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Research report

A re-examination of seasonal variation in suicides in Australia and New Zealand

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Abstract

Background: To examine the seasonality of suicides in Australia and New Zealand during the period 1981 to 1993. *Methods*: A chi-square test and a harmonic analysis were used to detect the seasonality of the suicide data. *Results*: The reduced amplitude and a smaller proportion of variance accounted for by seasonality suggested the seasonal effect on suicide is greatly diminished. The absence of biseasonal distribution of female suicides was also consistently found in the two countries. The finding was contrary to the reported results in seventies in many Western countries. *Conclusions*: The change in living condition, roles of males and females and communication pattern resulted in the reduction of climatic and environment effect in the seasonality of suicides were suggested. *Limitations*: The results would be better if a longer series of suicide date were available. © 1998 Elsevier Science B.V.

Keywords: Harmonic analysis; Seasonal variation; Suicides

1. Introduction

The seasonal variations of suicidal deaths has long been recognised and documented since the days of Durkheim (Durkheim, 1897). Most reports, despite great variations in locality and timing of study, socio-cultural backgrounds, and ways of ascertainment, did document a peak of suicidal deaths in the spring/summer seasons and a trough in winter months (Lester, 1971; Eastwood and Peacocke, 1976; Massing and Angermeyer, 1985; Micciolo et al., 1991; Souetre et al., 1987; Ho, 1996). The authors suggested a universal psychosocial process behind the phenomenon of suicides. More recently, further variations of this seasonal distribution has been noted. They included the sex differences in seasonal distribution of suicides and method specific seasonal distribution of suicidal deaths. In the past 15 years, at least four papers have documented a biseasonal distribution of suicidal deaths in females whereas there is only a single cycle in males. The years and place of these studies included Britain in 1958–1974 (Meares et al., 1981), Finland in 1961–

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1976 (Nayha, 1982), Australia in 1971–1976 (Parker and Walter, 1982), and Italy in 1969–1981 (Micciolo et al., 1989). All the above studies were carried out in the West and all consistently reported a small second peak of suicidal deaths were found in the autumn months for females. However, Flisher et al. (1997) investigated the monthly occurrence of suicides in South Africa between 1980–1989 and didn't detect a secondary (autumn) peak for females. More recently, Ho et al. (1997) examined suicide data in Hong Kong and Taiwan in the years 1981 to 1993. Despite the differences in ascertainment procedures and preferred methods of suicides only a single peak of suicidal deaths could be found in both males and females. It is noteworthy that the study was carried out in a non-Western social setting and a similar statistical method used by (Micciolo et al., 1989) was employed. Thus, the universality of biseasonal distribution of female suicides did not seem to apply at least in these three localities. Furthermore, a reduction of the proportion of variance accounted for by seasonality was noted. For example, Micciolo et al. (1989) suggested a 48–65% of variability of monthly occurrence were explained by seasonal components whereas only 25% and 32% were found in Hong Kong and Taiwan respectively (Ho et al., 1997). Similarly, the second harmonic (two cycles per year) were found to be significant for female suicides and accounted for 12.1% and 24.6% of the total variance and of seasonal variance respectively (Micciolo et al., 1989). The corresponding values for the proportion of variances explained by the second harmonic for females were 0.2% and 1% (Hong Kong); 3.9% and 11.6% (Taiwan) (Ho et al., 1997).

Another line of research began to suggest that the seasonal distribution of suicides is associated with the method of suicides. Lester and Frank (1988), based on suicide data in the U.S. in 1980, reported that the seasonal distribution of suicidal deaths varied with the methods of suicides. Maes et al. (1993) studied suicidal deaths in Belgium in the years 1979–1987. Seasonality was found to be present in violent but not in nonviolent suicides, and the young and elderly suicide victims had different peaks. It is hypothesised that the seasonal pattern of the availability of plasma L-tryptophan may be associated with seasonal distribution of violent suicides (Maes et al., 1995). In short, there could be several confounding factors in determining the seasonality of suicides, namely: gender, methods of suicides, and possibly age. The present study attempts to delineate the seasonal distribution of suicidal deaths by these three factors. Because of the large number of possible groupings, a large number of population based suicidal deaths are required. In the present study, monthly suicidal deaths in the two countries in Southern Hemisphere, namely Australia and New Zealand in the years 1981 to 1993 were the data base. To avoid confounding by the use of different statistical methods, we specifically apply the same type of analysis as employed by Micciolo et al. (1989) and Ho et al. (1997).

2. Method

Data of all suicide deaths in Australia and New Zealand in the period of January 1981 to December 1993 were made available by the Australian Bureau of Statistics (Australia) and National Health Statistics Centre of Department of Health (New Zealand) respectively. Both countries have a similar system of ascertainment of deaths due to unnatural causes through the Coroner's court. The suicide data included here related to cases where judicial inquiries established that the deaths were due to suicide. They were coded as the external cause of death E950-E959 of the ICD-9 (World Health Organization, 1978).

The seasonal variations of suicides were examined in three ways. First, the number of suicides for each month in the past 13 years for Australia and New Zealand were plotted separately for each sex. Second, a chi-square test is used to test the evenness of the monthly distribution of the suicide number. Third, a harmonic analysis was applied. The method was similar to that employed by Micciolo et al. (1991) and Ho et al. (1997) and described in details by Pocock (1974). It is assumed that the total variance of the distribution of the monthly suicide data for the period of 1981–1993 can be decomposed into three components: random, seasonal and non-seasonal; in this way it is possible to calculate the percentage of total variance attributable to seasonal variation as well as to random and non-seasonal

variation. The details of the method and testing the significance of various harmonics can be found in the Appendix.

3. Results

A total of 28073 (22017 males and 6056 females) and 5439 suicides (4200 males and 1239 females) were identified in Australia and New Zealand respectively for the period 1981–1993. Table 1 shows the standardized (with respect to the year 1986) and crude suicide rates for Australia and New Zealand respectively. The crude suicide rates are usually larger than the standardized suicide rates because of ageing problem and aged suicide rate is generally higher than average. The phenomenon was more obvious in Australia than in New Zealand. The average standardized suicide rates from 1981 to 1993 for males and females in Australia were 20.6 and 5.7 per 100,000 respectively. Likewise, the corresponding rates for New Zealand were 18.6 and 5.3 respectively. Australia and New Zealand both recorded a decrease in suicide rates since 1990. The monthly distribution of suicides, for males and females, in 1981–1993 is given in Fig. 1. There is no obvious pattern especially among female Australians. The cumulative number of suicides, both males and females, and the expected number (under the evenly distributed assumption) in the past 13 years in Australia and New Zealand can be found in Table 2. A χ^2 test gives the significance results for Australian males ($P < 0.01$) and New Zealand males ($P = 0.05$) and females ($P < 0.05$).

Table 3 shows the results of harmonic analysis and the proportion of variances in suicide explained by random, seasonal and non-seasonal components for Australia and New Zealand respectively. Only 17% and 3% of the total variations can be explained by the seasonal components for males and females in Australia respectively. For New Zealand only 6% of the total variations can be explained by the seasonal components for both males and females. The only important seasonal harmonic was the one cycle per year for males in Australia; one cycle for females in New Zealand which was just marginal significant ($P = 0.05$), see Appendix. Further analysis by age groups and methods of both countries are given in Tables 4–7. No significant results were found except among Australian males groups of aged 15–24 and 40–59 and the method of hanging which demonstrated the existence of one cycle per year. For New Zealand, males aged 15–24 demonstrated the existence of one cycle per year. The suicide deaths of the other groups can be treated as a random event and no significant pattern was found.

Table 1
Standardised Suicide Rates (per 100 000), Australia and New Zealand, 1981–1993

Year	Australia			New Zealand		
	Persons	Males	Females	Persons	Males	Females
1981	13.8 (13.8)	20.8 (20.5)	6.9 (6.8)	10.6 (10.2)	16.2 (15.5)	5.1 (4.9)
1982	14.0 (13.8)	21.0 (20.7)	7.1 (7.0)	11.6 (11.3)	16.5 (16.1)	6.8 (6.6)
1983	13.1 (13.0)	20.3 (20.1)	6.1 (6.1)	11.0 (10.8)	16.0 (15.8)	6.1 (6.0)
1984	13.3 (13.3)	20.6 (20.5)	6.1 (6.1)	12.5 (12.3)	19.1 (18.8)	5.9 (5.9)
1985	13.9 (13.9)	21.6 (21.5)	6.3 (6.3)	10.2 (10.2)	15.6 (15.5)	5.0 (5.0)
1986	15.0 (15.0)	23.3 (23.3)	6.8 (6.8)	12.8 (12.8)	19.0 (19.0)	6.8 (6.8)
1987	15.6 (15.6)	25.0 (25.1)	6.3 (6.3)	13.9 (14.0)	22.1 (22.2)	5.9 (5.9)
1988	15.3 (15.4)	24.2 (24.5)	6.4 (6.5)	14.8 (15.0)	23.5 (23.6)	6.4 (6.5)
1989	14.3 (14.4)	22.8 (23.0)	5.8 (5.9)	13.5 (13.6)	22.0 (22.2)	5.3 (5.3)
1990	15.0 (15.1)	24.1 (24.3)	6.0 (6.1)	13.5 (13.5)	22.0 (22.0)	5.2 (5.3)
1991	15.2 (15.5)	24.1 (24.6)	6.4 (6.5)	13.7 (13.8)	22.4 (22.5)	5.2 (5.3)
1992	14.9 (15.1)	23.8 (24.1)	6.1 (6.2)	14.4 (14.4)	23.7 (23.5)	5.4 (5.4)
1993	12.0 (12.2)	19.7 (20.1)	4.4 (4.5)	12.1 (12.2)	19.4 (19.4)	5.1 (5.2)
Average	14.3 (14.3)	22.4 (22.5)	6.2 (6.2)	11.9 (12.6)	18.6 (19.7)	5.3 (5.7)

Standardised per 100 000 of their respective mid-year 1986 population
Values inside the brackets are the crude suicide rates

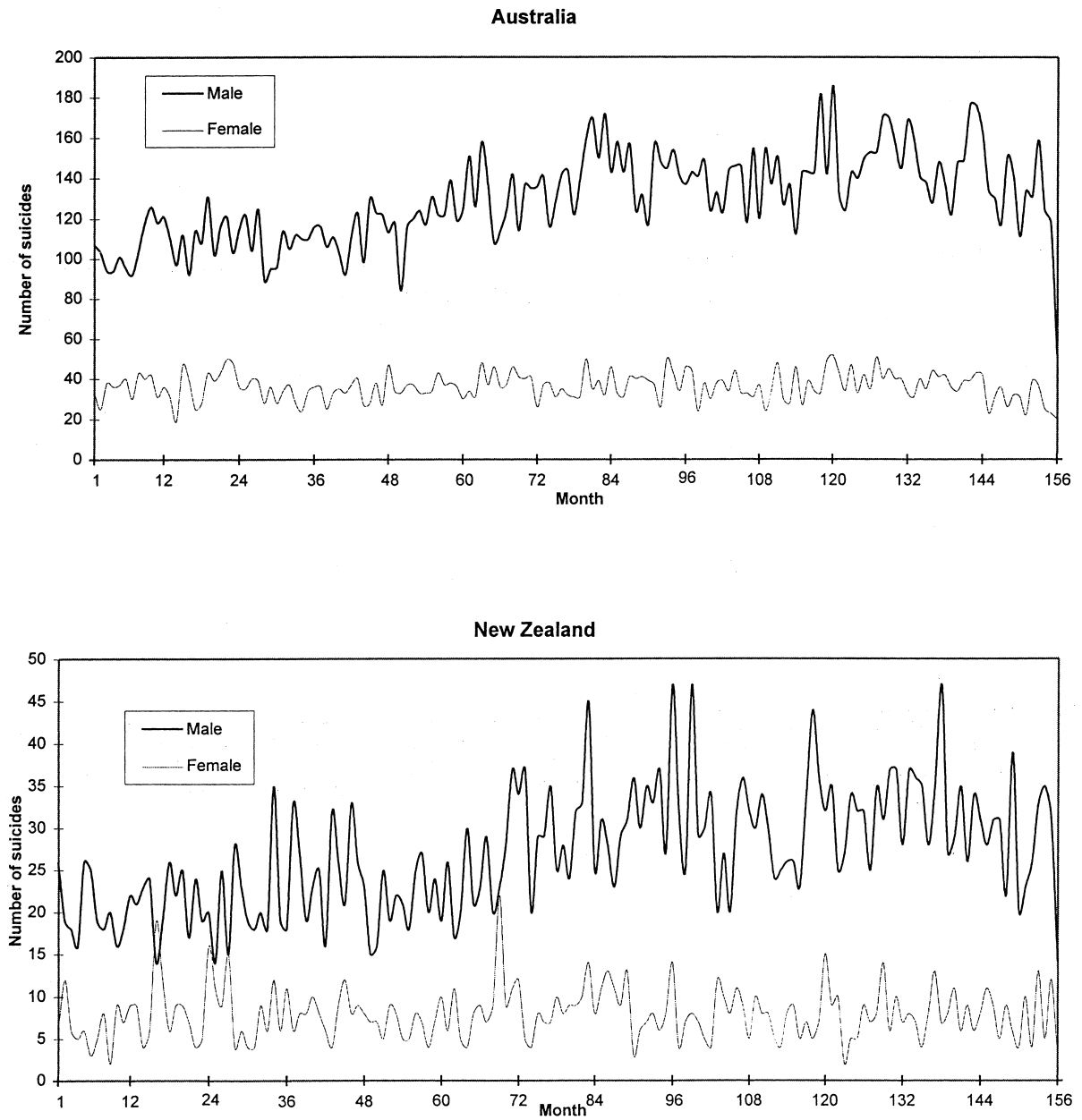

Fig. 1. Monthly Distribution of Suicide Death, 1981–1993.

4. Discussion

The present study attempted to examine the seasonality of suicides with respect to different gender, age groups and method of suicides. As far as gender is concerned, the only important seasonal rhythm we found, if there is any, is the one cycle per year. There is no convincing evidence of a second peak among females in both Australia and New Zealand. The finding, while in line with that of Ho et

Table 2
The Observed and Expected number of Suicides by Months and Gender, Australia and New Zealand, 1981–1993

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Australia												
Male												
Observed	1747	1552	1699	1571	1619	1516	1707	1720	1794	1818	1756	1695
Expected	1714	1561	1714	1659	1714	1659	1714	1659	1714	1659	1714	1659
Female												
Observed	438	405	518	450	464	465	507	490	484	469	487	
Expected	478	435	478	463	478	463	478	463	478	463	478	463
New Zealand												
Male												
Observed	365	326	343	325	363	350	317	333	344	400	389	345
Expected	357	325	357	345	357	345	357	345	357	345	357	345
Female												
Observed	103	109	91	101	101	78	94	106	121	98	111	126
Expected	105	96	105	102	105	102	105	102	105	102	105	102

Chi-square = 46.31 (male); 14.29 (female) for Australia
Chi-square = 19.29 (male); 19.78 (female) for New Zealand

Table 3
Harmonic Analysis of Monthly Suicide Data, Australia and New Zealand, 1981–1993

	Australia				New Zealand			
Component of variance	Male		Female		Male		Female	
All seasonal harmonics	37.03	17%	1.20	3%	1.88	6%	0.58	6%
one cycle	26.26	71%	0.03	3%	0.64	34%	0.30	52%
two cycles	4.58	12%	0.28	24%	0.66	35%	0.00	0%
three cycles	0.00	0%	0.00	0%	0.57	31%	0.08	14%
four cycles	0.00	0%	0.88	74%	0.00	0%	0.00	1%
five cycles	0.00	0%	0.00	0%	0.00	0%	0.20	34%
six cycles	6.19	17%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	46.80	22%	0.00	0%	0.52	2%	1.08	11%
Random variations	129.44	61%	36.10	97%	26.93	92%	7.95	83%
Total variance	213.27	100%	37.29	100%	29.33	100	9.61	100%

al. (1997), stood in contrast with previous studies reported in the West (Meares et al., 1981; Nayha, 1982; Micciolo et al., 1989). In a previous study on suicide data in the New South Wales of Australia in the years 1971–1976 (Parker and Walter, 1982), a second peak of female suicide was reported. Though Parker and Walter (1982) also applied harmonic analysis, they did not break the variances into components as the present study did. It makes a cross study comparison difficult. In any case, a biseasonal distribution of female suicide was not evident, at least in the 1980s in Australia and New Zealand. The present finding added weight to that report by Ho et al. (1997) that autumn peak of female suicides is not universal (not even in Western setting). And even if it was evident in the 1970s, it might not be true in the 1980s and early 1990s. On the other hand, some of the age groups of the suicide victims and the method of suicide made a significant contribution to the seasonal rhythm (one cycle per year) of suicides in the years studied. Our findings suggested that they alone could account for the seasonal distribution of suicide deaths. Hence, both age and method of suicides can be important confounding factors in the study of seasonality. There existed a large number of literature documenting the

Table 4
Harmonic Analysis of Monthly Suicide Data by age and gender, Australia, 1981–1993

	Males							
Component of variances	15–24		25–39		40–59		60 or over	
All seasonal harmonics	4.28	13%	0.93	2%	5.69	14%	1.07	4%
one cycle	1.74	41%	0.31	34%	4.00	70%	1.03	96%
two cycles	1.09	25%	0.00	0%	0.51	9%	0.00	0%
three cycles	0.35	8%	0.62	66%	0.40	7%	0.00	0%
four cycles	0.00	0%	0.00	0%	0.27	5%	0.00	0%
five cycles	0.00	0%	0.00	0%	0.05	1%	0.00	0%
six cycles	1.10	26%	0.00	0%	0.46	8%	0.04	4%
Non-seasonal harmonics	2.29	7%	5.76	12%	0.00	0%	1.38	5%
Random variations	26.33	80%	42.54	86%	35.48	86%	24.49	91%
Total variance	32.90	100%	49.22	100%	41.17	100%	26.93	100%
	Females							
Component of variances	15–24		25–39		40–59		60 or over	
All seasonal harmonics	0.35	7%	0.12	1%	0.67	5%	0.66	7%
one cycle	0.00	0%	0.00	0%	0.00	0%	0.33	50%
two cycles	0.00	0%	0.00	0%	0.11	17%	0.19	29%
three cycles	0.26	74%	0.00	0%	0.10	15%	0.05	7%
four cycles	0.00	0%	0.03	23%	0.33	50%	0.00	0%
five cycles	0.00	0%	0.10	77%	0.12	18%	0.09	13%
six cycles	0.09	26%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Random variations	5.02	93%	10.60	99%	11.58	95%	8.80	93%
Total variance	5.37	100%	10.72	100%	12.24	100%	9.46	100%

availability of a particular means of suicide may affect the overall or method-specific suicide rate (Kreitman, 1976; Oliver and Hatzel, 1972; Carrington and Moyer, 1994; Ho, 1996; Yip, 1996). It seems the choice of suicide method depends largely on the availability (and hence it affect the suicide rates). However, in some cases they can also be related to seasonal fluctuations of suicide occurrences.

The other finding in the present study is the reduced amplitude and small proportion of variances accounted for by the seasonality (all seasonal harmonics) was found with regard to the incidence of suicides. Examining studies that reported similar compartmentation of variances of seasonal distribution of suicides, Micciolo et al. (1989) reported 48–65% of variances were explained by seasonal components in Italy. Ho et al. (1997) found the corresponding values of 25–26% in Hong Kong and 31–33% in Taiwan. The corresponding values for Australia and New Zealand in the present study were 3–17% only. Furthermore, the second harmonic (two cycles per year) seems to disappear.

Durkheim (1898) explained the seasonal variation of suicides by the fluctuations in communal and social activity. In other words, in places where there are large seasonal variation in the pace of life, there will be correspondingly greater seasonal variation of suicide deaths. Micciolo et al. (1991), in their reanalysis of suicide deaths in Italy, came up with some supportive evidence in that the variances explained by seasonal harmonics were greater in rural areas than that found in urban areas. The life style and the mode of communications have changed significantly in the last decade, for example, Australian women working participation rate had increased from 43% to 52% from 1982 to 1993. The proportion of divorced has increased from 4% to 6% of the population aged 20–49 in the period 1981–1993. The roles of men and women have been

Table 5
Harmonic Analysis of Monthly Suicide Data by gender and method, Australia, 1981–1993

	Males													
Component of variances	Poisoning		Hanging		Drowning		Firearms		Cutting		Jumping		Other	
All seasonal harmonics	0.09	0%	5.71	15%	0.07	2%	5.31	12%	0.04	2%	0.15	3%	0.10	1%
one cycle	0.06	62%	3.18	56%	0.04	53%	4.26	80%	0.00	0%	0.05	33%	0.10	100%
two cycles	0.00	0%	1.11	19%	0.00	0%	0.74	14%	0.00	0%	0.06	43%	0.00	0%
three cycles	0.04	38%	0.00	0%	0.01	10%	0.13	3%	0.00	0%	0.00	0%	0.00	0%
four cycles	0.00	0%	0.00	0%	0.00	0%	0.18	3%	0.01	22%	0.00	0%	0.00	0%
five cycles	0.00	0%	0.00	0%	0.02	34%	0.00	0%	0.00	0%	0.04	25%	0.00	0%
six cycles	0.00	0%	1.42	25%	0.00	3%	0.00	0%	0.03	78%	0.00	0%	0.00	0%
Non-seasonal harmonics	2.35	5%	1.34	4%	0.25	8%	0.87	2%	0.00	0%	0.00	0%	0.00	0%
Random variations	43.09	95%	30.06	81%	3.01	90%	39.33	86%	2.31	98%	4.78	97%	6.86	99%
Total variance	45.53	100%	37.11	100%	3.33	100%	45.51	100%	2.35	100%	4.93	100%	6.96	100%
	Females													
Component of variances	Poisoning		Hanging		Drowning		Firearms		Cutting		Jumping		Other	
All seasonal harmonics	1.82	9%	0.25	4%	0.01	0%	0.10	3%	0.01	1%	0.01	1%	0.14	5%
one cycle	0.00	0%	0.09	34%	0.00	0%	0.00	0%	0.00	0%	0.00	20%	0.00	0%
two cycles	0.03	2%	0.00	0%	0.00	0%	0.03	31%	0.00	0%	0.00	0%	0.05	38%
three cycles	0.10	5%	0.00	0%	0.01	100%	0.00	0%	0.00	0%	0.00	0%	0.05	38%
four cycles	1.69	93%	0.12	49%	0.00	0%	0.07	69%	0.00	0%	0.00	0%	0.00	0%
five cycles	0.00	0%	0.04	17%	0.00	0%	0.00	0%	0.01	100%	0.01	80%	0.03	24%
six cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	0.00	0%	0.00	0%	0.00	0%	0.42	13%	0.00	0%	0.00	0%	0.00	0%
Random variations	18.83	91%	6.39	96%	2.63	100%	2.79	84%	0.77	99%	2.18	99%	2.50	95%
Total variance	20.65	100%	6.65	100%	2.64	100%	3.31	100%	0.78	100%	2.19	100%	2.64	100%

redefined continuously. Furthermore, the mode and frequency of human contacts have also changed so much. With the advance of new technological development and people tend to travel more often than before, the activities and social contacts nowadays are in many ways different from before. The exact impact of these changes on the seasonality of suicide is far from clear and they might have a rather weak influence than before.

Since we also have examined the seasonal distribution of suicides varied with the methods of suicide. Australian males used hanging showed the existence of one cycle per year. The proportion of suicides by hanging had increased from 16% to 28% of all total suicides deaths from 1981–1994 in Australia. The most common method of suicide among aboriginals who were held in custody was hanging. The effect on the results is certainly worthwhile to pursue further. However, the given data don't allow us to explore further in this aspect.

The present finding is unlikely to be due to ascertainment bias. If the seasonality of suicidal deaths for any particular groups are masked by the ascertainment procedures, it has to be postulated that the bias varies systematically with seasonality and operates in different ways for different gender, age groups, or suicidal methods. Neither can the differences in results be explained by variation in statistical methods. We followed exactly the same analysis as reported in previous studies Micciolo et al. (1989; Ho et al., 1997) and obtained the present findings. In short, the present study found that the seasonality of suicides are less obvious than previous studies suggested. Factors other than seasonal rhythm seem to have far more impact on the incidence of suicides. Nevertheless, certain age groups of suicide victims and their method employed did have significant contribution to the seasonal occurrence of suicidal deaths. The present finding challenged the existence of biseasonal distribution of female suicides. The

Table 6
Harmonic Analysis of Monthly Suicide Data by age and gender, New Zealand, 1981–1993

	Males							
Component of variances	15–24		25–39		40–59		60 or over	
All seasonal harmonics	0.47	6%	0.10	1%	0.08	1%	0.00	0%
one cycle	0.17	37%	0.00	0%	0.00	0%	0.00	0%
two cycles	0.01	1%	0.10	100%	0.06	75%	0.00	0%
three cycles	0.03	5%	0.00	0%	0.01	11%	0.00	0%
four cycles	0.16	33%	0.00	0%	0.00	0%	0.00	0%
five cycles	0.11	24%	0.00	0%	0.01	14%	0.00	0%
six cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	0.82	10%	0.00	0%	0.47	7%	0.41	7%
Random variations	7.04	84%	7.93	99%	6.52	92%	5.16	93%
Total variance	8.34	100%	8.03	100%	7.06	100%	5.57	100%
	Females							
Component of variances	15–24		25–39		40–59		60 or over	
All seasonal harmonics	0.09	6%	0.02	1%	0.07	3%	0.07	3%
one cycle	0.00	0%	0.02	100%	0.03	43%	0.04	57%
two cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%
three cycles	0.02	24%	0.00	0%	0.04	57%	0.03	43%
four cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%
five cycles	0.06	76%	0.00	0%	0.00	0%	0.00	0%
six cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	0.00	0%	0.13	6%	0.00	0%	0.23	10%
Random variations	1.41	94%	2.12	93%	2.45	97%	1.91	86%
Total variance	1.49	100%	2.28	100%	2.52	100%	2.21	100%

bimodal of females suicide phenomenon is certainly not universal and might be limited to certain geographical locations and historical only.

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Appendix 1

Here we give the details of the harmonic analysis and testing the significance of various harmonics. According to the time series model, variation between the months could be described by the sum of sinusoidal curves. The seasonal variations consisted of components with cycles which repeated themselves an exact number of times each year. We have 13 completed years divided into $12 \times 13 = 156$ monthly intervals. Such intervals are not of constant length, the suicide numbers of the months were adjusted as follows: let x_{ij}^{*} be the suicide number of ith year and jth month and the adjusted suicide number is calculated by

$$x_{ij} = \frac{x_{ij}^{*}}{\text{length of } j\text{th month} \in \text{the } i\text{th year}} \times \frac{4748}{156}$$

where 4748 is the total number of days in the period 1981–1993 and $4748/156 = 30.44$ is the adjusted factor for length of the month. To eliminate the year effect from the data, define the 'residuals' where $A_{ij} = x_{ij} - (\bar{x}_{i.} - \bar{x}_{..})$ and $\bar{x}_{i.}$ is the average number of suicide of the ith year and $x_{..}$ is the grand total mean. Following Pocock (1974), assume A_{ij} are independent and identical Poisson with mean α and relabel-

Table 7
Harmonic Analysis of Monthly Suicide Data by gender and method, New Zealand, 1981–1993

	Males													
Component of variances	Poisoning		Hanging		Drowning		Firearms		Cutting		Jumping		Other	
All seasonal harmonics	0.05	1%	0.80	8%	0.05	6%	0.06	1%	0.03	5%	0.01	2%	0.07	77%
one cycle	0.00	0%	0.26	32%	0.04	79%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
two cycles	0.00	0%	0.00	0%	0.00	0%	0.06	100%	0.01	30%	0.00	34%	0.00	0%
three cycles	0.00	0%	0.54	68%	0.00	0%	0.00	0%	0.00	5%	0.00	0%	0.00	0%
four cycles	0.05	100%	0.00	0%	0.01	21%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
five cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.01	46%	0.00	0%
six cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.02	65%	0.00	20%	0.07	100%
Non-seasonal harmonics	0.00	5%	0.00	0%	0.00	0%	0.09	1%	0.00	0%	0.00	0%	0.00	0%
Random variations	9.18	99%	8.75	92%	0.70	94%	5.91	98%	0.60	95%	0.90	98%	0.88	93%
Total variance	9.23	100%	9.55	100%	0.75	100%	6.06	100%	0.63	100%	0.91	100%	0.95	100%
	Females													
Component of variances	Poisoning		Hanging		Drowning		Firearms		Cutting		Jumping		Other	
All seasonal harmonics	0.26	6%	0.04	2%	0.02	2%	0.00	0%	0.00	1%	0.03	5%	0.00	0%
one cycle	0.04	16%	0.04	100%	0.00	0%	0.00	0%	0.00	14%	0.00	3%	0.00	0%
two cycles	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	65%	0.02	47%	0.00	0%
three cycles	0.00	0%	0.00	0%	0.00	30%	0.00	0%	0.00	0%	0.01	43%	0.00	0%
four cycles	0.12	45%	0.00	0%	0.00	29%	0.00	0%	0.00	0%	0.00	0%	0.00	100%
five cycles	0.10	38%	0.00	0%	0.00	0%	0.00	100%	0.00	21%	0.00	7%	0.00	0%
six cycles	0.00	0%	0.00	0%	0.01	41%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Non-seasonal harmonics	0.00	0%	0.00	0%	0.10	13%	0.00	0%	0.00	0%	0.06	10%	0.00	0%
Random variations	3.82	94%	2.03	98%	0.67	85%	0.43	100%	0.15	99%	0.53	85%	0.33	100%
Total variance	4.08	100%	2.07	100%	0.78	100%	0.43	100%	0.15	100%	0.63	100%	0.33	100%

ling the subscript ij to i for 1, 2, . . . , 156. According to the theory of Fourier analysis,

$$A_i = a_0 + \sum_{j=1}^{78} \left(a_j \cos \frac{2\pi ij}{156} + b_j \sin \frac{2\pi ij}{156} \right)$$

where a_j and b_j are constant, a_0 is the mean suicide number and

$$a_j \cos \frac{2\pi ij}{156} + b_j \sin \frac{2\pi ij}{156}$$

is commonly referred to as the j-th harmonic of A_i with period $13/j$ years and frequency per annum $j/13$. The harmonics with $j=13$, 26, 39, 52, 65 and 78 have periods 1, 1/2, 1/3, 1/4, 1/5, 1/6 years and frequency per annum 1, 2, 3, 4, 5, and 6 respectively. These harmonics have a cycle which repeat an exact number of times per year and follow the same pattern in years as any combinations of such harmonics. The total variance of A_i under the assumption that A_i are Poisson random variables can be decomposed, into three components: random, seasonal and non-seasonal. Let A_i have mean $\bar{A}$, and the sample variance $S^2 \equiv \frac{1}{k-1} \sum_{i=1}^{156} (A_i - \bar{A})^2$ can be decomposed into three components:

1. Random variation: $\bar{A}$ (mean = variance for Poisson variables)
2. Seasonal variation: The jth component of sample variance $= \left[\frac{(k/2)(a_j^2 + b_j^2) - 2\bar{A}}{k-1} \right] / S^2$ for $j=13$, 26, 39, 52, 65 and 78.
3. Non-seasonal variation: If random component plus random components is less than 100%, than the remainder is non-seasonal components.

In this way it is possible to calculate the percentage of total variance attributable to seasonal variation as well as to random and non-seasonal variation. Consider the null hypothesis, H_0 that suicide occur randomly in time but for variations by day of the month. Define the index of dispersion of $\{A_i\}$ as

$$I = \frac{\text{Sample variance}}{\text{Sample mean}} = \frac{\Sigma(A_i - \bar{A})^2}{(k-1)\bar{A}}.$$

Under H_0, $(k-1)I$ has approximately a χ^2 distribution on $k-1$ degrees of freedom. Hence I can be used to test for H_0, see Pocock (1974). Furthermore, it can be shown that

$$\frac{k(a_j^2 + b_j^2)}{2\bar{A}} \overset{\text{d}}{\sim} \chi_2^2$$

except for k even and $j = k/2$ when $ka_j{}^2/2\bar{A} \overset{\text{d}}{\sim} \chi_1^2$ which can be used to test the significance for any harmonic.

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