periods around exams.

$\therefore$ Do not reject H_0.

This is a frustrating borderline result. We can reject the null hypothesis with 94% confidence, but not with the magic 95% confidence for which one usually hopes. Even that confidence might be thrown in doubt if the data did not include summertime suicides. However, Dean Raldolph stated that, because of the need to suppress billing for tuition and student loans in the event of suicide, his office tracks, and the data include, all summertime suicides (note the 3 suicides in July and 6 in June listed in Table I).

A second potential objection is that depression and suicides have been correlated with wintertime and holidays. The data, however, do not show that suicides are especially prevalent around Christmas or in the December—January period of dark and cold.

Other Hypotheses

Due to limited time and data, we did not test some of the alternative hypotheses postulated in the second section.

Conclusions and Recommendations

Our principal problem is that the data are sparse. With such sparse data, it is very difficult to reject null hypotheses. Even a two-headed coin cannot be rejected as fair with 95% confidence with fewer than six flips. When dealing with the subtleties of human psychology, i.e. there are many factors that may contribute to suicide, it is difficult to draw reliable conclusions without a lot of data. Thus, for future work it would be valuable to get data from other universities.

Despite the rarity of suicide, what data are available seem to support a reasonable hypothesis: students are more likely to kill themselves during exams and shortly before or a few weeks after. Current MIT Medical Department psychiatry staffing levels result in long waiting periods for counseling, even during off-peak times (typically students must wait three weeks or more before getting an appointment unless they are willing to admit suicidal feelings to a receptionist). We suggest that the Medical Department hire part-time counselors from one week before until three weeks after exam periods so that students may get help without waiting more than a day or two.