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ORIGINAL PAPER

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Season-of-birth as a risk factor for the seasonality of suicidal behaviour

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Abstract Despite implicating the same biological systems, the relationship between suicide seasonality and season-of-birth has not been examined previously. The purpose of this study was to investigate the interaction between season-of-birth and the seasonality of suicidal behaviour. All adult suicides (N = 2923) and deliberate self harm (DSH) hospitalizations (N = 33321) in Western Australia (1970–96) were examined. A variable population at risk approach was used to determine season-of-birth. Seasonality was established by spectral analysis. We found that DSH has a significant season-of-birth (p = 0.047) and seasonality of occurrence, both peaking in spring. Individuals born in the 90 days centred on the peak birth period, however, show no DSH seasonality. In contrast, suicide has no season-of-birth (p = 0.53). We also found a season-of-birth effect among the DSH group that eliminates any seasonality of DSH among the high-risk by birth group. Further work is needed to identify the possible biological and environmental determinants of this interaction.

Key words seasons · suicide/statistics & numerical data · birth rate · suicide · DSH

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Introduction

Seasonality research has traditionally focused on two different relationships; the first is between disease risk and season of birth and the second the seasonality of disease onset or other important disease related events. However, the inter-relationship between these two areas has not received much attention despite studies implicating the same biological mechanism, namely serotonin regulation (Maes et al. 1993; Chotai and Adolfsson 2002). Here we present an analysis of suicide linking season of birth to the seasonality of suicidal behaviour.

Seasonality of suicidal behaviour

Seasonality is one of the oldest and most replicated findings in suicide research (for reviews see Kevan 1980; Preti et al. 2000). Most studies that show an effect find that suicide peaks in spring (northern and southern hemisphere inclusive). Some studies also find that males or those who use methods classified as violent (i. e. non-poisoning) determine the seasonality (see for example: Maes et al. 1993; Rock et al. 2003). Suicide seasonality has been linked to the circannual rhythm of the monoamine neurotransmitter serotonin (Maes et al. 1993; Preti 1997).

DSH is also seasonal (Masterton 1991; Barker et al. 1994; Jessen et al. 1999) and has also been related to circannual serotonin regulation (Preti 1997). In addition, we have shown that DSH seasonality is determined by those who use low case fatal methods (Rock et al. 2005). Case-fatality is defined as the proportion of attempters who die (Spicer and Miller 2000) and provides a measure for the relative lethality of a particular suicide method. Furthermore, Baca-Garcia et al. (2001, 2004) have shown that impulsive suicide attempters are more likely, not less likely to survive. These findings are in apparent contrast to the conclusions of some suicide seasonality studies (for ex. Maes et al. 1993). However, this may relate to the non-equivalence of the groups: methods classified as violent are not necessarily more lethal than those that are not.

Season-of-birth and suicidal behaviour

In contrast to the large number of studies on seasonality only a small number of studies have reported on season-of-birth for suicide and related behaviours. Around half find a season-of-birth effect (see Table 1).

Recently one group found season of birth variation linked to both adult monoamine turnover and risk for suicide (Chotai et al. 2001; Chotai and Adolfsson 2002). Given the evidence of a relationship between monoamine regulation and both suicide (Oquendo and Mann 2000; Mann et al. 2001) and impulsivity (for review see Mann 1998) the authors suggest that the suicide season-of-birth is mediated by season-of-birth variation in monoaminergic neurotransmitter turnover, the same neurotransmitters which have been implicated to drive the seasonality of suicide.

Yet, despite implicating the same biological systems, the relationship between suicide seasonality and season-of-birth has not been examined. The purpose of this study is to analyse season-of-birth and seasonality of suicidal behaviour in the same population. In particular, if the model proposed by Chotai's group is correct, season-of-birth will influence impulsive behaviour and, based on our previous work, we would predict that individuals who engage in DSH involving low case fatal methods will show a significant season-of-birth.

To test this we used a Kolmogorov-Smirnov type statistic and a variable population at risk approach to determine season-of-birth. Seasonality was determined using spectral analysis. We also carried out additional calculations to establish the specificity of our findings. In particular, some studies have found that individuals are more likely to attempt suicide close to their birthday (Shaffer 1974; Barraclough and Shepherd 1976; Kunz 1978). If this is the case, and there is a season-of-birth effect for suicidal behaviour then this may explain the seasonality of suicidal behaviour. A further potential confound is serious mental illness (SMI). SMI in general is associated with increased risk of suicide. In addition, a number of disorders, in particular schizophrenia and bipolar disorder, have been shown to have a seasonal pattern of occurrence and season-of-birth (Fossey and Shapiro 1992: Torrey et al. 1997). In order to reduce the potential confound SMI may have on our analyses we have eliminated, as far as possible, such cases from our data.

Materials and methods

Sample

Western Australia (WA) has a comprehensive hospital morbidity case register that records a range of demographic and clinically relevant details for all hospital admissions. In addition, all deaths irrespective of hospitalisation are recorded in the Register of Birth, Deaths and Marriages. Our data comprise: (i) all WA hospital admissions with an International Classification of Diseases 9th Revision (ICD9) (1986) diagnosis of intentional self inflicted injury (E950–958) without a fatal outcome (deliberate self harm); (ii) all suicide deaths irrespective of hospitalisation (E950–958). In WA, hospitalisation is an administrative category that includes assessment and, if necessary, treatment, at an accident and emergency department (A&E) irrespective of whether or not the person is subsequently transferred to another inpatient area. Furthermore, all DSH presentations are seen in an A&E. Sample characteristics are given in Table 2 below. In addition, all individuals with a prior lifetime ever (15–65 years) mental health admission (ICD-9 codes 290–319) in WA and cases where death occurred greater than one year after the attempt (E959) were excluded from the datasets. The data are for the years 1970–96. Other than diagnosis, variables extracted included age, sex, country of birth, date of birth (DOB) and date of hospital admission or death. Only Australian born individuals were included in the study. Population birth data were supplied by the Australian Bureau of Statistics

Determination of case fatality

Case fatality was calculated separately for each method (E950–8) and sorted in a single time-series according to year and calendar month of occurrence. Low case fatality was assigned to any method with any method with a percentage case fatality $\leq 40\%$. This cut-off was selected to be consistent with a previous analysis that found case-fatality to be strongly bimodal (Rock et al. 2005).

Determination of season-of-birth

DOB was collapsed into a single 365 day frequency series (Feb 29th data from leap years was censored). Season-of-birth was determined using a Kolmogorov-Smirnov type statistic (Freedman 1979). This test has been proposed as a more specific test of the curvilinear variation that is characteristic of birth series and has been used in other seasonality studies (see for example Verdoux et al. 1997; Daniels et al. 2000). Since this method compares the cumulative proportional difference curves between two contemporaneous time series it can accommodate the variable population of risk approach. Variable population of risk adjustment was achieved by comparing the birth distribution of suicide and DSH groups with whole population data (minus the suicide and DSH cases as appropriate), again collapsed into a single 365-day frequency series. Western Australian live birth data for a consecutive 3 year period centered on the median birth year of the suicide and DSH groups was used as the index or expected distribution. Using this approach we can determine whether there is a significant difference in the frequency distribution of birth days between individuals with a history of suicidal behaviour and the general population variation.

Determination of seasonality

Data were adjusted to a standard 31-day month to eliminate the "calendar effect" (Cleveland and Devlin 1980; Walter 1994). Linear trend was removed from the time series using Ordinary Least-Squares regression (OLS). Serial dependency was determined by examining the significance of the Box-Ljeung Q-statistic for the auto-correlation function (ACF) (up to a lag of 15) of the regression residuals. The stationarity requirement for spectral analysis was achieved by: (i) removal of any linear trends; (ii) application of the Levene's test for homogeneity of variance from an ANOVA of the event count (suicide or DSH) by 31 day month grouped by year as the independent variable.

A single series Fourier Transformation (FT) was applied to the OLS regression residuals, after the application of a split-bell-cosine taper, and prominent peaks were identified from the power spectrum (smoothed using a Daniell window (width 3)). Confidence intervals around the spectral estimates were determined using the method of Koopmans (1974). Peaks where the lower bound of the CI was greater

Table 1 Summary of season-of-birth of suicidal behaviour literature

Authors	Year	Location	Sample	N	Methodology	Results
Pokorny, 1960	1949–59	Houston, USA	Suicide	44 VA hospital patients (39 psychiatric patients) who committed suicide	Frequency count by birth month. No analysis	Excess of births in July but "probably not significant"
Lester et al. 1970	1966–69	Erie County, USA	Suicide	285	X2 goodness of fit Month of birth Calendar adjustment	No significant monthly variation in births
Beck and Lester, 1973	Not reported	Not reported	Attempted suicide	254 consecutive hospital admissions for attempted suicide	X2 goodness of fit Month of birth Calendar adjustment	No significant monthly variation in births
Sanborn and Sanborn, 1974	1955–69	New Hampshire, USA	Suicide and deaths by unknown cause pooled	Suicide 1164 Unknown cause 13	X2 goodness of fit Month of birth Season-of-birth (climatic seasons)	No significant variation in births by month or quarter
Lester, 1987 (9)	1982	Philadelphia, USA	Suicide, homicide, natural deaths	Not reported	X2 Month of birth	No significant monthly variation in births for any of the groups No significant monthly variation in births between any of the groups
Kettl et al. 1997	Alaska Natives 1979–84 Others various consecutive years 1981–88	USA & Canada	Suicide Alaska Natives and other populations living in Yukon, Saskatchewan, Montana, Wyoming, and Pennsylvania	90 Alaska Natives 39 Yukon 839 Saskatchewan 768 Montana 480 Wyoming 6859 Pennsylvania	Pearson correlation (percentage of suicide victims born each season cf latitude & photoperiod) Season-of-birth (May–July, Aug–Oct, Nov–Jan, Feb–Apr) based on solstices	Significant season-of-birth at all locations. Peak May–July, trough Nov–Jan Magnitude increases with increase in latitude
Chotai et al. 1999	1952–1993	Northern Sweden	Suicide 6 groups[a] E950, E952, E953, E954, E955 E951, 6, 7, 8, 9	1457	Odds ratio (E953 – hanging as reference method) of being born in one of four 3-month seasons cf the rest of the year adjusted for sociodemographic covariates using multiple logistic regression	Those who preferred hanging rather than poisoning and petrol gases were more likely to be born Feb–Apr Those who preferred poisoning to hanging were more likely to be born during Oct–Jan Those born Feb–Apr were younger than the rest of the sample
Chotai and Salander Renberg, 2002	1961–1980	Vasterbotten, Northern Sweden	Pooled suicide (E950–9)[a] and undetermined deaths (E980–989) divided into two groups based on any prior contact with psychiatric clinics or institutions in the same locality	E950–9[a] 400 E980–9 96 Total Pool 693 Prior psychiatric contact = 341 No prior psychiatric = 352	Odds ratio (E953 – hanging as reference method) of being born in one of two seasons (Feb–Apr, Oct–Jan) cf the rest of the year adjusted for age, method and sex using multiple logistic regression	Those with no psychiatric contact born Feb–Apr preferred hanging rather than poisoning and petrol gases pooled Those with no psychiatric contact born Oct–Jan preferred hanging rather than poisoning and petrol gases pooled Those with a history of local mental health contact showed no significant variation

[a] Suicide and self inflicted injury (ICD 9 Supplementary classification of external causes of injury and poisoning)
E950 poisoning by sold or liquid substances; *E951* poisoning by gases in domestic use; *E952* poisoning by other gases and vapours; *E953* hanging strangulation and suffocation; *E954* submersion (drowning); *E955* firearms, airguns and explosives; *E956* cutting and piercing instrument; *E957* jumping from high place; *E958* other and unspecified means; *E959* late effects of self inflicted injury

than the mean spectral density of the entire power spectrum were considered significant (Warner 1998). A 95 % CI was used. The final explained variance of any significant cycle or cycles was determined by dividing the individual power spectrum intensity estimates by the total power spectrum intensity. A more detailed overview of this whole method is described by Warner (1998).

Determination of birthday effect

For both the suicide and the low case fatality DSH series the absolute difference in days between each individual's birthday and the event (suicide or DSH) was calculated. These were collapsed into a single series with the range 0–182 days and compared to a monotonous series using the Kolmogorov-Smirnov type statistic described above (Freedman 1979). Any significant difference between these two series would indicate that an individual's birthday has an impact on the timing of suicidal behaviour.

All analyses were conducted using Statistica (2000).

Results

Sample characteristics are given in Table 2.

Season-of-birth

Suicide has no season-of-birth ($p = 0.53$). Individuals who engage in DSH demonstrate a significant season-of-birth ($p = 0.047$) (Fig. 1). This season-of-birth is driven by individuals who exclusively engage in DSH involving low case fatal methods ($p < 0.001$).

The variation is not explained by seasonal variation of birth at the population level (a variable population at risk methodology was used). This variation is independent of any mental illness associated season-of-birth. As Australian population birth data are not available by sex for the years we require it is not possible to determine if there is a sex effect. The peak in the DSH season-of-birth involving low case fatal methods is in October (spring) and reaches a nadir at the end of March (autumn). The December trough, although prominent, is not statistically significant (see Fig. 1).

Table 2 DSH and suicide by sex and case-fatality

	Low case fatal (%)[a]	High case fatal (%)	Total
DSH			
Male	12307 (95.3)	613 (4.7)	12920
Female	20253 (99.3)	148 (0.7)	20401
Total	32560 (97.7)	761 (2.3)	33321
Suicide			
Male	452 (19.5)	1868 (80.5)	2320
Female	316 (52.4)	287 (47.6)	603
Total	768 (26.3)	2155 (73.7)	2923

[a] all percentages are cross-wise (males, females)

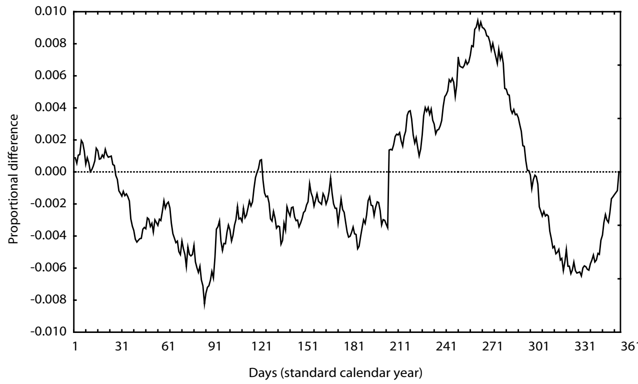

Fig. 1 Season-of-birth for low case fatility DSH

Seasonality of DSH

Low case fatal DSH has a significant 12-month rhythm that peaks in October and explains 19.2 % of the non-linear variation (see Table 3).

Relationship between DSH season-of-birth and seasonality

The DSH group born in the 3 months (90 days) around the peak season-of-birth (i. e. Sept–Nov) do not show DSH seasonality. This is specific to this quarter of the year. The seasonality of low case-fatal DSH is determined by the group born outside of the high risk birth months. There is no relationship between day-of-birth and day-of-suicide ($p = 0.74$) or DSH ($p = 0.56$). Case fatality by method shows little variation over time (see Table 4).

Discussion

We found no evidence for a season-of-birth effect for suicide. It is difficult to interpret the importance of this result in terms of the literature as the results are mixed: Three studies find suicide has a significant season-of-birth (Kettl et al. 1997; Chotai et al. 1999; Chotai and Salander Renberg 2002) and four studies do not (Pokorny 1960; Lester et al. 1970; Sanborn and Sanborn 1974; Lester 1987) (Table 1). The DSH group, however, shows a significant season-of-birth, peaking in October (Spring) and reaching a nadir in late March (Autumn). This effect is accounted for by the season-of-birth for the group who use low case fatal methods (Fig. 1). Further, low case-fatal DSH is seasonal and also peaks in spring. This is not surprising as we have reported previous positive findings from an over-lapping sample with around 15 % concordance of cases between the two samples (Rock et al. 2005). The lack of a temporal relationship between birthday and suicidal behaviour argues against a "birthday effect" (Shaffer 1974; Barraclough and Shepherd 1976; Kunz 1978).

Our results also indicate that the two DSH seasonal

Table 3 Spectral analysis results for low case fatal DSH

Frequency	Period (months)	Cosine coefficient A	Sine coefficient B	Percent explained variance
(upper boundary 0.075)	13.3	−3.8	−2.4	
0.0833 (bandwidth ± 0.0083)[a]	12	4.35	−1.7	19.2[b]
(lower boundary 0.092)	10.9	1.77	−1.21	

[a] Circannual rhythm determined across the 0.075–0.092 frequency band
[b] Total explained variance within the circannual frequency band

Table 4 Case fatality by method (ICD9) grouped in 3-year blocks, 1970–1996

Method[a]	DSH (N)	Suicide (N)	1970–72	1973–75	1976–78	1979–81	1982–84	1985–87	1988–90	1991–93	1994–96
E950	37105	745	0.05	0.05	0.03	0.03	0.02	0.03	0.03	0.03	0.03
E951	73	15	0.40	0.31	0.11	0.00	0.00	0.00	0.00	0.00	0.00
E952	478	1079	0.79	0.85	0.85	0.85	0.86	0.84	0.82	0.76	0.78
E953	218	832	0.89	0.85	0.77	0.88	0.89	0.95	0.91	0.85	0.83
E954	31	95	0.90	0.86	0.84	0.75	0.65	0.61	0.69	0.72	0.67
E955	191	692	0.79	0.84	0.86	0.80	0.71	0.69	0.76	0.81	0.79
E956	3445	62	0.03	0.02	0.01	0.03	0.03	0.04	0.04	0.04	0.03
E957	154	90	0.41	0.43	0.55	0.66	0.68	0.74	0.67	0.57	0.41
E958	687	127	0.06	0.12	0.10	0.09	0.14	0.16	0.19	0.15	0.21

[a] Suicide and self inflicted injury (ICD 9 Supplementary classification of external causes of injury and poisoning)
E950 poisoning by sold or liquid substances; *E951* poisoning by gases in domestic use; *E952* poisoning by other gases and vapors; *E953* hanging strangulation and suffocation; *E954* submersion (drowning); *E955* firearms, airguns and explosives; *E956* cutting and piercing instrument; *E957* jumping from high place; *E958* other and unspecified means

risk factors, season-of-birth and seasonality of behaviour, are interrelated. Individuals who engage in low case-fatal DSH, born during the high risk months do not show a seasonality of behaviour: it is the group born outside of this period that accounts for the seasonality of low case fatal DSH. This suggests that, whatever the nature of the season-of-birth effect, it is sufficient to either wash out or mask any subsequent seasonality of DSH among this high risk by birth group.

There is evidence that the selection of low case fatal suicide methods is associated with increased impulsivity (Klerman 1987; Baca-Garcia et al. 2001, 2004). Given the evidence for a link between lowered levels of serotonin and suicidal behaviour (Mann et al. 2001) the finding of birth peak in October for the Australian born cohort also lends support to the proposal that monoamine turnover is associated with season-of-birth (Chotai and Adolfsson 2002; Chotai and Asberg 1999). If the season-of-birth variation in cerebrospinal fluid (CSF) monoamine metabolites in Swedes (Chotai and Adolfsson 2002; Chotai and Asberg 1999) can be extrapolated to Australia this difference may be related to season-of-birth mediated differences in monoamine regulation. The proof of this proposition needs carefully designed studies that directly relate suicidal behaviour to biology.

A season-of-birth effect for a condition of unknown aetiology is considered at least suggestive evidence that in utero or neo-natal infection may be involved (Hall and Peckham 1997). A number of maternal, particularly second trimester infections, especially respiratory infections, are associated with adult onset disease, including brain disorders in the offspring (for review see Castrogiovanni et al. 1998). Children born in October would have been in their second trimester in May–July. This is winter in Australia, the period when respiratory infections have an increased incidence (Hope-Simpson 1981). Supporting the possible role of maternal respiratory infection Joiner et al. (2002) found that Australians in utero during the Southern Hemisphere high risk flu period were more likely to experience suicidal thoughts as young adults compared with those in utero outside of this high risk period.

However, this does not address why two apparently related phenomena (DSH and suicide) do not show a common pattern of risk within our study, namely that low case fatal DSH shows a season-of-birth whilst suicide does not. Suicide requires both the behaviour (deliberate self harm) and one particular extreme outcome (death). In this, it is a more complicated marker of behaviour than DSH alone. If, as has been proposed by Chotai and Salander Renberg (2002), the season-of-birth effect for suicidal behaviour is associated with season-of-birth variation in temperament indices, including impulsiveness, there is no reason that this should automatically translate into season-of-birth variation in suicide. Indeed, increased impulsivity and lack of planning is associated with increased, not decreased survival (Klerman 1987; Baca-Garcia et al. 2001, 2004).

As circannual serotonin regulation is the most widely promulgated biological explanation for the seasonality of suicidal behaviour, it is worth considering whether our findings can be accommodated within this model. There is evidence that individuals born in spring have overall lower levels of serotonin (Chotai and Asberg 1999; Chotai and Adolfsson 2002). Whether or not spring born individuals have a different pattern of circannual regulation is unknown. What is known, however, is that just reducing the mesor (the rhythm adjusted mean) of a rhythmic signal does not itself alter the amplitude. This would suggest that simply having a lower serotonin mesor would not, on its own, be sufficient to explain the lack of seasonality in the high risk by birth group.

If the serotonin hypothesis is correct and circannual regulation of serotonin drives the seasonality of suicidal behaviour then this would predict that the lack of seasonality found in the high risk by birth group is related to an attenuation of the amplitude of the circannual serotonin rhythm. Furthermore, any variation in baseline or mesor serotonin levels would relate not to the seasonality of suicidal behaviour but the overall risk of self-harm. Examination of the aetiology, nature and relationship between season of birth and seasonality of behaviour risk factors would provide an important test of serotonin hypothesis; a model of suicide that is more often inferred than demonstrated (Muller-Oerlinghausen et al. 2004). The results presented in this study provide the first tentative evidence that this approach is worth pursuing.

In considering such a possibility it is also worth considering more mundane explanations. It is possible that there are seasonal differences in the willingness of self harmers to attend A&E and since we use hospital attendance as a proxy for the incidence of DSH, such differences could underlie the DSH seasonality we observed. Furthermore, the seasonality may not be specific to DSH and could be a result of a more general pattern of seasonal hospitalisation or even a measure of the competition for beds. Also, and importantly the relationship that we describe between DSH seasonality and season-of-birth may simply be a chance finding. We did not specify the nature of this relationship a priori: Instead this emerged during the analysis and therefore should be considered a hypothesis awaiting confirmation.

In addition, some studies have found that multiple self harmers are more impulsive than those with only one episode of self harm (for example, Dougherty et al. 2004). If this is the case and DSH season-of-birth is related to low case fatality through impulsivity in the manner we suggest, one might predict that multiple DSH cases would have an augmented season-of-birth compared with the once only cases. In our analyses we did not differentiate single from multiple self harmers. Primarily this was because we did not use a cohort design which would have allowed us to adjust for differences in the period at risk. In addition, as we have already stated, the specific relationship we found was not based on an a priori hypothesis. Furthermore, not all studies find that multiple self harmers are more impulsive than once only cases (for example, Evans et al. 2000). Therefore, we did not feel it was reasonable to attempt such an analysis. However we believe our findings now provide sufficient justification for such a more detailed analysis.

Limitations and strengths

Most importantly, as we did not start the study with an a priori hypothesis about the nature of the relationship between season-of-birth and seasonality, our results should be considered suggestive rather than confirmatory and require replication. In addition, the analyses are based on mortality and morbidity data, both of which are open to misclassification bias. Death by suicide, for example, may be under-reported (Ohberg and Lonnqvist 1998). Furthermore, a number of "accidental" or "undetermined" verdicts may indeed be suicides. However, for this to impact substantially on our study such misclassification would need to be seasonal. As far as we are aware this possibility has only been examined in one suicide study (Barraclough and White 1978), who found no evidence for seasonal misclassification. There have been no studies, to our knowledge, that have examined for such an effect for DSH. We did however re-analyse our data with all of the "undetermined" cases included and the finding are essentially identical (results not shown). Moreover, our speculation about a possible role for serotonin in explaining our findings is based solely on the comparison of our results with those from other studies and not on any direct evidence we have on serotonin regulation in the WA population. Also, we have used population birth data based on the median year of birth of our sample. We made this choice a priori in order to avoid the problem of multiple comparisons. Given the very large number of other estimates we could have used it is likely that at least one of these would have given a null result. However, even in this case, it does not explain why individuals born in one 90 day period show no seasonality of self harm, irrespective of the frequency of birth, whilst those born outside of this period do demonstrate seasonality.

Against these limitations the study has a number of strengths. We have extracted whole of population data from a validated case register and have confined our data to suicide and self-inflicted injury. Not all of the studies cited previously use the same definition for their sample with at least one including undetermined deaths (Chotai and Salander Renberg 2002) and others grouping suicide and attempted suicide together (Beck and Lester 1973). In addition, the WA case fatality rates are in considerable agreement with other published findings (Spicer and Miller 2000). Also, by using caseness based on hospitalisation we have set a minimum morbidity threshold. Furthermore, as our definition of admission is not dependent on bed availability but presentation to A&E we reduce the possibility that the seasonal variation in DSH is dependent on the competition between all patients for hospital beds. Moreover we have used a rigorous statistical approach (Preti et al. 2000) incorporating all of the relevant recommendations made in a recent methods review (Hakko et al. 2002). Many of the earlier studies of both seasonality and season-of-birth that use any statistical test use chi-square analyses (for reviews see Castrogiovanni et al. 1998; Hakko et al. 2002). Recent authors have been critical of chi-square type of analyses because they can only detect fairly large variation, ignore time ordered structure of the data and are insensitive to the type of curvilinear variation often associated with season-of-birth effects (for reviews see Torrey et al. 1997; Reijneveld 1990; Hakko et al. 2002). In addition, most of the studies cited above fail to adjust for unequal length of month (called the "calendar effect"). Failing to adjust for the calendar effect can produce spurious results (Cleveland and Devlin 1980; Walter 1994). Also, none of the studies cited in Table 1 take into account any overall seasonal variation of birth in the source population. There is a great deal of evidence for seasonal asymmetry of birth at the whole population level, including in Australia (Mathers and Harris 1983). Without adjusting for seasonal variation at the population level it is difficult, if not impossible to judge the importance of failing to find a season-of-birth in any subgroup, such as those who go on to attempt suicide (Torrey et al. 1997).

Conclusions

This is the first study to describe a season-of-birth effect for DSH. It is also the first study to describe a relationship between season-of-birth and the seasonality of self harm. We have determined that Australian born self harmers show a season-of-birth effect. In addition, we have found that those at increased secular risk for DSH by season-of-birth also have a seasonally invariant pattern of risk. DSH seasonality is confined to those born outside of the high risk birth period. These findings suggest that there are two related seasonal risk factors for DSH. One possible explanation is that these effects are related to season-of-birth effects on subsequent serotonin regulation, although more mundane administrative and social determinants cannot be excluded.

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