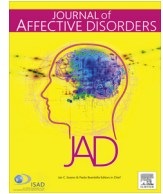




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Research paper

## Sunshine on my shoulders: Weather, pollution, and emotional distress



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## ABSTRACT

**Background:** Researchers have examined the relationship between mental health and weather/pollution with mixed results. The current study aimed to examine a range of weather and atmospheric phenomena and their association with time-bound mental health data.

**Methods:** Nineteen different weather/pollution variables were examined in connection with an archive of self-reported mental health data for university students participating in mental health treatment ( $n=16,452$ ) using the Outcome Questionnaire 45.2 (OQ-45). Statistical approach involved randomly selecting 500 subjects from the sample 1000 different times and testing each variable of interest using mixed models analyses.

**Results:** Seasonal changes in sun time were found to best account for relationships between weather variables and variability in mental health distress. Increased mental health distress was found during periods of reduced sun time hours. A separate analysis examining subjects' endorsement of a suicidality item, though not statistically significant, demonstrated a similar pattern. Initial results showed a relationship between pollution and changes in mental health distress; however, this was mediated by sun time.

**Limitations:** This study examined a relatively homogenous, predominantly European American, and religious sample of college counseling clients from an area that is subject to inversions and is at a high altitude and a latitude where sun time vacillates significantly more than locations closer to the equator.

**Conclusions:** Seasonal increases in sun time were associated with decreased mental health distress. This suggests the need for institutions and public health entities to plan for intervention and prevention resources and strategies during periods of reduced sun time.

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## 1. Introduction

There is a common perception that weather can play a critical part in the way a person feels at a given moment (Watson, 2000). Common metaphors such as “under the weather” reflect evidence of the pervasiveness of this belief. The belief that weather influences mood has also resulted in multiple research hypotheses which have been well researched with varied results. For example, Harmatz et al. (2000) found strong seasonal effects on levels of depression, hostility, anger, irritability, and anxiety. Kämpfer and

Mutz (2013) found that respondents surveyed on sunny days reported higher life satisfaction compared with those surveyed on days with “mixed or rather bad weather” (p. 587). One study in Helsinki, Finland found significant correlations between atmospheric pressure and suicide attempts, especially for men (Hiltunen, 2012).

Conversely, Keller et al. (2005) found that neither temperature nor pressure was directly related to mood, but rather moods improved with time spent outside on warm, high-pressure days. Denissen et al. (2008) found no significant main effects of temperature, wind power, sunlight, precipitation, air pressure, or photoperiod on positive affect. They also found that increases in temperature resulted in increased negative affect, but increases in sunlight and wind power decreased negative affect.

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Other studies exploring the relationship between weather and mental health found no significant effects overall. [Traffanstedt et al. \(2016\)](#) found no correlation between sunlight, season, or geographic latitude on depression scale scores. [Clark and Watson \(1988\)](#) found that neither temperature-related complaints nor actual weather were related to mood. [Huibers et al. \(2010\)](#) showed that weather and sad mood or depression were not associated. [Watson \(2000\)](#) learned that mood was not strongly nor consistently related to temperature, barometric pressure, or level of sunshine. [Deisenhammer \(2003\)](#) also stated that due to the high variance of change among methodological approaches, risk for suicide in a population could not be identified by weather conditions based on the available information in the literature.

Researchers have also explored the relationship between Seasonal Affective Disorder (SAD) and weather, with a focus on correlations among weather variables, treatment, and outcomes. The [American Psychological Association \(2016\)](#) has asserted that lack of exposure to the sun, especially during the winter season, impacts depressive symptoms. Current research has shown the positive effects that natural light, artificial light, and blue light can have on clients diagnosed with SAD ([Dalgleish et al., 1996](#); [Gordijn, t Mannetje, and Meesters, 2012](#); [Lam et al., 2006](#); [Martiny et al., 2004](#); [Rastad, et al., 2008](#); [Roeklein, Schumacher, Miller, and Er-necoff, 2012](#); [Wesson and Levitt, 1998](#)). These positive effects span from overall quality of life to a reduction in depression symptoms ([Michalak et al., 2005](#); [Rastad et al., 2008](#)), and findings from [Levitt et al. \(2002\)](#) show that better outcomes are associated with more exposure to light. [Kadotani et al. \(2014\)](#) found that there were increases in railway suicide attempts after a few days with lower levels of sunlight in Japan. While research findings regarding weather and its correlations to mental health are varied, it appears that there is some basis for the idea that amount of sunlight correlates with mental health.

Examining the varied results of this body of literature shows that there is still significant work to be done to understand the impact of meteorological phenomena on mental health. In the current study the researchers used innovative methods to attempt to clarify some of the confusion and contradiction. In previous studies, weather has typically been analyzed only on a seasonal or daily scale. In the current study the researchers examined both weather and mental health variables much more precisely (often down to the hour). The researchers also broadened the examination of weather variables to include multiple aspects of meteorological phenomena (dew point, wind-chill, rainfall, solar irradiance, wind speed, barometric pressure, temperature, and lunar day), and pollution variables (PM2.5, PM10, ozone, and nitrogen dioxide) as potential factors impacting mental health. In addition, instead of using a sample from the general population, the researchers investigated a clinical population. This may help clarify how meteorological phenomena impact persons already experiencing distress and possibly experiencing difficulty with their moods.

Rather than using a simple outcome, such as administration of a mood measure ([Clark and Watson, 1988](#)), number of attempted suicides ([Kadotani et al., 2014](#)), online diaries ([Denissen et al., 2008](#)), or criteria for diagnosis ([Huibers et al., 2010](#)) as a dependent variable, mental health distress and treatment outcome were assessed using repeated measures on the Outcome Questionnaire-45.2 (OQ-45, a brief, validated outcome measure that examines multiple aspects of psychological distress each time a client attends a mental health treatment session; [Lambert et al., 2011](#)). The number of participants in this study was also significantly larger than most due to the already existing archival data set of mental health variables. Meteorological phenomena data were obtained from the six-year period that coincided with the archival data set.

The current study sought to answer the following questions:

1. In the available data, are there relationships between mental health distress (both generally and specifically related to suicidality) and weather/pollution variables?
2. What weather/pollution variables best correlate with changes in mental health distress/suicidality?

## 2. Methods

### 2.1. Participants

Mental health distress data for this study came from a 6-year period (from October 2008 through September 2014) of a de-identified, archival dataset continually collected by the large university counseling center at Brigham Young University. This university is located in Provo (Utah County), Utah. The latitude of the university is 40.2497, the longitude is  $-111.6489$ , and the altitude is 4630 feet. Demographically, the 16,452 university students were, 55.4% female, 44.6% male, aged 16–68 ( $M=23.14$ ), and identified as 84% Caucasian/White, 6.5% Hispanic, 4.2% Asian, 1% Black, and 4.3% Other.

### 2.2. Measure

The OQ-45 ([Lambert et al., 2004](#)) is a 45-item, self-report measure of psychological functioning. Items are measured on a 5 point Likert scale: 0=never, 1=rarely, 2=sometimes, 3=frequently, 4=almost always. The range of scores possible on the OQ-45 is 0–180, with higher scores reflecting greater distress. The OQ-45 assesses three broad domains of client functioning: (a) subjective discomfort, (b) interpersonal relationships, and (c) social role performance. The OQ-45, which was normed on local and national populations, clearly discriminates between clinical and nonclinical samples ([Lambert et al., 2004](#); [Umphress et al., 1997](#)), and is currently available in 17 languages. Using formulas developed by [Jacobson and Truax \(1991\)](#), clinical and normative data for the OQ-45 were analyzed by [Lambert et al. \(2004\)](#) to provide cutoff scores for the reliable change index (RCI; 14 points) and clinically significant change (dysfunctional/functional cutoff: 64/63). These formulas for cutoff scores and classifications for change are supported by multiple studies ([Bauer et al., 2004](#); [Lunnen and Ogles, 1998](#)) and provide consensus with other self-report measures like the Beck Depression Inventory ([Beck et al., 1996](#)) and the Symptom Checklist-90 ([Derogatis, 1996](#)).

### 2.3. Procedure

Mental health treatment sessions at the university Counseling and Psychological Services center are offered free of charge and without session limits to full-time students of the university. Clients are referred or self-referred for a wide range of presenting concerns, the majority of which are adjustment, anxiety, or depression related, and are given the OQ-45 at each session to track change in symptom distress. Although outcome measurement is a part of routine practice at this center, clients are asked for permission for their anonymized data to be included in research as part of the intake process; only consenting clients' data were included and each client was given an ID number unique to the dataset. The study was conducted in compliance with the university's Internal Review Board.

### 2.4. Environmental data

Weather data were gathered from the university Physics and Astronomy Weather Station. Pollution data were downloaded from the [US Environmental Protection Agency \(EPA\) online database](#)

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