Seasonal Variation in the Occurrence of Homicide in Finland

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Objective: Although seasonal variation in impulsive aggression related to circannual rhythms of central serotonin neurotransmission is a topic of current interest, there is little firm knowledge on seasonality in the occurrence of homicide. Longitudinal studies on the seasonal rhythms of platelet imipramine binding and L-tryptophan levels have placed the circannual peaks around January and February and the nadirs around May and August. The aim of this study was to test the hypothesis that the number of homicides is the lowest during winter and the highest during spring and summer. A secondary hypothesis was that the seasonal variations in homicides and violent suicides are correlated. Method: The largest database on the monthly occurrence of homicide thus far (N=4,553) was used in this study, in which the monthly occurrence of all murders and manslaughters in Finland during the years 1957–1995 was analyzed. Results: During winter the homicide rate was 6% below the expected rate. Correspondingly, during summer there was a 6% elevation above the expected homicide rate, but no significant peak was observed in spring. There was a significant association between the monthly occurrence of homicides and violent suicides but not between homicides and nonviolent suicides. Conclusions: The results suggest that a seasonal variation in the occurrence of homicide exists. On the basis of current literature, it could be hypothesized that this seasonal variation and the correlation between the monthly occurrence of homicides and violent suicides are associated with the observed circannual rhythms of serotonin transmission.

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Low concentrations of the major serotonin metabolite 5-hydroxyindoleacetic acid (5-HIAA) in the CSF are known to be related to impulsivity and aggression (1–4), as are low levels of platelet paroxetine binding (5). A substantial seasonal variation in the frequency of suicide has been found, with peaks occurring in the spring and summer and lows in the autumn and winter (6–11). Seasonal effects associated with aggressive and impulsive behavior have been studied by investigating weekly or monthly variation in the occurrence of suicides and by examining the annual variation in factors reflecting serotonin (5-HT) function in the brain (12). Some studies on platelet 5-HT uptake (13, 14) and [^{3}H]imipramine binding (14–17) have detected the lowest levels in the spring and the highest levels in the late summer, whereas some other platelet 5-HT uptake studies (18) and imipramine binding studies (19, 20) have shown the lowest levels in the spring or summer and the highest levels in the winter. It has been reported that among normal control subjects, 5-HIAA concentrations were lower in the late winter and early spring than the values obtained in the summer and fall (21). There are no published data that would reveal the quantitative correlation between CSF 5-HIAA and platelet 5-HT uptake values, but several studies have confirmed that the 5-HT transporter protein in 5-HT neurons and the one in platelets are identical (22, 23).

Recent state-of-the-art longitudinal studies on plasma L-tryptophan levels and platelet imipramine binding indicate that tryptophan levels are highest in January and February and lowest in May (12, 24) and that the peaks of imipramine binding density are in February and the troughs are in August (25, 26). Maes et al. (12) noted a significant temporal relationship between seasonal variations in L-tryptophan availability and the occurrence of violent suicide in Belgium: there was a significant negative correlation between plasma L-tryptophan levels and the weekly total number of suicides.

There are grounds to suspect that seasonality of dysfunctional central 5-HT neurotransmission is related to both internally and externally directed violent behavior (21, 27). Studies on seasonal variation in the occurrence of suicide and 5-HT function in humans indicate that

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TABLE 1. Observed and Expected Frequencies of 4,553 Homicides in Finland in 1957–1995 by Season

Season[a]	Number of Homicides		Ratio[b]	95% Confidence Interval[c]
	Observed	Expected		
Winter	1,056	1,124.8	0.94	0.89–0.99
Spring	1,143	1,146.9	1.00	0.95–1.05
Summer	1,215	1,146.9	1.06	1.01–1.11
Autumn	1,139	1,134.4	1.00	0.95–1.05

[a]Winter=December to February, spring=March to May, summer=June to August, autumn=September to November.
[b]The observed number of homicides divided by the expected number of homicides if the null hypothesis is true.
[c]The difference between actual homicides and expected homicides is statistically significant if the value 1.00 does not fall within the 95% confidence interval.

there might exist seasonal variations in the occurrence of homicide, but no significant seasonal variation has been reported thus far. On the basis of the platelet L-tryptophan and imipramine binding studies (12, 24–26) it can be assumed that if a seasonal variation in the occurrence of homicide does exist, the peaks of occurrence would be in May and August and the lows in January and February.

Although the seasonality of suicides and the seasonal variations in biochemical factors related to aggression and impulsivity are topics of current interest, very little research has been carried out to evaluate circannual rhythms in the severity of violent acts or in the incidence of homicide. To our knowledge, no seasonality has been reported for impulsive or aggressive behavior other than homicidal or suicidal behavior, except for a study by Michael and Zumpe (28) which showed that the rape rate reaches its peak during the summer. So far, one of the largest studies of seasonality in homicide has been that of Maes and co-workers (10), in which all homicides in Belgium during the years 1979–1987 (N=1,462) were studied by means of spectral analysis. No significant circannual rhythms were found in the time series of homicides, nor has any significant seasonal variation in the occurrence of homicide been reported thus far in any other studies with smaller samples (28–32), although Goodman et al. (33), with a large sample (N=2,702), observed a slightly higher frequency of homicides during July and August.

If the magnitude of seasonal variation is related to the magnitude of the variation in climatic conditions, Finland is an ideal country in which to study the issue because of its extreme northern location. In addition, for several decades homicide statistics have been registered each month, providing a very large database. The aim of this study was to investigate seasonality in homicides occurring in Finland during the years 1957–1995 and to test the hypothesis that the number of homicides would be the lowest around January and February (winter) and the highest around May (spring) and August (summer). The relationship between the monthly frequency of homicides and violent versus nonviolent suicides was also investigated.

METHOD

The monthly numbers of homicides in Finland in the period from 1957 to 1995 were obtained from the *Official Statistics of Finland* from the series "Criminality Known to the Police" (Statistics Centre, 1957–1995). The numbers of all murders and manslaughters known to the police were sampled and analyzed in season intervals. The winter season was defined as December, January, and February; the spring season as March, April, and May; summer as June, July, and August; and autumn as September, October, and November. The monthly numbers of suicides were available for the years 1980–1995 and were also obtained from the *Official Statistics of Finland*, Statistics Centre. Suicides were classified in two categories: violent (hanging, drowning, shooting, wrist slashing, jumping from a high place) and nonviolent (poisoning, gas, other methods).

The chi-square test for multinomials was used as an overall measure of deviation (34). The null hypothesis was that homicides occur in a time interval (season) with a probability proportional to the length of that time interval. If there is no difference in homicide rates between time intervals, the chi-square value is small. The expected frequency of homicides in each time interval was calculated taking into account the unequal numbers of days in time intervals and the effect of leap years during the study period.

To locate more precisely the time intervals in which there was a possible departure from the null hypothesis, we calculated for each time interval the equation

$$\Pi/\Pi_0 \pm \left(\sqrt{\Pi\ (1-\Pi)/n)}\right) / \Pi_0\ ,$$

where Π is the observed proportion of homicides in the sample, Π_0 is the expected proportion of homicides when the null hypothesis is true, and n is the total number of homicides in the study period. If the null hypothesis is true, the value of the ratio Π/Π_0 is approximately 1.00. The null hypothesis was rejected if the 95% confidence interval of the ratio did not include the value 1.00. The relationship between homicides and suicides was studied with use of the Spearman correlation coefficient.

RESULTS

During the study period in the years 1957–1995, 4,553 homicides were recorded. The null hypothesis of no difference in homicide rates between seasons was rejected (χ^2=8.29, df=3, p=0.04). To identify the seasons in which the departure of the observed frequency of homicides from the expected frequency was statistically significant, the ratio Π/Π_0 with the 95% confidence interval was calculated for each season (table 1). In the winter the observed frequency of homicides was about 6% lower than the expected frequency, and in the summer about 6% higher. In the spring and autumn, the observed frequency of homicides did not differ statistically from the expected frequency. Table 2 demonstrates the deviations (%) between the observed and the expected homicide frequencies by month. The monthly mean number of homicides varied between 8.38 (SD=2.94) and 10.85 (SD=4.26).

During the years 1980–1995, the total number of suicides in Finland was 21,279, and 70.3% (N=14,965) of them were violent. When the monthly ratios of suicides and homicides (observed divided by expected) were analyzed, the homicide ratios were correlated with the violent suicide ratios (r=0.62, N=12, p=0.03) but not with the nonviolent suicide ratios (r=0.15, N=12, p=0.63).

TABLE 2. Observed and Expected Frequencies of 4,553 Homicides in Finland in 1957–1995 by Month

Variable	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Number of observed homicides	334	327	378	380	385	384	408	423	383	382	374	395
Number of expected homicides	386	352	386	374	386	374	386	386	374	386	374	386
Deviation[a] (%)	–13.6	–7.1	–2.2	1.6	–0.3	2.7	5.6	9.5	2.4	–1.1	0.0	2.2

[a]Of the observed number from the expected number.

DISCUSSION

The main finding of this study was that there is seasonal variation in the occurrence of homicides in Finland, with the peaks in summer (especially in July and August) and the troughs in winter (especially in January and February), and thus our hypothesis was accepted. The result was confirmed by analyzing the data with two statistical methods (34). To our knowledge, this is the first study to demonstrate a statistically significant seasonal variation in the occurrence of homicide.

The previous published studies with relatively small samples (10, 11, 28–31) failed to detect any seasonal variation in homicides, but the study by Goodman et al. (33) with a large sample showed a minor seasonal trend for homicides with a peak in summer, and especially in August, which is consistent with our results. The reasons for the partial discrepancy among different studies may be that true seasonal variations in aggressive behavior are so small that a very large database and a long follow-up time are needed for the phenomenon to be revealed. In addition, there are reports that latitude and climatic factors (i.e., day length, daily temperature, daylight, and humidity) may influence mood (35–37) and impulsive behavior (9). Since Finland is located in the extreme north (with the geographical coordinates between 60° and 70° N) and the climatic conditions vary greatly between seasons, the effect of season on violent offenses should be seen more clearly there than in countries nearer the equator.

A large proportion of Finnish homicide offenders have been reported to be impulsive antisocial alcoholics (38–40), and therefore it is possible to hypothesize that the frequency of homicides is lowest when serotonergic turnover has its seasonal peak and highest when serotonergic turnover is at its lowest. The low observed number of homicides in January and February is in line with longitudinal studies on plasma L-tryptophan levels (12, 24) and on platelet imipramine binding density (25, 26) which indicate that the seasonal peak in serotonergic turnover is around January and February. Our results showed a significant association between the monthly occurrence of homicides and violent suicides but not between homicides and nonviolent suicides. This is in accord with studies suggesting that both externally and internally directed violent behaviors are associated with dysfunctional 5-HT neurotransmission (21, 27).

The seasonal peak of homicide occurrence was seen in summer, which is consistent with studies on platelet imipramine binding showing the lowest values in August (25, 26). However, no prominent peak was seen in spring, as would have been anticipated on the basis of studies on seasonal variation of L-tryptophan levels (12, 24). It is well established that there is a seasonal variation in several other biochemical variables, not just in 5-HT-related markers (24, 41). Therefore, it is possible that seasonal variations in dopamine and testosterone may contribute to the seasonal variation in the occurrence of homicide, because both of these factors are associated with aggressive behavior (4, 42, 43).

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