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Research paper

Seasonal and meteorological associations with depressive symptoms in older adults: A geo-epidemiological study

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ABSTRACT

Background: Given increased social and physiological vulnerabilities, older adults may be particularly susceptible to environmental influences on mood. Whereas the impact of season on mood is well described for adults, studies rarely extend to elders or include objective weather data. We investigated the impact of seasonality and meteorological factors on risk of current depressive symptoms in older adults.
Methods: We used data on 8027 participants from the first wave of The Irish Longitudinal Study of Ageing, a population-representative cohort of adults aged 50+. Depressive symptoms were recorded using the Centre for Epidemiological Studies Depression Scale. Season was defined according to the World Meteorological Organisation. Data on climate over the preceding thirty years, and temperature and rain over the preceding month, were provided by the Irish Meteorological Service and linked using Geographic Information Systems techniques to participant's geo-coded locations at a resolution of one kilometre.
Results: The highest levels of depressive symptoms were reported in winter and the lowest in spring (mean 6.56 [CI95% 6.09, 7.04] vs. 5.81 [CI95%: 5.40, 6.22]). In fully adjusted linear regression models, participants living in areas with higher levels of rainfall in the preceding and/or current calendar month had greater depressive symptoms (0.04 *SE* 0.02; $p=0.039$ per 10 mm additional rainfall per month) while those living in areas with sunnier climates had fewer depressive symptoms (-2.67 *SE* 0.88; $p=0.003$ for every additional hour of average annual daily sunshine).
Limitations: This was a cross-sectional analysis thus causality cannot be inferred; monthly rain and temperature averages were available only on a calendar month basis while monthly local levels of sunshine data were not available.
Conclusions: Environmental cues may influence mood in older adults and thus have relevance for the recognition and treatment of depression in this age group.

1. Introduction

Rosenthal's seminal description of Seasonal Affective Disorder confirmed a place in modern psychiatric thinking for hypotheses linking affective state and light (Rosenthal et al., 1984). In the intervening decades, accumulating evidence ranging in scope from the basic neurosciences (Ciarleglio et al., 2011) to population-based observational studies (Magnusson, 2000), has continued to point to the meteorological determinants of mood.

Depressive symptoms are common, under-recognised and often inappropriately treated in older adults (Mojtabai, 2014). Older adults' mood may be particularly vulnerable to the effects of changing environmental stimuli owing to pragmatic considerations (e.g. reduced physical activity in winter months (Tucker and Gilliland, 2007)) but also due to changing neurophysiology which accompanies ageing (e.g. altered circadian rhythms (Smagula et al., 2014)). Much of the work investigating seasonality in the epidemiological literature however has not extended to include older age groups (Blazer et al., 1998) or has focused on particular age extremes (de Craen et al., 2005). In addition, clinical research on Bright Light Treatment in older adults has largely been based in institutionalized or tertiary care settings, hence limiting the generalisability of results to the wider older population (Sumaya et al., 2001).

In tandem with the ageing demographic, climate change is one of the most pressing public health concerns of our time (Smith and Woodward, 2014). Despite this, investigation of the impact of

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long-term climate (i.e. the long-term or thirty year prevailing weather conditions) on mood has received little attention. Rather, prior research has often relied on self-reported seasonality of mood or season alone, eschewing the use of objective weather variables (de Graaf et al., 2005; McConville et al., 2002). Interestingly, a recent study from Spain using local objective climate data found that those living in areas with the highest temperatures, least rain and longest duration of sunshine were most likely to be become depressed (Henriquez-Sanchez et al., 2014) while a prospective study noted little relationship between objective weather data and mood (Kerr et al., 2013). The relationship between weather and mood is thus complex and competing psychosocial explanations must be explored. Furthermore, regional level weather data may not accurately reflect the weather to which the individual is exposed, as even within a small country such as Ireland there may be significant variations in local weather conditions (Kiely et al., 2010; Walsh, 2012). The availability of objective weather data combined with the power of modern analytical geographical mapping tools, now allows linkage of individual level weather conditions to an individual's mental health.

Based on the island of Ireland, located in a temperate region at 53 N bound by the Irish Sea to the East and the Atlantic Ocean to the West and South, we sought to investigate the impact of seasonality on risk of current depressive symptoms in a large cohort of older adults, while controlling for a wide array of important confounders. We additionally wished to explore the impact of accurately mapped (at a resolution of 1 km) objective state-compiled records of climate and proximal (within one month of interview) meteorological data.

2. Methods

2.1. Sample

We used data from first wave of The Irish Longitudinal Study on Ageing (TILDA) which was collected from late 2009 to early 2011. TILDA contains a nationally representative sample of 8175 people aged fifty and above who are resident in Ireland. The study covers the Republic of Ireland only and not Northern Ireland. As part of the sampling procedure the addresses of all participants included in the study were geo-coded. A detailed description of the survey methodology and the weighting scheme for TILDA has been published (Kearney et al., 2011).

Researchers at TILDA used the ‘RANSAM’ system (Whelan, 1979) to construct the sample. Under the RANSAM system, all residential addresses in Ireland are grouped into 3155 geographic clusters which range in size from 500 to 1180 addresses. 640 of these clusters were selected, stratified by socioeconomic group and geography so as to maintain a nationally representative sample based on the most recent census taken before TILDA data collection. Given a target sample size of 8000 and a target response rate of 60%, within each of the chosen clusters, 40 addresses were visited by field workers so as to ascertain whether anyone aged over 50 was living in the household and, if so, to invite the person(s) for interview. The overall response rate among randomly chosen eligible households was 62%. To eliminate potential bias due to differential participation by certain groups of people in TILDA, weights were constructed by comparing the number of sample members in each gender, age group (age 50–64, 65–74 and 75+) and educational attainment group (primary, secondary and tertiary) with the corresponding cell in the Quarterly National Household Survey from the Irish Central Statistics Office.

For our analysis, we used a sample of 8027 participants who had complete information for the variables that we included in our models. 148 from the total of 8175 observations (or 2% of the sample) are omitted from the final working sample as they did not complete the CES-D questionnaire in the survey. However as discussed, we use the sampling weights calculated using the Quarterly National Household Survey so as to ensure our results are nationally representative relative to the joint distribution of educational attainment and age group in the overall population.

The 148 participants who did not answer the CES-D were older and had lower levels of education. To ensure that we used as many observations as possible, dummy variables indicating missing values were used in relation to use of medications (78 observations), exercise levels (75 observations), delayed recall tests (154 observations) and wealth (459 observations). Information was missing in relation to these variables due to the respondent's refusal to answer the relevant question or not knowing the answer. Our results do not change qualitatively when using complete cases only.

2.2. Ethical standards

Trinity College Dublin Health Research Ethics Committee granted ethical approval for the study. Each participant provided written informed consent prior to enrolment in the study.

2.3. Data collection

Interviewers carried out face-to-face interviews with respondents in their homes. The location of each TILDA respondent was geo-coded using Global Positioning System technology (Fig. 1). Data was collected at a constant rate throughout late 2009 to early 2011. TILDA collected detailed information on many aspects of the respondents' lives such as economic circumstances, health (e.g. physical health, cognitive function, mental health, health service needs and usage) and other socio-demographic information.

2.4. Assessment of depression

Levels of depressive symptoms over the previous week were recorded using The Centre for Epidemiological Studies Depressions Scale (CES-D). Each question offers a four-point response scale with options ranging from, 'Rarely or none of the time (less than 1 day)' to 'All of the time (5–7 days)'. This is a 20-item questionnaire, which produces a total score ranging from 0–60 and is validated for use in epidemiological populations (Radloff and Teri, 1986). Higher scores indicate greater levels of depressive symptoms. A cut-off score of sixteen on the CES-D has been shown to have high-levels of sensitivity and specificity for clinical depression (Beekman et al., 1997).

2.5. Season

When controlling for season at date of interview, we used the World Meteorological Organisation's (WMO) definition of season (i.e. summer starting on the 1st of June).

2.6. Weather data

We used the Irish Meteorological Service's gridded data which consists of meteorological data for a national grid of points 1 km apart. The gridded data are derived using data from weather stations extrapolated to the grid points using meteorological models. Monthly averages are available for 2009–2011 in relation to rainfall and temperature. Given that monthly data was available at the calendar month level only, in analysis relating to participants interviewed before 15th day of each calendar month, we averaged