The seasonal relationship between assault and homicide in England and Wales

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Summary Investigating the seasonal asymmetry of violent behaviour has a long history. Despite this, there still remains considerable debate about the nature and aetiology of this phenomenon. Reports on homicide, for example, are mixed: some have found homicide seasonality but most have not. In contrast, all published studies on assault report that this behaviour is seasonal. Moreover, only two studies, both using US data, have examined the seasonal variation of assault and homicide in the same population over the same period of time. One group found assault was seasonal but homicide was not, whilst the other found, overall, that both homicide and assault were seasonal. This first of these findings seems paradoxical, in that there is no seasonal variation in injury related deaths (i.e. homicides), despite the antecedent behaviour (i.e. assaults) having a seasonal pattern of occurrence. We examined the seasonal variation in homicide and assault in the same population and found a similar result. Furthermore, our findings are not easily understandable using conventional social models of seasonal behaviour and we suggest biologically mediated seasonal variation in the capacity of equally injured individuals to survive trauma may also play a role, which should be investigated further.

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Background

Investigating seasonal variation in violent offending (assault and homicide) has a long history. As far as we can ascertain all published studies have found assaults vary seasonally, including assault related hospital admissions. Conversely, only some studies have described a seasonal variation for homicide, whilst a majority have failed to find any seasonal variation. In other words, when studied separately assault is consistently seasonal, whilst the outcome, homicide, is not. However, it is critical to note that since none of these studies

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examined assault and homicide in the same population at same time, it is not possible to conclude the seasonality of assault and homicide do not coincide. To examine this possibility we need to consider studies that use contemporaneously collected assault and homicide time-series data. In other words, we require the assault and homicide data to come from the same population over the same time period.

Only two studies, to our knowledge, have examined assault and homicide seasonality using contemporaneously collected data sets, both from the US. Michael and Zumpe analyzed short (2–3 year) time-series from 16 separate US locations. They found that in most locations (12/16) assault was seasonal, peaking in summer, whilst homicide, predominantly, was not (15/16). Block, in a large series of analyses, examined homicide and assault in the US (1970–82), and, separately, overlapping homicide (1965–81) and aggravated assault (1967–81) time-series in Chicago. In both pairs of data homicide and assault were seasonal, peaking in summer with assault seasonality greater than homicide seasonality.

Neither study considered the relationship between assault and homicide nor, in particular, the impact the evident association between assault severity and the likelihood of a fatal outcome may have on whether the case is categorised as an assault or a homicide. In essence, we have a behaviour, assault, where in a small number cases the victim dies and this then becomes a homicide. The likelihood that one will lead to other is, at the population level, associated with the severity of the assault. Therefore, it is difficult to create a coherent model of assault and homicide seasonality without considering the relative lethality of the assaults. An analogous situation occurs in the seasonality of suicide and deliberate self-harm literature (DSH). That is, DSH can be seasonal, whilst suicide is not, in the same population over the same period of time. We have shown that this apparent paradox is a consequence of the relative lethality of the suicide methods. If DSH has a seasonal pattern of occurrence but is associated with the use low case fatal methods, as we found, the seasonal DSH “signal” does not convert into a corresponding seasonal variation in suicide. If a similar relationship exists between assault and homicide then this may help to explain the previous inconsistent findings. Unfortunately, no prior studies have considered assault severity in this way.

Block speculated that her seasonality of assault findings resulted from a seasonal reporting bias. Also, in the homicide analyses, seasonality was limited to one type, homicide occurring out of doors or in a vehicle, suggesting to her that homicide is not specifically seasonal, and the reported seasonality is an artefact related to a more general pattern of normal human seasonal behaviour (i.e. we spend more time outside in summer than in winter). If this were the case, however, this would predict that homicides occurring indoors would show a reciprocal seasonality, peaking in winter, which they do not.

There are, at least, three plausible interpretations of the contemporaneous series findings.

1. Assaults are more likely to be reported in summer, i.e. the difference is a reporting artefact.
2. There may be seasonal variation in assault severity, leading to an attenuated homicide seasonality relative to assault, i.e. the difference is related to perpetrator factors.
3. There is seasonal variation in the proportion of equally injured assault victims who die, i.e. it is a victim related factor.

The aim of the present study is to characterise the seasonality of assault and homicide in the UK. Included in this, we will examine the association between assault severity and seasonality. Secondly, we will contrast these results with the putative explanations summarised above.

**Methods**

**Data**

All data were grouped and analysed by calendar month of occurrence.

**Offence data sources**

Violent crime time-series data 1993–97 for England and Wales were provided by the Home Office Crime and Criminal Justice Unit. Data were grouped by date of offence. These comprised data from two sources. The homicide data is from the Home Office Homicide Index. This is based on court outcome. The data is also coded by circumstance and method. The assault data is from the Home Office recorded crime series. The term “recorded crime” covers notifiable offences, that is, those offences recorded by the police which are reported to the Home Office. Statistics relating to notifiable offences concern the offence as initially recorded. The most serious offence is determined according to the maximum sentence.
**Homicide data**

The Homicide Index data is broken down by final court outcome into murder \((N = 1111)\), manslaughter (common law) \((N = 919)\) and manslaughter (diminished responsibility) \((N = 292)\). Manslaughter (common law) is unlawful killing of another human "without malice aforethought". Homicides where the perpetrator is found to be suffering from an "abnormality of the mind" that substantially impairs responsibility for the action are defined as cases of manslaughter (diminished responsibility). Given their small number neither the infanticide cases \((N = 15)\) nor the two cases of a suicide pact survivor convicted of murder were included as groups in the analyses.

**Assault data**

Two assault series have been analysed. The most serious, "Wounding and Other Acts Endangering Life" (WEL) \((N = 56,879)\), are a class of serious violent offences that include wounding with intent to do grievous bodily harm, attempting to choke, suffocate, etc. The other series of less serious assaults are classified as "Other Assaults and Wounding" (OAW) \((N = 1,021,426)\).

**Statistical analysis**

**Seasonality**

The assault and homicide time-series data have been analysed using univariate spectral analysis according to the following procedure. To correct for the "calendar effect" data were adjusted to a standardised 31-day month.\(^{10}\) In order to satisfy the stationarity requirements, linear trend was removed from the time-series using Ordinary Least-Squares regression (OLS) and Levene's test was used to determine homogeneity of variance across the series. Serial dependency was determined by examining the significance of the Box-Ljung Q-statistic for the auto-correlation function (ACF) (up to a lag of 15) of the regression residuals. Only series with at least one significant ACF value were analysed further. In order to identify significant rhythms a single series Fast Fourier Transformation (FFT) was applied to the regression residuals.\(^{7}\) The periodogram intensity estimates were extracted from the power spectrum (which was smoothed using a Daniell window width 3). Explained variance was estimated by calculating the percentage periodogram intensity per frequency band. Confidence Interval (CI) estimation for the derived spectral estimates was undertaken using the method of Koopmans.\(^{13}\) Only spectral peaks with a lower CI boundary greater than the mean spectral density of the whole bandwidth were considered significant.\(^{32}\) As the spectral estimates are tested post hoc and as this can inflate the Type 1 error a 99% CI was set a priori. The detailed background to our overall process of univariate spectral analysis can be found in Warner.\(^{32}\) Other supplementary analyses were conducted as indicated.

**Results**

**Spectral analysis**

**Homicide**

After the removal of linear trends none of the homicide series (murder, manslaughter total [common-law plus diminished responsibility], manslaughter common-law, manslaughter-diminished responsibility) demonstrated significant, nor a trend towards, serial dependency (the \(p\)-value for the Box-Ljung Q-statistic \(>0.1\) for all 15 lags in each data series). These findings indicate that the homicide time-series does not meet the initial indicator of seasonal asymmetry, that the detrended series is significantly different from white-noise.

Homicides were also analysed according to (1) most common methods (sharp instrument, blunt instrument) and (2) most common circumstances (rage and quarrels). None of these series individually or in combination demonstrated significant serial dependencies for any of the lagged auto-correlations (lag 1—15) and so no further time-series analyses were indicated for any of the homicide series.

Analyses of the less frequent method and circumstance groups were precluded because the number of zero counts in the time-series made reliable analysis impossible.

**Recorded crime data: assault**

"Wounding and other acts endangering life" and "Other assaults and woundings" have highly significant Box-Ljung Q values at all lags (1—15). Spectral analysis reveals that both series have significant 12-month rhythms. For WEL this explains 22% of the non-linear variation and for OAW 56% of the non-linear variation (Table 1). No other significant rhythms are present in either series. WEL and OAW peak in June (Fig. 1).

In order to examine the possibility that the differences between the assault and homicide results is simply an artefact related to the differences in the size of their populations, we carried out the following additional analysis. We fitted a model \(y(t) = a + b \times t + c \times \cos(\pi \times t/6) + d \times \sin(\pi \times t/6)\)
where \( t \) is in (adjusted) months and \( y(t) \) is the observation to the homicide and assault (WEL) time-series. We then calculated a one-way ANOVA for zero mean of the residuals using (adjusted) month as category. The periodic component of the assault series (WEL) was, as expected, highly significant \((p = 0.0007)\), however, for the homicide series (Murder and manslaughter combined) was not \((p = 0.1204)\). This indicates the periodic component contributes nothing to the model. Furthermore, since \( \sqrt{c^2 + d^2} = 0.32742 \) for the homicide data, even if there is a small, but hidden, periodic component in the homicide series it cannot be greater than one per month.

**Conclusion**

This is the first study to consider the relationship between assault and homicide seasonality in the same population over the same period of time. The most important finding is the proportion of people who die following assault varies in a seasonally periodic fashion. Specifically, as the frequency of assault increases the proportion of victims that die decreases and vice versa. Such a fluctuating correspondence over time between assault and homicide rates has not been highlighted previously and suggests a more complex seasonal process is occurring than has been considered hitherto for assault and homicide. It is, however, consistent with what we have found previously for deliberate self-harm and suicide.26

In addition, we found less serious assaults have greater seasonal amplitude than more serious assaults. This also has not been reported previously for assault but, again, is consistent with a previous finding for suicidal behaviour that found increased lethality is associated with decreased seasonality.25 For suicidal behaviour we have speculated that this decrease in seasonality with increased lethality may be related to a corresponding decrease in impulsivity.25 This rests on two premises. Firstly, that seasonal variation in suicidal behaviour reflects a more general seasonal variation in impulse control. Secondly, that increased lethality is associated with greater planning. There is some evidence to support both of these suppositions, at least for suicide and self-harm. As we have found a similar pattern for assault and homicide, this suggests there may be some aetiological commonality that should be investigated further. In particular, it would be interesting to develop a common metric that would allow us to more directly compare, at the population level, impulsivity and injury severity across a range of harming behaviours.

| Table 1 Results of spectral analysis of time-series data (only significant results shown) |
|---------------------------------|-----------------|-----------------|-----------------|
|                                    | Cosinor coefficients from FFTs |                 |                 |
| N                                | Significant frequencies (±bandwidth) | Equivalent periods in month | cos A | sin B | Percentage explained variance |
| Other assaults and woundings (OAW) | 1,021,426 | 0.0833 (±0.0083) | 12 | −1455.56 | 158.30 | 0.56 |
| Wounding and other acts endangering life (WEL) | 56,879 | 0.0833 (±0.0083) | 12 | −57.21 | 12.85 | 0.22 |

**Figure 1** Seasonal assault rhythms shown against original (detrended) data.
In contrast to assault, homicide (murder or manslaughter) did not show any seasonal variation. Moreover, as our homicide data is broken down according to the degree of premeditation (premeditation distinguishing murder from manslaughter) our results further challenge the view, developed from the suicide literature, that seasonal variation in impulse control is largely responsible for the seasonal variation in various injury related mortalities. If this were the case, we would have expected manslaughter to have been seasonal, which it was not.

Indeed, we would argue more generally that the use of mortality data to "test" models of seasonal injurious behaviour is flawed because it assumes a monotonous correspondence over time in the fraction of equally injured individuals who die. Contrary to this view, we observe seasonal variation in the proportion of equally injured individuals who die by homicide. What explanations could underlie this apparently counter-intuitive result?

It could be, as suggested by Block, that the seasonality of assault we find is simply the result of a reporting bias, i.e. the same numbers of assaults occur throughout the year but there is seasonal asymmetry in police reporting/recording. In order to circumvent such a possibility, Sivarajasingam and Shepherd calculated the 3-month moving average for assault related hospital admissions, rather than reported assaults, in England and Wales finding these were highest in July—September and lowest from February—April. We extracted the raw data from this publication and reanalysed both these data and our recorded crime data, for the same period, using the same 3-month moving average method. The profiles show essentially the same pattern of variation over time (Fig. 2). This provides converging evidence that the recorded crime statistics provide a valid estimate of the seasonal variation in violent offending and, therefore, seasonal reporting differences are not an explanation for our findings.

Another possible explanation for the seasonality of assault is the 'availability of victim' hypothesis (reviewed in Ref. 19)—namely, that the seasonality of offending is a function of the number of potential victims available and this varies in a predictable and periodic fashion throughout the year. Since all homicides are also the result of an assault, the victim availability hypothesis implies that assault and homicide rates should be in a relatively stable equilibrium. Our results show, however, assaults have a significant seasonal periodicity peaking in June, but the homicide distribution is essentially monotonous: a pattern contrary to predictions based on victim availability.

There is also the evident observation that our data is from UK in the 1990s, whilst the majority of studies we are comparing with were performed using US data from many decades previously. It is possible that these temporal and geographic differences may mask any individual and environmental important risk factors for violent behaviour, some of which, such as unemployment, may be seasonal. Our data do not allow us to specifically examine for these factors. Nonetheless, our results support the idea that the conventional finding of season being a risk factor in assault but not homicide is not confined to a single geographic location or a specific era. It also suggests that if there are specific individual and environmental seasonal risk factors for assault, these are relatively stable over time and not confined to a single location.

One major difference between homicide and assault is the fate of the victim. By definition, homicide involves only one specific victim response. Interestingly in all of the studies discussed previously, indeed throughout the literature homicides are considered as a type violent behaviour, rather than an outcome. Furthermore, none of the studies consider that processes other than the behaviour of the perpetrator determine this outcome. However, death following assault is a biological event and seasonal factors may impact on the pathophysiology of the trauma response.

As a corollary, the number of victims who are less able to withstand the trauma of serious physical assault such as the physically frail may vary seasonally. The most obvious seasonal factor that may act on health outcome is weather (reviewed in Ref. 19). However, Sivarajasingam and Shepherd found no sex or age related differences in seasonality for assault related hospitalisations for an overlapping period. This would, at least, suggest that the proportion of vulnerable victims does not vary season-
ally (assuming gender and age are reasonable proxies for physical vulnerability). A modification to the "variation in proportion of vulnerable victims" hypothesis suggested above is that there is seasonal variation in the ability of victims to survive. In other words it is not that there is a different mix of victim groups at different times of the year but that victims as a whole are less able to survive serious assault as a function of the time of the year.

Notwithstanding that the physiological response to trauma is highly complex, there is some evidence that supports this proposition. Coagulopathy, estimated from prothrombin time (PT) is a good predictor of trauma related mortality. It has been shown that the activation markers for this process are highly heritable. PT has a circannual rhythm that peaks in winter and it is likely that this is also genetically determined. Indeed, the seasonality of PT (and related factors) has been proposed as a mechanism to explain the seasonal variation in cardiac deaths. Whilst the aetiological underpinnings of the seasonal relationship between assault and homicide are likely to be multivariate and involve the interaction of many biological, social and environmental risk factors, the concept of seasonal variation in the biological response to trauma, at least, has the advantage that it can be used to generate testable hypotheses and, in this way, extend our understanding of the seemingly paradoxical relationship between assault seasonality and homicide rates.

Limitations and strengths

We have used court determined outcome data, which are only one estimate of the true number of offences. Such data, for example, does not, by definition, include cases such as unsolved homicides and unreported assaults. However, for this to impact on our results, there would have to be a seasonally asymmetrical reporting bias. The evidence from the hospital attendance data suggests that this is not the case. This assumes, of course, that there is not an identical seasonal bias in the hospital admissions, however, we can think of no plausible reason why this should be. In addition, by contrasting our findings with the extracted, separately collected assault hospitalisation data provides a validation check not previously utilised.

Against these limitations the study has a number of strengths. We have used national data extracted from centrally administered databases of assaults and homicides collected within the same sampling frame and a statistical approach that is stringent.

Implications and future directions

Generally, our results suggest that seasonality researchers need to carefully consider how they use data from population-based registers and, importantly, what these data represent. The literature review of assault and homicide seasonality highlights the conceptual problems that can occur when these related phenomena are considered separately and/or as if both are behaviours. We think little can be gained by adding more studies of homicide seasonality to the literature without consideration of the time-dependent variation between assault and homicide rates. Of particular interest in this regard is our finding that there is a decrease in assault seasonality with increasing severity, albeit, based on a judicial estimate of injury severity. It would be very informative, therefore, to examine whether the same effect is found in clinical samples, such as emergency department cases, where injury severity can be defined and ranked according to more physiologically refined criteria.

Our major finding is that assault and homicide rates do not show a monotonous correspondence over time and one plausible explanation is there is seasonal variation in the capacity of equally injured individuals to withstand trauma, a previously undescribed phenomenon. Simply put, when the seasonality of serious assaults reaches its nadir more of the victims die. Should this result be replicated it would have far reaching implications, not only for trauma care, but across many areas of medicine. The notion that the time of year may be an important risk factor for trauma responsiveness should be discernable. Examining for seasonal variation in important physiological indices of the trauma response, such as blood loss, in patients undergoing elective surgery might provide one potentially useful "test bed" for examining our speculations and extending our research from the population to the person level. This would allow us to more carefully disaggregate biological, environmental and social risk factors and, thus, provide more specific understanding of the intriguing observation that trauma survivability is seasonal. The identification of consistent recurring circannual periodicity in the underlying pathophysiology of trauma could provide potential new insights for the development of more efficacious therapeutic approaches. Clearly, however, much more work is needed. A more considered approach to the chronoepidemiology of trauma is a necessary first step.

In conclusion, we have used contemporaneously collected sets of epidemiological time-series data to extend our knowledge and understanding of the
relationship between assault and homicide, and have proposed a novel aetiological model that suggests seasonal variation in normal physiology may be an important determinant of assault outcome at the population level. Future research should be developed that examine and extend our findings in order to gain a better understanding of the seasonal factors associated with trauma survival.

Conflicts of interest

The authors have no conflicts of interest to declare.

References