DATA SUPPLEMENT 1

Derivation of the excess pair statistic as an underestimate of the number of imitative suicides

We assume a suicide imitation model:

A1 imitation is the sole reason for space–time interaction in suicide rates;

A2 imitative suicides occur within the same space unit as the index case;

A3 imitative suicides occur with a maximum delay time, T, equal to the time threshold chosen to define closeness in time;

A4 the imitation process is such that each imitation causes only one close pair.

Assumption A4 that an index case gives rise to only one imitative case is an approximation. However, for the observed imitation rate of about 10%, the probability of an index case giving rise to two or more imitations decreases rapidly with the number of imitative cases.

A suicide can be classified as either imitative or spontaneous, where spontaneous suicides occur purely by chance.

By assumptions A1 to A3, pairs of cases can be close in time and space either: (1) as a result of imitation (such pairs consist of an imitative suicide and its index case) or (2) by chance.

The expected number of close pairs P is given by:

$$P = P_{(1)} + P_{(2)},$$

where $P_{(i)}$ is the expected number of close pairs in category $i \in \{1,2\}$.

The observed number of pairs that are close in space and time, O, is an unbiased estimate of the theoretical quantity P.

The mean number of close pairs of the permutation distribution, E, resulting from the Mantel procedure carried out with the whole sample size, n, is an estimate of the number of close pairs expected by chance under the independence model. Provided imitative suicides are rare, E can be considered an estimate of $P_{(2)}$, that is the number of close pairs expected by chance under the suicide imitation model. However, in this case the estimator suffers from upwards bias since the Mantel procedure counts all close pairs, including those from permutations that allocate imitative cases close in space and time to their respective index cases.

Owing to assumption A4, the number of close pairs due to imitation is, in fact, the number of imitative suicides in the sample, s. Thus $P_{(1)} = s$ and a downwards-biased estimate of s is given by the excess pairs statistic

$$O - E$$

Similarly the suicide rate s/n can be estimated by the relative excess pairs statistic

$$\frac{O - E}{n}$$