



Climate–Suicide Relationships: A Research Problem in Need of Geographic Methods and Cross-Disciplinary Perspectives

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Abstract

Many locations on Earth experience peaks in suicide rates during the late spring and early summer, and there is evidence that climatic variables may be causal factors. Beyond this seasonal characteristic, there is little consistency in the results of various climate–suicide studies. Almost all of the published climate–suicide research has been conducted by mental health experts with relatively little input from geographers and/or climatologists, thus highlighting the need for future collaborative efforts. Previous research has shown how the use of a single statistical method, as opposed to multiple methods, can yield misleading or confusing results. Future research on climate–suicide relationships should allow for more consideration for spatial and temporal variations in climate, culture, demographics, etc. Ultimately, improved methods and the use of cross-disciplinary methods will help arrive at consistent results that identify climate variables that significantly affect suicide rates, if any exist.

1 Introduction

Suicides account for more deaths globally than homicide and war-related deaths, combined (Krug et al. 2002). Thus, considering the ubiquitous nature of suicide, as well as the impacts of climate on the human population, it seems that climate–suicide relationships receive relatively little attention outside of academia. On average, there have been approximately ten articles per year covering this topic over the past several years. Although these manuscripts are often published in leading scientific journals (e.g., *Journal of Affective Disorders*, *American Journal of Epidemiology*, *American Journal of Psychiatry*, *International Journal of Biometeorology*), the public rarely hears about these studies despite some staggering statistics on suicide frequency. One probable explanation for the sparse media treatment is the lack of a consistent message from scientists. Despite several decades as an active research problem, there are few widely accepted findings on the topic, and perhaps the only standard conclusion of most studies is that suicide seasonality, if present, will most often result in more suicides during late spring and early summer. This is in contrast to popular beliefs that clouds and rain are associated with increased suicide (owing to the wide dissemination of research on seasonal affective disorder), so it seems that future research should focus on explaining the ‘spring peak’ to educate the public. Instead, most research on this topic continues the pattern of simply identifying temporal patterns of suicide and then relating them to climatic variables, such as surface temperature, which display similar variance at small spatial scales and/or coarse temporal scales. Thus, as a result of the seasonal cycles observed in both the climatic and suicide data, these studies often

2 Climate–suicide relationships

result in statistically significant correlations, with little or no evidence of any causal mechanisms.

1.1 SUICIDE STATISTICS

During the year 2000, suicide accounted for an estimated 815,000 deaths worldwide (14.5 per 100,000 in population). Some countries, especially those in Eastern Europe, display much higher rates, whereas lower rates are most commonly found in Latin America (Figure 1; Krug et al. 2002). Rural areas around the world also typically experience greater rates of suicide than urban areas (Dudley et al. 1998; Hawton et al. 1998; Ji et al. 2001). Suicide rates are consistently higher among men, and they generally increase with age (Table 1). It should be noted that some countries experience secondary spikes in people of 15–24 years of age (Krug et al. 2002).

In the United States, there were 33,300 suicides recorded in 2006, the most recent year of available data (CDC 2009). This equates to approximately 11 suicides per 100,000 people, but most states display much higher suicide rates (Figure 2). Even those

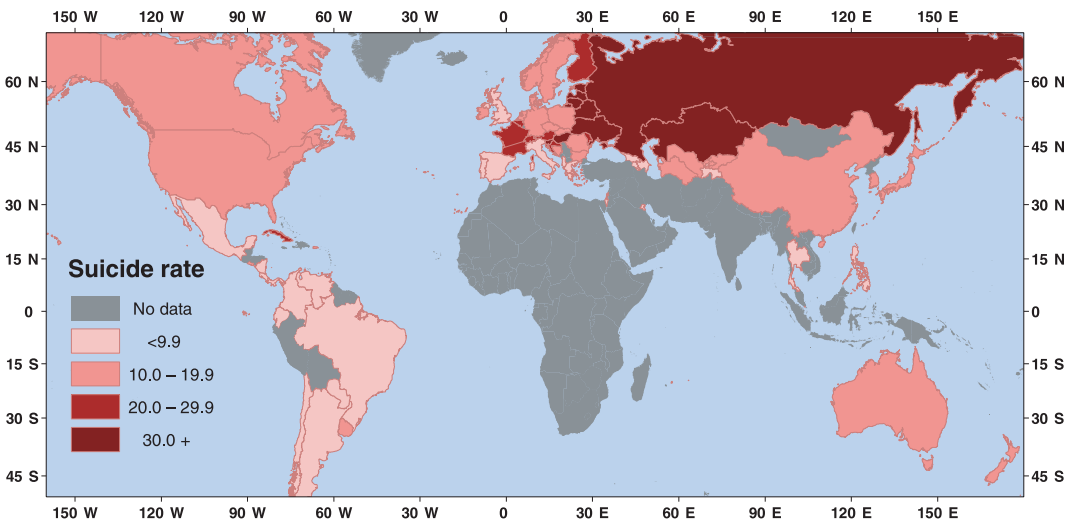


Fig. 1. Suicide rates (per 100,000 population) for the most recent years of available data (Krug et al. 2002).

Table 1. Estimated global suicide rates by age group, 2000 (Krug et al. 2002).

Age group (years)	Suicide rate (per 100,000 in population)	
	Men	Women
0–4	0.0	0.0
5–14	1.7	2.0
15–29	15.6	12.2
30–44	21.5	12.4
45–59	28.4	12.6
≥60	44.9	22.1
Total	18.9	10.6

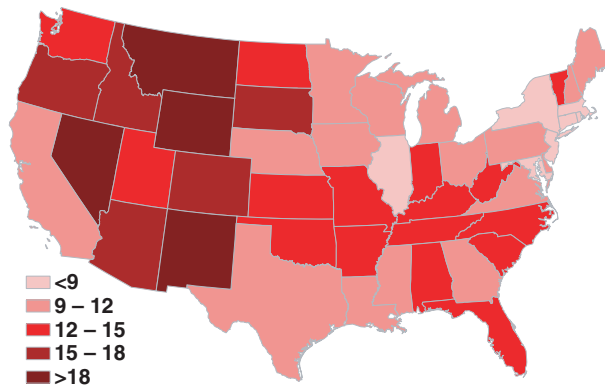


Fig. 2. Suicide rates (per 100,000 people), by state, for the years 1998–2002.

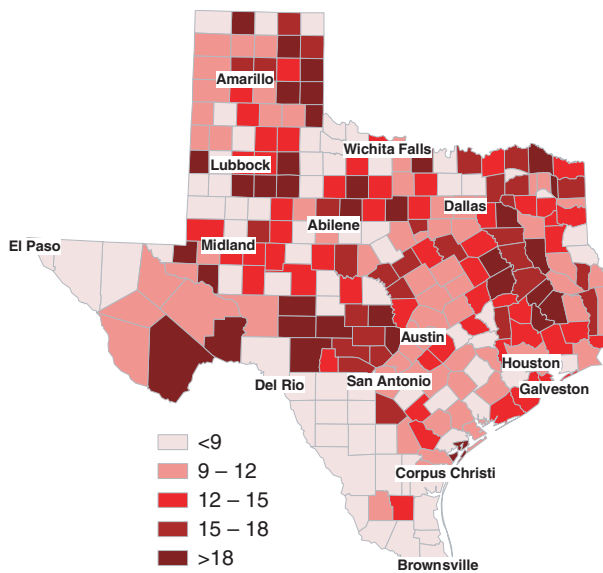


Fig. 3. Suicide rates (per 100,000 people), by county, for the state of Texas, 1998–2002.

states averaging relatively low suicide rates can display wide ranges of suicide rates, by county, with mostly ambiguous spatial patterns (Figure 3). Although women attempt suicide two to three times more often, the suicide mortality rate among men is nearly four times the rate of women. Adults older than 65 years committed suicide most often with a rate of 14.2 per 100,000. Suicide is the third leading cause of death among young adults aged 15–24 despite the fact that only 1 in 100–200 suicide attempts are fatal among this age segment. Similarly, suicide is the second leading cause of death among 25–34-year-olds, and it is the fourth leading cause for ages 10–14 and 35–44 (CDC).

In addition to emotional impacts, deaths exact economic tolls owing to health care, legal expenses, missed work and lost productivity by surviving friends and relatives. Based on 1996 data, the mean cost per suicide in New Brunswick, Canada was greater than US\$ 849,000, equivalent to just over US\$ 1.1 million in 2008 (Clayton and Barcel 1999).

Caution should be exercised when studying suicide rates as data often underestimate reality owing to inconsistent application of criteria required to classify a death as suicide (Graham et al. 2000). It has been theorized that these errors underestimate suicide rates by as much as 18% in China and Hong Kong (Yip et al. 2001). Further, religious and cultural stigmas are often cited as reasons for the underreporting of suicides. Such effects have been credited with errors of 40% in parts of England (Cooper and Milroy 1995).

2 Previous Climate–Suicide Research

Countless relationships between weather variables and human health have been documented dating back to the observation by Hippocrates that cold and warm winds affected the physical and psychological health of his patients (Deisenhammer 2003; Schory et al. 2003). Likewise, observations by Posidonius and Strabo, Greek philosophers and geographers, are often considered the first to make claims about significant influences of the climate and environment on physical and mental traits of people (Sanderson 1999). As translated from his original work published in 1897, Durkheim ([1951] 1997) theorized that there are two sorts of extra-social variables that might influence suicide rates: organic-psychic dispositions and the physical environment. In other words, Durkheim ([1951] 1997) suggests that certain groups (e.g., countries) of people are more likely to possess biological suicidal inclinations and that ‘climate, temperature, etc.’ might also have similar effects on some people. Just as some diseases emerge only under certain environmental conditions, the idea of environmental factors enhancing or suppressing suicide should not be discounted. However, although acknowledging that climate is a possible factor, Durkheim ([1951] 1997) is also careful to explain more plausible social factors (population clusters, economic cycles, political control) that might first appear as ‘environmental’ causes simply because they are focused on a single latitude, region, elevation, etc.

Durkheim’s ([1951] 1997) often-cited work is actually the English translation of his original French version published in 1897. Prior to the widespread popularity of Durkheim’s treatise, climate–suicide research was dominated by stereotypes of entire countries, regions, races or sexes (Curtin 1909; Platt 1889). Therefore, it should be noted that contemporary climate–suicide research has succeeded in avoiding the ideas of environmental determinism. Most studies limit their analyses to a single country and do not separate races. Hence, much of the climate–suicide research results are rather disjointed, with little overlap between similar projects around the world, and there has yet to emerge a set of widely accepted theories on how climate affects suicide rates.

In one of the most comprehensive reviews of climate–suicide research, Deisenhammer (2003) explains that despite much research on the topic, the pathophysiological mechanisms of climate effects on humans are widely unknown. Previous research suggests that the causal mechanisms behind suicides are complex, often driven by numerous variables, and no individual suicide can be causally related to a single event (Deisenhammer 2004; Deisenhammer et al. 2003; Sher 2004). Rather, a patient’s suicide risk usually increases with the number of risk factors, of which some weather variables might contribute (Sher 2004). To further complicate matters, Deisenhammer (2003) allows for the possibility that such mechanisms might vary considerably between disorders. Unfortunately, most climate–suicide research is based upon statistical correlations that do not necessarily equate to causal relationships, and many studies yield conflicting results owing to varying methods, data sources, study periods, etc. (Deisenhammer 2003; Dixon and Shulman 1983; Driscoll 1971). The statistical relationships can be misleading, but they are usually among

the first steps in identifying possible effects of weather on human health, and are quite important. Regardless of the specific physical mechanisms involved, this is an important issue as the identification of links between environmental conditions and behavioral responses are able to be mitigated even if causes are poorly understood.

Some studies, albeit a relative few, have found that there are no associations between meteorological variables and suicide (Chiu 1988; Deisenhammer 2003; Dignon and Bock 1966; Dixon and Shulman 1983; Pokorny 1966; Pokorny et al. 1963). The relative lack of significant results can likely be attributed to a number of factors. For example, Chiu (1988) examined data covering only 1 year in one location (Hong Kong) so sample size was likely an issue. Dixon and Shulman (1983) only examined a specific portion of the population, whereas conflicting results from previous studies led to the findings reported by Deisenhammer (2003).

Among the studies that do identify positive weather–suicide connections, there are often contradictory results. For instance, although some of the studies correlating suicide with temperature claim to find an increase in the number of suicides when temperatures are colder (Linkowski et al. 1992; Sou  tre et al. 1990; Thorson and Kasworm 1984; Tietjen and Kripke 1994), most find just the opposite (Breuer et al. 1986; Deisenhammer et al. 2003; Lester 1986; Maes et al. 1994; Preti and Miotto 2000; Salib 1997; Salib and Gray 1997; Sou  tre et al. 1987). Many studies have identified significant relationships between suicide rates and atmospheric variables (Deisenhammer et al. 2003; Lambert et al. 2003; Nicholls et al. 2006; Partonen et al. 2004a; Preti and Miotto 2000; Salib 1997). However, considering that some studies analyze multiple (as many as 46) meteorological variables, thus increasing the likelihood of statistically significant results, it is difficult to differentiate between actual relationships and those attributed to random chance (Deisenhammer 2003).

2.1 CONFLICTING RESULTS

Despite the conflicting results discussed in the previous section, one of the most consistent themes that has emerged from climate–suicide research is that suicide rates tend to display seasonal distributions with the most common peak occurring in late spring or early summer (Barker et al. 1994; Bridges et al. 2005; Chew and McCleary 1995; Deisenhammer 2003; Deisenhammer et al. 2003; Dixon et al. 2007; Lester 1971; Maes et al. 1994; Maldonado and Kraus 1991; Masterton 1991; Meares et al. 1981; Nayha 1982; Oravec et al. 2006; Papadopoulos et al. 2005; Partonen et al. 2004a,b; Petridou et al. 2002; Preti 1997, 2002; Preti and Miotto 2000; Preti et al. 2007; Rocchi et al. 2007; Rock et al. 2003; Sou  tre et al. 1987; Thorson and Kasworm 1984; Yip et al. 2006; Zung et al. 1974). If the seasonality of suicide is widely accepted, then the next logical step in the research process might be to isolate seasonable variables (e.g., temperature, sunlight, humidity, agriculture, school-related events, etc.) to determine those that affect suicide.

There are many possible explanations for why past studies have had such varying results, but one of the most obvious is the lack of consistent research methods. Many studies suffer from fundamental problems with respect to data collection and/or analyses. To confidently test relationships involving weather variables (temperature, seasonality, precipitation, humidity, etc.), the sample in question must span several years to avoid drawing general conclusions from a single, anomalous year. Likewise, a study of weather effects on people should certainly represent multiple locations to avoid anomalous local variables. Many past studies have made claims about relationships between suicide and

weather variables based on a single, relatively small study area (i.e., city or county) and/or a single year of data (Breuer et al. 1986; Chiu 1988; Deisenhammer et al. 2003; Partonen et al. 2004a; Salib 1997; Salib and Gray 1997; Schory et al. 2003; Wang et al. 1997). Other studies seek correlations between suicide rates and climate data without considering the utility of normalization techniques (Chiu 1988; Lester 1999; Linkowski et al. 1992; Sou etre et al. 1990). Climate data can easily be normalized to remove the seasonality. If temperature is a driving force behind variation in suicide rates, then changes in temperature should yield changes in suicide rates regardless of the month. In one particularly well-done psychiatry study, Barker et al. (1994) used daily climate and suicide data, and they also accounted for seasonal variations in temperature. They even analyzed climate data 1 day prior to suicide events to capture any potential lag effects, yet they found no climate variables that could explain even 1% of the variance in suicide rates.

Some studies draw conclusions from data with course temporal resolutions, hence, any correlations provide little help with cause–effect explanations. Further, such studies often become ‘self-fulfilling prophecies’ as they find correlations between climate variables and suicide rates in regions already known to display suicide seasonality whereas no attempts are made to account for the collinearity (Ruuhela et al. 2009). Thorson and Kasworm (1984) cite research from the 1970s that shows a negative correlation ($r = -0.53$) between annual hours of sunshine and suicide rates for several European countries (Department of Economic and Social Affairs 1975; Wallin 1970). More detailed analyses reveal significant exceptions to these relationships as many states and countries display suicide rates that contradict those of nearby locations and/or of those expected because of sunshine patterns (Dixon et al. 2007; Thorson and Kasworm 1984). Such exceptions have been blamed on cultural and religious differences between locations, which are almost always beyond the scope of the climate–suicide researchers (Hendin 1964; Kastenbaum and Aisenberg 1972; Thorson and Kasworm 1984).

As most published research on this topic has been conducted within the mental health professional community, it is no surprise that climate data (poor quality, unrepresentative, misinterpretations, etc.) are commonly the source of confusion and inconsistency. For example, Preti et al. (2007) entitled their paper, ‘Global warming possibly linked to an enhanced risk of suicide: Data from Italy, 1974–2003’. This title alone should be enough to draw the ire of geographers and climatologists as it is not possible for a study using only ‘data from Italy’, to produce conclusions about ‘global warming’. Places around the planet are responding differently to climate change; some are warming, some are drying, some are cooling and some are experiencing increased precipitation (Easterling 2002; IPCC 2001, 2007; Karl et al. 1996; Zhang et al. 2004). Throughout the manuscript of Preti et al. (2007), spatial analysis is almost completely neglected as no description is given of the variance in temperature or suicide rates even across Italy. Are some regions with increasing urbanization and temperature affected more significantly than others? Are the results of this study strongly affected by one or two locations? Most importantly, however, is that the observed warming trend across Italy does not match the fluctuations in suicides observed across the same temporal period.

Unfortunately, simply ignoring studies with flawed methods (e.g., short study period, testing a single location, course data, non-normalized data, etc.) does not clear up the confusion about the effects of weather on suicide. There are other studies with no obvious methodological problems that directly contradict each other (Chew and McCleary 1995; Geltzer et al. 2000; Lambert et al. 2003; Lester 1999; Linkowski et al. 1992; Preti and Miotto 2000; Zung et al. 1974). For example, Lester (1999) and Geltzer et al. (2000) both find that cloudiness and rainfall are associated with increased suicide rates, whereas

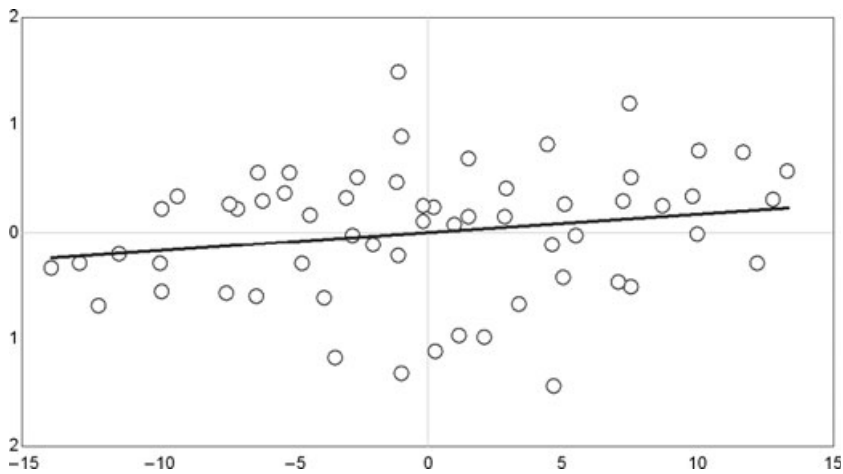


Fig. 4. Linear regression (with trendline) of monthly departure from annual mean temperature ($^{\circ}\text{C}$) and monthly departure from annual mean suicide rate (per 100,000 people). $R^2 = 0.040$, $\rho = 0.123$. Source: Adapted from Dixon et al. (2007).

Lambert et al. (2003) suggest just the opposite, finding a correlation between sunshine and suicide. In short, some of these authors identify positive correlations between weather variables and suicides, some identify negative correlations and some identify no correlations. There are even contradictory results by the same authors as Sou tre et al. (1987) found that monthly suicides in France tend to increase with increasing temperature and sunlight duration only to later find that annual suicides in France decrease with increasing temperature and sunlight duration (Sou tre et al. 1990).

Owing to the fact that temperature is so closely related to the seasons, it can be difficult to separate the two during analyses. If a seasonal signal exists in a dataset, temperature is usually one of the first explanations. Further tests of the relationship between temperature and the dependent variable often yield positive results, even if there is no significant relationship, simply because temperature covaries with seasons. The varying statistical results yielded by Dixon et al. (2007) when using linear regression and discriminant analysis regarding departure from normal suicide and temperature provide one example. Dixon et al. (2007) show a simple linear regression leading one to believe that there is a positive correlation between above-average temperatures and above-average suicide rates (Figure 4). However, further inspection of the scatter plot and implementation of discriminant analyses show that there is little, if any, correlation between the two variables. Rather, the fact that the top-left and bottom-right quadrants have approximately the same number of occurrences as the other two shows that the relationship between temperature and suicide is not reliable (Dixon et al. 2007). In other words, a month with above-average temperatures has nearly equal chances of experiencing an above- or below-average suicide rate. The same applies for a cooler-than-average month.

3 Non-Climatic Variables

Owing to contradictory results of weather-related studies, suicide researchers must question whether suicide seasonality is due to climatic or social causes. As listed before, many studies have been focused on the bioclimatic causes, but some seasonal social variables have also been identified as possible causes of suicide. The beginning and end of school

years, agricultural cycles and major holidays have all been cited as possible causes of suicide that would contribute to a seasonal signal (Deisenhammer 2003). Meares et al. (1981) found a single annual suicide cycle for men in England, but found two cycles for women with a peak in autumn in addition to the usual peak in spring. This finding has been attributed to increased suicide rates among mothers of school-aged children at the beginning of the school year (Deisenhammer 2003). Nayha (1982) found that the fall suicide peak in Finland is disproportionately composed of students. Finally, Durkheim ([1951] 1997) dismissed environmental influences on suicide rates and explained that ‘voluntary deaths increase from January to July ... because social life is more intense’.

In one of the more extensive studies on suicide seasonality, Chew and McCleary (1995) found that agricultural countries experience more pronounced seasonal cycles (i.e., spring peak) than industrialized countries. This is attributed to the fact that the well-being of citizens in industrialized regions is not ‘linked’ to natural seasonal cycles as it is for agricultural societies (Chew and McCleary 1995). These claims are supported by an earlier study that shows decreasing suicide seasonality in Finland since the 1920s (Nayha 1982).

It is also possible that the spatial, and even temporal, variations in suicide seasonality are because of the age distribution in each local population. Age-specific responses of suicide rates to climate variation could ultimately be the cause of differences in suicide seasonality over time and space as certain areas gain or lose members of the age group in question. This highlights the advantages of using age-standardized mortality, which can control for these fluctuations. Thorson and Kasworm (1984) propose the possibility that some sunny locations experience greater suicide rates because they are destinations for weather-sensitive people trying to escape the effects of more ‘gloomy’ locations. The common example is that of retirees moving from the northern United States to Florida or Arizona. If satisfaction is not provided by the move, these at-risk individuals then have to deal with the likely disruption to their social support networks and distance to family and friends, which often help prevent suicide (Thorson and Kasworm 1984).

Finally, published research has shown significant variation in suicide rates between ethnic groups and age groups (CDC; Krug et al. 2002). Even among locations with relatively homogeneous demographics within the United States, suicide rates can vary greatly (CDC; Dixon et al. 2007; Dixon and Kalkstein 2008). This could provide yet another potential explanation for the apparent contradictions observed in weather–suicide research.

4 Application of Geographic Methods

The idea of ‘geographic methods’, even when restricted to climate-related studies, can provide enough information, examples and discussion to fill several papers (Balling 2000; Bryson 1997; Carleton 1999; Mather et al. 1980; Yarnal et al. 1987). Some of the consistent themes of geography–climatology methods include spatial (i.e., interstation) analysis, the use of composites and multi-scale ensembles rather than individual case studies, the use of statistics to control for variables in the ‘laboratory’ that is planet Earth and the integration of multiple disciplines into a ‘climate system’. The application of these research principles commonly applied by geographers might be valuable in efforts to understand climate–suicide relationships. Spatial analysis does not necessarily require the identification of clear patterns and gradients across horizontal distances. Rather, it can simply imply the analysis of several locations to determine spatial consistency or variance. Traditional climatological methods of compositing data to identify long-term trends and patterns can

also be applied to mortality data, whereas the study of a single year (or just a few years) might result in conclusions based on an anomalous year. In laboratory science, the common idea is to control the samples to focus primarily on a particular dependent variable. In field-based disciplines, it can be difficult to physically control variables; statistical normalization techniques aid in this process. With suicide being affected by innumerable factors, controlling for non-climatic variables, when possible, is vital for finding any climate–suicide relationships. Finally, the idea of multi-disciplinary, or cross-disciplinary, research is crucial to geographers seeking to apply their knowledge to problems in other subject areas.

It is important to note that privacy must be taken into careful consideration when conducting any study on suicide. This is vital in locations with relatively small populations, as it is easier to identify people associated with specific events. For example, if a sparsely populated county experiences only one death on a given day, and if a suicide is also recorded on that day, the connection is obvious. Therefore, most studies must be restricted to monthly data or to areas with larger populations (usually 100,000+). In the United States, the National Center for Health Statistics now requires special permission to access geographic identifiers, including state and county, associated with suicides after 2004. For post-2004 data, researchers must contact individual state agencies to acquire suicide data with geographic information. Some previous research has shown that suicide rates tend to increase with increasing population densities (Deisenhammer et al. 2003), yet others have shown that rural areas around the world often experience greater rates of suicide than urban areas (Dudley et al. 1998; Hawton et al. 1998; Ji et al. 2001). Either way, researchers must try to account for population, demographic and privacy issues if they are studying a large area or comparing multiple locations.

As a result of both privacy concerns and data availability, analyses of monthly data have been most common in climate–suicide research thus far. The use of monthly data must involve the smoothing of extreme events (with respect to weather or suicide rates), so interpretation of ‘signals’ or correlations can be ambiguous (Dixon and Kalkstein 2008). Of course, the use of daily data requires special consideration for possible lagging relationships between independent and dependent variables. Much like climatologists demand proper sampling of climate data, mental health professionals are likely to point out the innumerable causal variables that might lead to suicide attempts on one day instead of another (Sher 2004). Regardless, as mentioned earlier, geographer-climatologists have a history of compositing fine-resolution data to identify larger-scale relationships (Carleton 1999).

5 Future Research

Although it is important to study multiple locations in search of similar patterns, scientists should avoid the selection of very broad study areas. There are 70 countries with suicide data reported by the World Health Organization. The annual suicide rates of these countries range from 1.1 to 51.6 suicides per 100,000, with an average value of 16.1 and a standard deviation of 10.9. Studying locations within the same country is useful because it provides some consistency with respect to suicide classification methods, cultural effects, etc. Nevertheless, variations in culture and climate within countries should be taken into account. For example, comparing results from Moscow with Vladivostok, separated by nearly 10,000 km in Russia, could be insightful as both locations likely follow very similar methods for collecting suicide data while experiencing different climate patterns and different cultures. However, using values from twenty Russian cities to arrive at

conclusions about the entire country would be misleading as those climate and cultural variations would not be accounted for.

Daily mortality data, although potentially more useful, are more difficult to acquire, and such data are less likely to be accompanied by useful geographic information as a result of privacy concerns. If daily data are available, climate data for each day should be compared with suicide rates for that day as well as each of the next several days to account for potential lags or cumulative effects. It is unclear, based on previous research, whether suicide rates are more likely to be altered by a sudden change in climate conditions or the ‘accumulation’ of certain uninterrupted conditions.

Statistical analysis is a necessary tool for the interpretation of climate–suicide relationships, and some sophisticated methods have been previously employed. Perhaps the most crucial role of statistics in climate–suicide research is to normalize the data in a way that minimizes the effects of non-climatic variables on suicide rates. Many climate–suicide studies have employed methods to account for climatic seasonality (Partonen et al. 2004a,b), age of the victims (Paulozzi et al. 2007), sex of the victims (Meares et al. 1981) and several other variables (Breuer et al. 1986; Geltzer et al. 2000; Linkowski et al. 1992). Future research can benefit greatly from assessing the utility of normalization techniques implemented by these prior studies.

6 Conclusions

It is our opinion that geographers and/or climatologists have a great deal to contribute to the climate–suicide research. Geography’s history of spatial analysis, multi-scale and composite analysis, using statistical methods to control for certain factors, and the integrated-discipline approach of applying geographical (climatic) data to the problems of other disciplines all seem to support the idea that geographers can be helpful in the study of climate–suicide relationships. This is especially true for studies involving the analysis of numerous suicide events over extended periods of time. Conversely, the utility of geographers and climatologists decreases with shorter study periods as such research is more likely to focus on individuals and their specific clinical diagnoses. For extended study periods, the suicide data can be viewed simply as a variable dependent (at least in part) upon climate. Geographer–climatologists are quite accustomed to using climate data in statistical studies that also involve non-climatic variables (Ashley and Ashley 2008; Dixon et al. 2005, 2008; Jones and Goodrich 2008), and the use of suicide totals as another non-climatic-dependent variable fits well within the realm of traditional geographical research.

Research on the threat of extreme heat to human health has become a topic commonly studied by teams of climatologists, geographers and health experts. The ‘Human’ session of at the 2008 International Congress on Biometeorology featured climate–health presentations by researchers from departments focused on geography, meteorology, human physiology, welfare and health improvement, integrative biology and physiology, environmental sciences, public health sciences, geosciences, civil protection, international studies, sport sciences, ergonomics, epidemiology and population health and hydrometeorology (<http://www.icb2008.com>). Climate–suicide researchers would certainly be wise to follow the lead of the broader climate–health community.

At this point in the research process, it is unclear whether climate variables provide significant effects on suicide rates. That is why it is important to thoroughly apply multiple tests to reliable data and normalize for complicating factors such as age, race, culture, location, etc. If such relationships do exist, they are likely to be masked by lagging and/or

cumulative effects. Otherwise, it seems that there would be more agreement regarding the details of how these variables increase or decrease suicide rates. Of all the climatic variables, those displaying the most consistent and predictable seasonality (e.g., day length and sun exposure) seem like prime variables to explain the common spring-time peak in suicides, as well as other seasonal signals. Research methods seeking to connect non-seasonal variations in climate and suicide have been less likely to find significant relationships than those that simply analyze seasonality. There is also the possibility that suicide rates happen to vary seasonally with climate variables despite no causal relationship.

Short Biographies

Grady Dixon's research has been primarily focused on human–environment interactions whereby humans alter their local climate and climate variations affect human health and mortality. His research has been published in the *International Journal of Biometeorology*, *Journal of Applied Meteorology and Climatology*, *Monthly Weather Review*, *Bulletin of the American Meteorological Society* and others. Recent research has been primarily focused on climate–suicide relationships and the application of geographical methods to other disciplines. Dixon is currently an assistant professor in the Department of Geosciences at Mississippi State University. He earned a BS in Geosciences from Mississippi State University, a MS in Geography from University of Georgia and a PhD in geography from Arizona State University.

Adam Kalkstein is a geographer–climatologist whose research and teaching interests focus primarily on human–environment interactions. He has authored or co-authored numerous articles in peer-reviewed journals covering topics as diverse as the impact of jet contrails on climate, the geography of human mortality in the United States and the effects of heat on human health. Most recently, his research has focused on examining the role of weather on suicide and determining how climate influences influenza and winter mortality. Kalkstein is currently an assistant professor at the United States Military Academy in West Point, New York. He earned a BA in environmental sciences from University of Virginia, and both MA and PhD in geography from Arizona State University.

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