ABSTRACT

Objectives: The authors examined the relationship of suicide in the elderly (65 years and older) to season and weather and compared it to that in the younger population (10-64 years).

Methods: Information on suicides and on weather was obtained for British Columbia for the period 1981 to 1991. The association of suicide with season and weather was assessed using Poisson regression.

Results: Whereas younger suicides were associated with season, showing a spring-summer peak, elderly suicides were associated with actual weather. They increased with higher mean daily temperature for the current month (RR=1.16, 95% CI 1.05-1.28 for each 2.5° C change in mean temperature), and with lower mean daily temperature for the preceding three months (RR=1.12, 95% CI 1.01-1.23).

Conclusions: Elderly suicide rates appear to be affected by deviations of monthly mean temperature from values expected for that time of year. Increased support by service agencies at times of predicted high risk is suggested.

ABRÉGÉ

Objectifs : les auteurs ont étudié le rapport existant entre le suicide chez les personnes âgées (65 ans et plus) d'une part et la saison ainsi que le temps d'autre part, et l'ont comparé aux mêmes données chez les plus jeunes (de 10 à 64 ans).

Méthodologie : les données sur les suicides et sur le temps ont été fournies par la Colombie-Britannique pour la période allant de 1981 à 1991. À l'aide d'une régression de Poisson, on a évalué l'association entre le suicide d'une part, et les saisons et le temps d'autre part.

Résultats : alors que les suicides chez les plus jeunes étaient correlés avec la saison, avec notamment une crête printemps-été, les suicides chez les personnes plus âgées étaient associés au temps. Le nombre de suicides augmentait parallèlement à l'augmentation de la température moyenne pour le mois en cours (RR = 1,16, 95 % IC 1,05 – 1,28 pour chaque changement de 2,5 ° C de la température moyenne), et parallèlement à une température moyenne plus basse au cours des trois mois précédant (RR = 1,12, 95 % IC 1,01 – 1,23).

Conclusions : les taux de suicide chez les personnes âgées semblent être influencés par les fluctuations des températures moyennes mensuelles par rapport aux prévisions pour la même période de l'année. On conseille de renforcer les services de soutien lors de prévisions de risque élevé.

The Effect of Season and Weather on Suicide Rates in the Elderly in British Columbia

Stephen A. Marion, MD, FRCPC,[1] *M. Oluwafemi Agbayewa,* MB, FRCPC,[2] *Sandi Wiggins,* MSc[1]

Suicide accounts for 2% of deaths in Canada.[1] As in many other countries, elderly suicide is an important public health issue, those 70 years of age and older having the highest suicide rate.[2-6] Suicide rates vary regionally,[7-15] and among Canadian provinces British Columbia had the highest suicide rate at the time of a national overview.[16] Among many factors with potential influence, season and weather effects are of interest. Better understanding of the relationship of suicide rates to season and weather may shed light on the biological and/or social pathways involved in suicide.[11,15,17-22] The relationship is also of practical interest since a demonstrated association might permit better timing of community interventions and lead to potentially more effective preventive strategies.

Many studies have investigated the relationship between season or weather and suicide.[11,15,20,23-28] We are aware of only one previous study that has related actual measurements of weather to suicides in specific age groups.[29]

Two distinct questions about suicide and weather have been investigated. The first is whether differences in suicide rates in different regions are due in part to differences in weather. This geographic variation question has been addressed in several ecological studies.[30-38] As potential confounders, one must also consider latitude, longitude, and demographic, social and economic factors that vary across regions and may also influence suicide rates.[20,24,39] These studies have tended to show higher suicide rates in areas with lower temperatures, decreased sunshine and more precipitation. However, this does not imply that suicides in these areas with "bad" weather actually occur at the time of the bad weather. In fact, studies of temporal variation have often (though not always) found that suicide rates tend to peak in the spring and summer,[25-27,30] and that higher temperatures are associated with an increased suicide rate.[40] By making comparisons between suicide rates and weather for different months within the same region, one can eliminate many of the potential confounders that complicate a geographic variation analysis.

The focus of this paper is the temporal variation of suicide rates in the elderly (age 65 and over). We examined the relationship of suicide, within local areas of British Columbia, with both season and basic elements of weather: daily sunshine, precipitation, maximum and minimum temperature. For comparison we also examined suicides in younger age groups. Geographic variation and socio-demographic factors are addressed in a separate report.[41] While deaths from motor vehicle accidents may include a substantial number of concealed suicides, they were not included in our study because any relation to the weather would be difficult to interpret given the obvious possible direct relationship between bad weather and genuine motor vehicle accidents.

University of British Columbia
1. Department of Health Care and Epidemiology
2. Department of Psychiatry
Correspondence and reprint requests: Dr. S.A. Marion, Department of Health Care and Epidemiology, Mather Building, 5804 Fairview Ave, Vancouver, BC, V6T 1Z3
Supported by a grant from the British Columbia Health Research Foundation

METHODS

The study spanned 11 years (1981-1991) and included all 21 health units in

British Columbia. Mortality information was obtained from the Division of Vital Statistics, Province of British Columbia. Two outcomes were constructed from ICD9 external codes: suicide (ICD9 codes E950-959), and selected possible suicides (E850-869, accidental poisoning; E922, accidental death firearm; E980-989, injury undetermined). Information included for each death consisted of all ICD9 codes, the health unit of residence, age, and gender.

Provincial populations by age and gender for the years 1981 to 1991 were estimates obtained from tables published by BC Stats (Ministry of Government Services, Province of British Columbia, Victoria, British Columbia). Trends in suicide rates over the 11-year period were evaluated using logit models with the actual population as the denominator, and adjusting for age (categorized into 5-year age groups to age 74, then 75 and over combined) and gender.

For each health unit one or more weather stations were identified with the assistance of an Environment Canada consultant (Earl Coatta, Scientific Services Division, Environment Canada, Vancouver, British Columbia, personal communication) based on proximity to the health unit and completeness of data. Thirty-two weather stations were selected.

Monthly suicide counts for each health unit over the 11-year period were calculated. These were compared with daily weather data for the same health unit averaged over the same month, and over three time periods prior to the given month. The prior periods were 1) the previous month, 2) the previous three months, and 3) the one-month period covering the second half of the previous month and the first half of the same month. As a validity check, we also examined associations of suicides in a given month with the corresponding three time periods following that month.

Expected counts for each month were derived by apportioning the annual total of outcome events for each health unit equally over the 12 months of that year, corresponding to the null hypothesis of no systematic variation within months of the same year. The (log of the) ratio of observed monthly counts to expected counts was analyzed by Poisson regression.

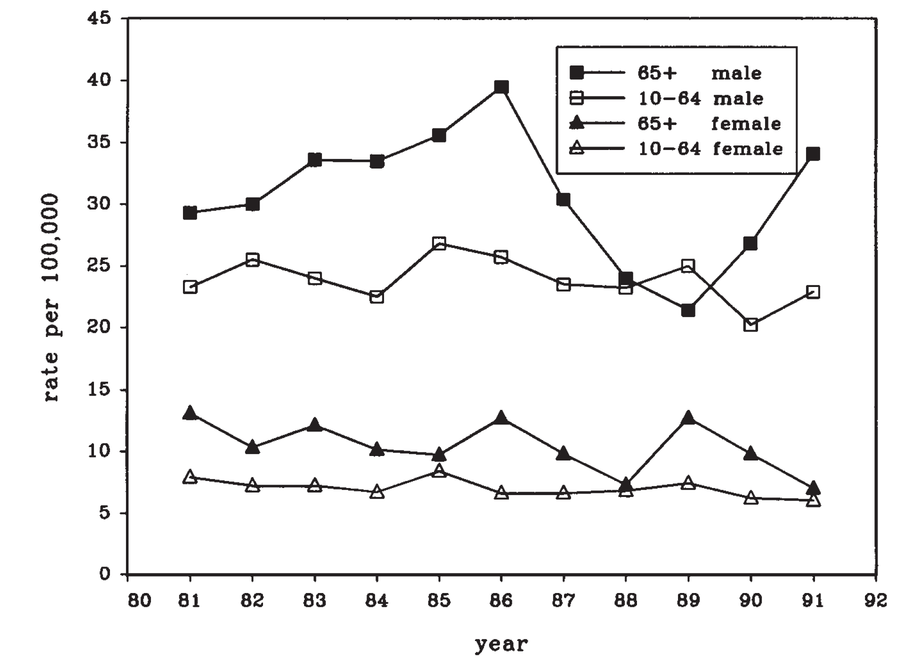

Figure 1. Rate of suicide in British Columbia by year, age group and gender.

TABLE I
Monthly Averages of Daily Weather Elements for 21 Health Units Over 11 Years (1981-1991)

	Mean	Standard Deviation*	Minimum	Maximum	Jan Mean	July Mean
Precipitation (mms)	6.0	1.94	0	51.0	12.9	1.6
Sunshine (hours)	5.0	1.03	0.1	13.6	1.6	8.8
Maximum temperature (° Celsius)	12.7	1.75	-25.9	33.2	2.7	22.9
Minimum temperature (° Celsius)	3.6	1.11	-33.3	14.6	-3.4	11.5

* median of 12x21 across year within month and health unit standard deviations

Regression models assessed the influence of each weather element separately both with and without adjustment for month of the year or season. Season was defined by dividing months into four categories (December-February, March-May, June-August, September-November). Stepwise regression was used to build a multivariable weather model, adjusted for season. Variables with a two-tailed p-value of 0.1 or less by the score test were considered statistically significant. Interactions among significant variables as well as with gender and season were assessed. Homogeneity of effects across all 21 health units was checked.

Based on preliminary data from coroners' reports,[7] we anticipated about 425 elderly suicides over an 11-year period. Our calculated power to detect a relative risk of 1.4 due to adverse weather (i.e., weather for each time period dichotomized into above average or below average) was 93%. Actual power was greater since the number of suicides in Vital Statistics data was substantially higher than had been estimated from coroners' reports.

RESULTS

There were 758 (69.4% male) suicides in the elderly over the 11-year period. The corresponding number for the younger population was 3,900 (77% male). The trend over time is shown in Figure 1. A decreasing trend is evident for the younger group (X^2=5.58, df=1, p=0.02). There were decreasing trends in selected possible suicides for both the senior and the younger age groups (graphs not shown).

A summary of monthly weather data is presented in Table I. Even within a given

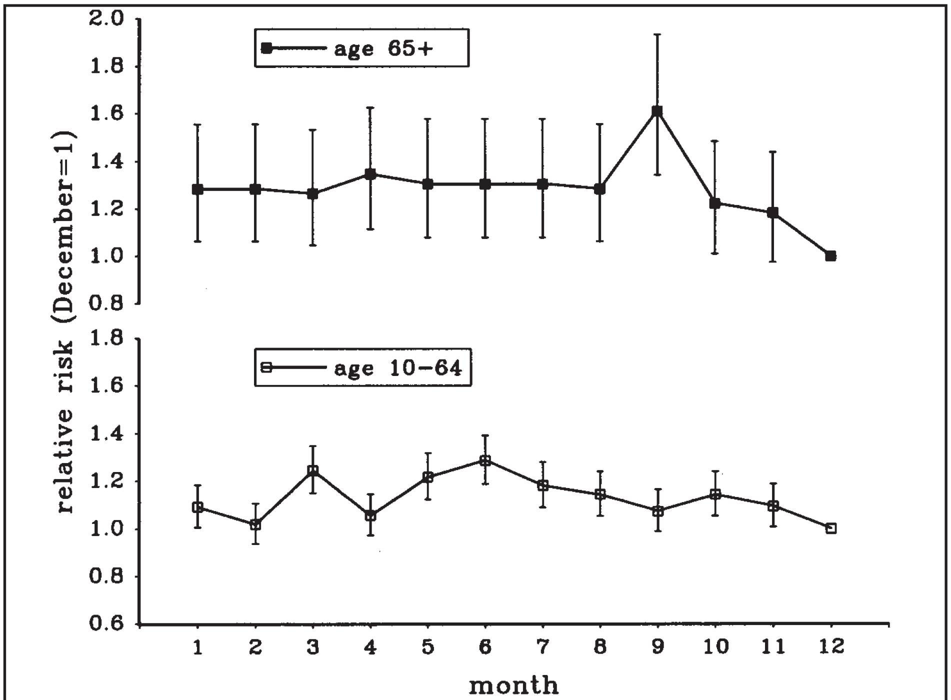

Figure 2. Relative risk of suicide for each month compared to December, with adjustment for health unit and year. Error bars indicate one standard error (calculated on the log scale and translated back to the relative risk scale).

TABLE II
The Relationship of Weather Elements, Adjusting for Season, to Elderly Suicide Rates in British Columbia 1981-1991: Final Model*

Variable	Coding	Coefficient	Standard Error	Relative Risk	95% CI for Relative Risk
Month	**Categorical**				
January	0 or 1	0.0594	0.2114	1.06	0.70–1.61
February	0 or 1	-0.0357	0.2337	0.96	0.61–1.53
March	0 or 1	-0.1929	0.2596	0.82	0.50–1.37
April	0 or 1	-0.2103	0.2717	0.81	0.48–1.38
May	0 or 1	-0.3635	0.2964	0.70	0.39–1.24
June	0 or 1	-0.4869	0.3104	0.61	0.33–1.13
July	0 or 1	-0.4022	0.3051	0.67	0.37–1.22
August	0 or 1	-0.3116	0.2852	0.73	0.42–1.28
September	0 or 1	0.1561	0.2321	1.17	0.74–1.84
October	0 or 1	0.1137	0.2142	1.12	0.74–1.70
November	0 or 1	0.1821	0.2022	1.20	0.81–1.78
Current Month Mean Daily Minimum Temperature	Continuous (units of 2.5° C)	0.1458	0.0500	1.16	1.05–1.28
Preceding Three Month Mean Daily Minimum Temperature	Continuous (units of 2.5° C)	-0.1117	0.0500	0.89	0.81–0.99

* Mathematically: $\ln(E(r)) = \sum_{i=1 \text{ to } 11} b_i M_i + \sum_{i=1 \text{ to } 2} c_i T_i$

where E is expectation, *r* is the relative risk (observed/expected), b_i and c_i are the coefficients in the table, M_i are the month indicator variables with December as reference, and T_1 and T_2 are the deviations of mean minimum temperatures for the current month and the prior three months, respectively, from reference values. (The choice of reference values does not affect the coefficients.)

health unit, there was substantial variation in monthly averages for all four weather elements. The different weather elements for a given month were highly correlated and there was also a high correlation across neighbouring months.

Figure 2 shows the variation in elderly suicide rates by month. The rates were lowest in December and highest in September, but the monthly variation overall was not statistically significant (X^2=13.7, df=11, p=0.24). The variation by season was also not statistically significant (X^2=1.47, df=3, p=0.69). Figure 2 also shows the seasonal variation in rates of younger suicides. This was statistically significant (X^2=22.5, df=11, p=0.02), with spring and summer having higher rates than winter and fall (X^2=12.8, df=3, p=0.005).

In the elderly, higher suicide rates were associated with higher temperatures for a given month, but with very modest relative risks (for a 2.5° C rise in daily maximum temperature RR = 1.02, 95% CI = 1.00-1.05 and for a similar rise in daily minimum temperature, RR = 1.03, 95% CI = 1.00-1.07). Minimum and maximum temperature remained significant after adjustment for month of the year. Similar associations were found when minimum and maximum temperature were lagged by half a month. No other weather variables approached significance. The observed temperature effect appeared to be homogeneous across health units and across seasons.

After adjustment for the mean daily minimum temperature for the current month, lower mean daily minimum temperature for the preceding three months was significantly (X^2=4.87, df=1, p=0.03) and independently associated with higher suicide rates in the elderly (Table II). The relative risk associated with a 2.5° C increase in current month daily minimum temperature was 1.16 (95% CI 1.05-1.28), and with a 2.5° C decrease in the daily minimum temperature for the preceding three months was 1.12 (95% CI 1.01-1.23).

In the younger age group elevated mean daily minimum and maximum temperature for the current month were also associated with a higher suicide rate, but these associations disappeared after adjustment for the calendar month. There was no association of selected *possible* suicides with month or with minimum or maximum temperature in either seniors or in the under 65 group.

DISCUSSION

We found an association between higher elderly suicide rates and warmer temperatures. This is similar to the findings of Salib et al. in England.[29] Since the association that we found persisted with adjustment for month of the year, we conclude that it was the deviation of the mean temperature from the expected mean temperature for that month, rather than the absolute temperature, that was important. This differs from the younger population where season was important. We also found an independent association of suicide rates in the elderly with colder temperatures in the three preceding months. Particularly inauspicious, according to our model, is a transition from unusually cool weather to unusually warm weather. The combination of a 2.5° C cooler preceding three months together with a 2.5° C warmer current month is associated with a 30% increase in the elderly suicide rate. The temperature deviation effects appeared similar across health units and across seasons. The number of suicides among elderly women was too small to permit a separate analysis, and we are unable to say whether the results apply equally to women.

Elderly suicide rates in British Columbia did not have a discernible independent relationship to season, nor to average sunshine or precipitation. This negative result was not due to lack of power (considering the prior power calculation). It was also not due to lack of variability in the observed weather: British Columbia experienced large year-to-year variations in weather for a given month and health unit.

In the younger age group we found a clear seasonal effect with an 11% increase in suicide rate in spring and summer versus fall and winter. Higher temperatures were associated with a higher suicide rate in the younger group, but this effect disappeared with adjustment for season. The association between season and suicide rates in the younger age group is similar to that observed in many previous temporal variation studies.[25-27,30] The September peak that we observed for rates of suicide in the elderly was not statistically significant, but for all ages combined, Populi et al.[11] found a September peak, and other researchers have found a secondary fall maximum.[36]

Confounding by age, gender, latitude, longitude, and socio-demographic factors, as well as geographic and longer-term temporal variation in categorizing deaths as suicides, is controlled in our season/weather analysis by stratifying by health unit and year. Expected counts were specific to each health unit and year and thus adjust for health-unit-specific factors that can be assumed to be reasonably constant within a given year. As a corollary, however, factors which do not vary within health units within a given year, such as degree of urbanization, cannot be addressed by this methodology.

Errors in classifying deaths as suicides would only affect our results if misclassification varied systematically across months *within* health units and years. Such misclassification should produce a complementary shift in possible suicides, which was not found. There was an imperfect correspondence between weather stations and health units in our study, and hence misclassification of the true local weather. The British Columbia weather data could not be obtained at a geographically finer level because the number of weather stations with reasonably complete data is too small. A strength of our results, however, is that we showed an association in spite of this, indicating that one does not need unrealistically precise weather information to predict changes in elderly suicide rates.

Suicide is a complex phenomenon. We do not believe that suicide in the elderly can be explained by the weather, but rather suggest that a certain weather pattern may be a trigger mechanism. Colder than normal weather may cause depression in the vulnerable, either because of a direct biological effect or because of interference with mobility, activities of daily living or social contacts. Subsequent return of better weather tends to relieve the depression, but during the initial phase of activation, the suicide risk may actually increase (analogous to the initial response of some patients to antidepressants). If this hypothesis is true, some elderly suicides may be preventable by interventions which counteract the biological and/or isolating effects of cold weather and anticipate the paradoxical response to warming weather.

REFERENCES

1. Canadian Centre for Health Information, Statistics Canada. Deaths 1993. *Health Reports* 1995;7:51-60.
2. Delisle I. [Suicide at the age of retirement]. [French]. *Canadian Nurse* 1992;88:39-41.
3. Ohara K, Xie D, Matsunaga T, et al. The middle-aged generation is at high risk for suicide in Japan. A comparison between the 1950s and the 1980s. *Acta Psychiatrica Scandinavica* 1994;90:14-15.
4. McIntosh JL. Suicide among the elderly: Levels and trends. *Am J Orthopsychiatry* 1985;55:288-93.
5. Manton KG, Blazer DG, Woodbury MA. Suicide in middle age and later life: Sex and race specific life table and cohort analyses. *J Gerontol* 1987;42:219-27.
6. De Leo D, Ormskerk SC. Suicide in the elderly: General characteristics. [Review]. *Crisis* 1991;12:3-17.
7. Agbayewa MO. Elderly suicide in British Columbia: An exploration of regional variation and related factors. *Can J Public Health* 1993;4:231-36.
8. Crombie IK. Suicide in England and Wales and in Scotland. An examination of divergent trends. *Br J Psychiatry* 1990;157:529-32.
9. La Vecchia C, Lucchini F, Levi F. Worldwide trends in suicide mortality, 1955-1989. *Acta Psychiatrica Scandinavica* 1994;90:53-64.
10. Diekstra RF. Suicide and attempted suicide: An international perspective. *Acta Psychiatrica Scandinavica, Supplementum* 1989;354:1-24.
11. Popoli G, Sobelman S, Kanarek NF. Suicide in the State of Maryland, 1970-80. *Public Health Reports* 1989;104:298-301.
12. Surtees PG, Duffy JC. Suicide in England and Wales 1946-1985: An age-period-cohort analysis. *Acta Psychiatrica Scandinavica* 1989;79:216-23.
13. Woodbury MA, Manton KG, Blazer D. Trends in US suicide mortality rates 1968 to 1982: Race and sex differences in age, period and cohort components. *Int J Epidemiol* 1988;17:356-62.
14. Dyck RJ, Newman SC, Thompson AH. Suicide trends in Canada, 1956-1981. *Acta Psychiatrica Scandinavica* 1988;77:411-19.
15. Massing W, Angermeyer MC. The monthly and weekly distribution of suicide. *Soc Sci Med* 1985;21:433-41.
16. National Task Force on Suicide. Suicide in Canada. Ottawa: Health and Welfare Canada, 1987.
17. Pine DS, Trautman PD, Shaffer D, et al. Seasonal rhythm of platelet [3H] imipramine binding in adolescents who attempted suicide. *Am J Psychiatry* 1995;152:923-25.
18. Jones JS, Stanley B, Mann JJ, et al. CSF 5-HIAA and HVA concentrations in elderly depressed patients who attempted suicide. *Am J Psychiatry* 1990;147:1225-27.
19. Arango V, Ernsberger P, Marzuk PM, et al. Autoradiographic demonstration of increased

serotonin 5-HT2 and beta-adrenergic receptor binding sites in the brain of suicide victims. *Arch Gen Psychiatry* 1990;47:1038-47.
20. Araki S, Murata K. Suicide in Japan: Socioeconomic effects on its secular and seasonal trends. *Suicide & Life-Threatening Behavior* 1987;17:64-71.
21. Arora RC, Meltzer HY. Serotonergic measures in the brains of suicide victims: 5-HT2 binding sites in the frontal cortex of suicide victims and control subjects. *Am J Psychiatry* 1989;146:730-36.
22. Pandey GN, Pandey SC, Dwivedi Y, et al. Platelet serotonin-2A receptors: A potential biological marker for suicidal behavior. *Am J Psychiatry* 1995;152:850-55.
23. Maes M, Cosyns P, Meltzer HY, et al. Seasonality in violent suicide but not in nonviolent suicide or homicide. *Am J Psychiatry* 1993;150:1380-85.
24. Kok LP, Tsoi WF. Season, climate and suicide in Singapore. *Medicine, Science & the Law* 1993;33:247-52.
25. Kevan SM. Perspectives on season of suicide: A review. *Soc Sci Med* 1980;14D:369-78.
26. McCleary R, Chew KSY, Hellsten JJ, Flynn-Bransford M. Age- and sex-related cycles in United States suicides, 1973 to 1985. *Am J Public Health* 1991;81:1494-97.
27. Aschoff J. Annual rhythms in man, In: Aschoff J (Ed.), *Handbook of Behavioral Neurobiology.* New York: Plenum Press, 1981;475-87.
28. Tietjen GH, Kripke DF. Suicides in California (1968 - 1977): Absence of seasonality in Los Angeles and Sacramento counties. *Psychiatric Research* 1994;53:161-72.
29. Salib E. Elderly suicide and weather conditions: Is there a link? *Int J Geriatric Psychiatry* 1997;12:937-41.
30. Durkheim E. *Suicide.* (Translation of *Le Suicide* Paris: 1897). New York: The Free Press, 1951.
31. Dublin LI. Seasonal rhythms in suicide, In: Anonymous (Ed.), *Suicide: A Sociological and Statistical Study.* New York: Ronald Press Co., 1963;56-60.
32. Pokorny AD, Davis S, Haberson W. Suicide, suicide attempts and weather. *Am J Psychiatry* 1963;120:377-81.
33. Eastwood MR, Peacocke J. Seasonal patterns of suicide, depression and electroconvulsive therapy. *Br J Psychiatry* 1976;129:472-83.
34. Wenz FV. Effects of seasons and sociological variables on suicidal behavior. *Public Health Reports* 1977;92:233-39.
35. Moser KA, Jones DR, Fox AJ, Goldblatt PO. Unemployment and mortality: Further evidence from OPCS longitudinal study 1971 - 1981. *Lancet* 1986;II(15):365-66.
36. Lester D. Suicide and homicide rates: Their relationship to latitude and longitude and to weather. *Suicide and Life-Threatening Behavior* 1986;16:356-59.
37. Souêtre E, Salvati E, Blugou JL, et al. Seasonality of suicides: Environmental, sociological and biological covariations. *J Affective Disorders* 1987;13:215-25.
38. Morgenstern H. Uses of ecological analysis in epidemiological research. *Am J Public Health* 1982;72:1336-44.
39. Araki S, Murata K. Social life factors affecting suicide in Japanese men and women. *Suicide & Life-Threatening Behavior* 1986;16:458-68.
40. Maes M, De Meyer F, Thompson P, et al. Synchronized annual rhythms in violent suicide rate, ambient temperature and the light-dark span. *Acta Psychiatrica Scandinavica* 1994;90:391-96.
41. Agbayewa MO, Marion SA, Wiggins S. Socioeconomic factors associated with suicide in elderly populations in British Columbia: An 11-year review. *Can J Psychiatry* 1998;43:829-36.

Received: November 5, 1996
Accepted: June 24, 1999