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Season, weather, and suicide–Further evidence for ecological complexity

Fhionna R. Moore[a,*], Martin Bell[a], Mairi Macleod[a], Eleanor Smith[a], Joanna Beaumont[a], Linda Graham[b], Trevor A. Harley[a]

[a] Department of Psychology, University of Dundee, Dundee, DD1 4HN, UK
[b] NHS Tayside Department of Psychological Therapies, 15 Dudhope Terrace, Dundee, DD3 6HH, UK

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ABSTRACT

Background: easonality in suicide is reported worldwide, and peaks in late spring. Despite the potential connection to the weather, associations between meteorological variables and suicide does not explain seasonality. Studies testing for seasonality while controlling for the weather show patterns that are more complex than a straightforward link between spring-like weather and suicide.

Methods: We tested whether seasonality in suicide was due to meteorological variation (hours of sunshine, rainfall, or temperature) in a novel population (Scotland; 2003–2013). We also sought to further explore the ecological complexity demonstrated in previous work by testing associations at a single location (Tay Road Bridge; 1968–2017). RESULTS: We found peaks in suicidal behavior in June at the bridge, but no seasonality for Scotland as a whole. Seasonality was reduced when we controlled for maximum temperature and hours of sunshine. We found patterns to be dependent upon sex, with stronger seasonal and meteorological effects amongst men.

Limitations: Our study was exploratory and relies on population-level data.

Conclusions: Seasonal and meteorological effects on suicide are dependent upon local and individual context, with significant effects apparent at the Tay Road Bridge and not across Scotland as a whole. Men may be more sensitive to season and weather. In order to determine whether seasonality in suicide is due to meteorological variation, future research should test patterns in small geographical units, in men and women, and for different suicide methods, and seek to identify the social and physical factors which predict variation in patterns.

1. Introduction

Suicide rates peak in late spring and early summer, and fall during the winter (Barker et al., 1994; Bridges et al., 2005; Chew and McCleary, 1995; Christodoulou et al., 2012; Dixon and Kalkstein, 2018; Durkheim, 1897; Khorshidi et al., 2014; Partonen et al., 2004; Petridou et al., 2002; Preti et al., 2000; Rocchi et al., 2004; Zonda et al., 2005). Patterns are strongest for suicides by violent methods (Hakko et al., 1998; Kadotani et al., 2014; Räsänen et al., 2002; Qi et al., 2015), and women may have a second peak in the autumn (Meares et al., 1981; Micciolo et al., 1989; Nayha, 1982).

One obvious potential mechanism is seasonal variation in the weather via, for example, effects of sunlight on serotonin regulation (e.g.Spindelegger et al., 2012), or the sleep-wake cycle via melatonin (Lavebratt et al., 2010a, 2010b) with consequences for insomnia symptoms (Pompili et al., 2013). Hours of sunshine, however, have been found to correlate with suicide rates both positively (Lambert et al., 2003; Souetre et al., 1987) and inversely (Rock et al., 2003), even within different regions in the same study (Tietjen and Kripke, 1994). Temperature and precipitation are, of course, closely correlated with hours of sunshine, and the independent consequences of each are difficult to disentangle (Bazas et al., 1979; Lambert et al., 2002). As with hours of sunshine, suicide rates have been shown to increase with both colder (Linkowski et al., 1992; Souetre et al., 1987; Souêtre et al., 1990; Tsai, 2010) and hotter (Dixon et al., 2014; Dixon and Kalkstein, 2018; Kim et al., 2011; Lee et al., 2006; Likhvar et al., 2011; Page et al., 2007) temperatures, and to be uncorrelated (Dixon et al., 2007). Higher rainfall has been shown to be associated with increased numbers of suicide attempts (Barker et al., 1994), but not with suicide rates (Ajdacic-Gross et al., 2007).

Diversity in findings may stem from heterogeneity in research methodologies and target populations, which differ in social and physical ecology (Dixon et al., 2007; Ajdacic-Gross et al., 2010). There is also no consensus amongst researchers as to which variable - if any - is the driving meteorological mediator of seasonality in suicide. Furthermore, demonstrating correlations between suicide rates and

* Corresponding author.
E-mail address: f.moore@dundee.ac.uk (F.R. Moore).

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meteorological variables is not sufficient to explain seasonality. What is required is demonstration that seasonality is reduced when adjusted for meteorological variables (Ajdacic-Gross et al., 2007). Relatively few studies have attempted this, and those that have show complex patterns. In data from Australia, Greece, and Norway, seasonality was not due to variation in hours of sunshine (White et al., 2015). A positive relationship between temperature and suicide rates was strongest in the winter over 100 years in Switzerland, suggesting that the association between temperature and suicide was not due so much to warm temperatures in the summer, but rather to a lack of cold temperatures in the winter (Ajdacic-Gross et al., 2007). Interestingly, two suicide methods (jumping from high places and railway deaths) were most closely associated with temperature, suggesting method to be a further moderating factor (Ajdacic-Gross et al., 2007).

The state of our understanding of the contribution of meteorological mechanisms to seasonality in suicide, then, is in its infancy. We need to test for seasonality in suicide rates while controlling for meteorological variables, associations between meteorological variables and suicide rates while controlling for seasonality, and the interaction between the two, in populations that differ in latitude, climate, and socioecology (Ajdacic-Gross et al., 2007). We should also determine whether any such patterns differ for men and women (Meares et al., 1981; Micciolo et al., 1989; Nayha, 1982). Here we tested for (i) seasonality in suicide, (ii) relationships between meteorological variables and suicide, (iii) mediation of seasonality by meteorological variables, (iv) interactions between seasonal and meteorological variables in associations with suicidality, and (v) whether any of the associations described above differed for men and women. We tested for relationships in (a) Scotland and (b) at a single specific location (the Tay Road Bridge, Scotland; Fig. 1) in order to determine whether geographical scale contributes to heterogeneity in results. We tested for rates of suicidal behavior more broadly (i.e. attempted, suspected, and completed suicides) at the Tay Road Bridge, as completed suicides are only the tip of the iceberg of suicidality and there is evidence for seasonality in suicidal behavior more broadly (Coimbra et al., 2016). We chose the Tay Road Bridge as there is evidence that seasonal patterns are strongest for violent suicide methods such as jumping from high places (Ajdacic-Gross et al., 2007; Hakko et al., 1998; Kadotani et al., 2014; Qi et al., 2015; Räsänen et al., 2002), and testing patterns in a single location close to a weather station increases the precision of measures of meteorology. Therefore, we hoped that testing patterns in this single location would provide a sensitive test of seasonal and meteorological contributions to suicide. Finally, Scotland is a reasonably novel population for testing as only one study, published over 25 years ago, has tested for seasonality in suicide here (Masterton, 1991), reporting seasonal patterns in parasuicide for women but not for men.

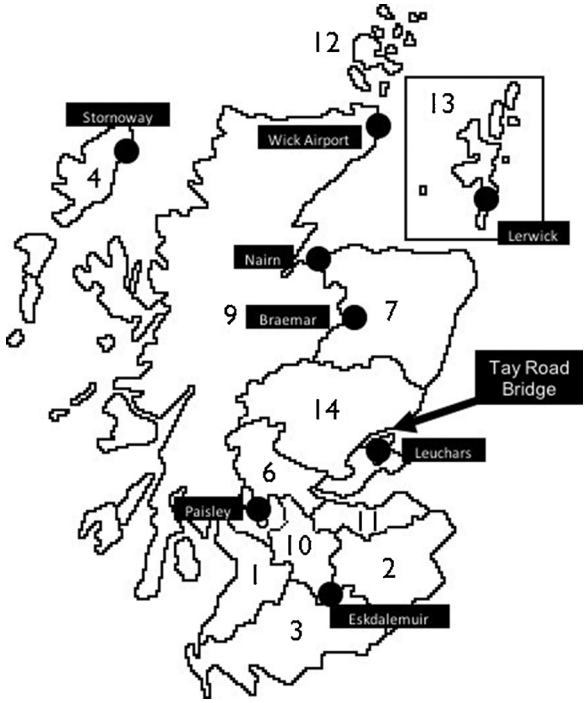

Fig. 1. Map of Scotland showing weather stations from which meteorological data were extracted, and the location of the Tay Road Bridge.

2. Methods

2.1. Locations

(a) Scotland has a population of approximately 5.4 million, and covers an area of approximately 30, 000 square miles (see Fig. 1)(b) The Tay Road Bridge spans the estuary of the River Tay between Dundee and Fife, and is approximately 2.25 km (1.4 miles) long (see Fig. 1 for location). It is comprised of 2 dual carriageways with a central walkway.

2.2. Suicidal behavior

(a) *Scotland*. We obtained numbers of male and female suicides for each month from January 2003 to December 2013 inclusive from the Scottish Records Office. In 2011, coding of deaths changed so, to maintain consistency, we used numbers of suicides calculated using the old coding rules for each year. The Scottish Records Office collates data on causes of deaths from the Crown Procurator Fiscal's office, following established national codes (National Records of Scotland, 2017). We calculated the monthly male and female suicide rate per 100, 000 of the sex-specific population ((number of male or female suicides / mid-year sex-specific population size)*100, 000).

(b) *Tay Road Bridge*. Data on suicidal behavior were extracted from the Tay Road Bridge Incident Log, which has been kept by bridge staff since 1968. Each incident of suicidal behavior has been recorded, including the gender of the individual and a description of the incident. In total, 759 incidents were recorded of which 685 (90.25%) were classified as 'suicidal behavior'. Other incidents included unconfirmed sightings, non-suicidal disruptive behavior or were recorded but the nature of the behavior was unspecified. Suicidal behavior was classified by bridge staff as anyone who crossed from the central walkway, across the carriageway to the barriers at the edge of the bridge, in combination with judgement of suicidal intent based on the individual's behavior, expressed intent, and visible distress. Date, gender, and nature of suicidal behavior (suspected suicidal behavior, attempted suicide, completed suicide) were extracted for all reports. We calculated the monthly rate of suicidal behavior by men and women per 100, 000 of the sex-specific population of Dundee ((number of incidents of suicidal behavior by men or women / mid-year sex-specific population size)*100, 000). We chose Dundee as our reference population as one end of the bridge is situated in the city centre, and it is the largest population centre close to the bridge. As numbers of incidents were so small, and completed suicides are likely to represent only a small proportion of total suicidality, we did not distinguish between incidents on the basis of their nature, rather we grouped them as 'suicidal behavior'.

2.3. Meteorological conditions

We obtained monthly maximum temperature (°C), total rainfall (mm), and hours of sunshine from Met Office historical archives (Anon., 2018). The Met Office is the UK national weather service with weather stations located across the UK. We extracted data from the 8 Scottish