Medical Hypotheses 72 (2009) 338–341

Contents lists available at ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

The hypothesis of an impact of ozone on the occurrence of completed and attempted suicides

Teresa Biermann [a,*], Nikolaos Stilianakis [b,c], Stefan Bleich [a], Norbert Thürauf [a], Johannes Kornhuber [a], Udo Reulbach [a]

[a] Department of Psychiatry and Psychotherapy, University Hospital of Erlangen, Schwabachanlage 6, D-91054 Erlangen, Germany
[b] Joint Research Centre, European Commission, Ispra, Italy
[c] Departments of Biometry and Epidemiology, University of Erlangen-Nuremberg, Germany

ARTICLE INFO

Article history:
Received 13 August 2008
Accepted 12 September 2008

SUMMARY

Air pollution and its impact on human health are of growing concern throughout the world. Recent studies have mainly focussed on respiratory and vascular mortality. The existence of seasonality of ozone distribution and also of the occurrence of suicides as well as suicide attempts is generally accepted, though an interconnection of both phenomena has not yet been established. This hypothesis of an influence of ozone on the occurrence of suicidality was tested on preliminary data (1008 suicides and 917 suicide attempts from a larger epidemiological sample in Middle-Franconia from 2004 to 2007). A higher suicide rate than expected could be observed from July to September, whereas the rates of the suicide attempts did not show a seasonality in relation to ozone levels. To further strengthen the hypothesis, ozone levels differed significantly ($T = -2.5$; $p = 0.014$) between days where one or no suicide were observed (mean ozone: 79.8 μg/m^3; SD: 36.3) and days with two or more suicides (mean ozone: 86.4 μg/m^3; SD: 39.4). This phenomenon might be explained including sociological, biological as well as psychological effects. Sociologically, behaviour precipitating suicide might be influenced by climatic variables such as the weather or air pollution causing fatigue or cardio-respiratory symptoms influencing individual well-being in general thereby possibly leading to the decision to end one's life. Biologically, ozone is able to influence the immune system, is a strong trigeminal irritant and might influence neurotransmitter systems such as serotonin, which are known to vary with season and play a major role in impulsivity, aggression, depression and thereby suicidality. Putative psychological explanations for the suicide peak in summer include the influence of a higher ambient temperature leading individuals to a more disinhibited, aggressive and violent behaviour possibly resulting in an increased proneness for suicidal acts that is influenced by ozone.

This might lead one to speculate whether ozone is able to account – at least amongst others – for the seasonal distribution of suicides or might even be a causative agent in the multifactorial genesis of a suicide. If this hypothesis is found to be true, further research should focus on the underlying mechanisms. Furthermore, this might be a strong argument to further encourage environment protection.

Hypothesis in brief

The existence of a seasonal distribution of ozone as well as of the occurrence of suicides is well established in research on both subjects. Nevertheless, a connection between both phenomena has not been established so far. Therefore, we hypothesize that the occurrence of suicide, especially with its peak in summer months might be related to elevated ozone levels in the environment leading to – among a variety of other factors – increased suicide rates.

Background

Air pollution and its impact on human health are of growing concern throughout the world. Environmental exposures such as outdoor and indoor air pollution contribute to the global burden of disease [1,2]. Epidemiological studies using time-series analyses have demonstrated an association between short-term exposure to air pollution and increased mortality after adjusting for confounding factors [3]. Research on the effect of air pollutants on general human health has particularly focused on respiratory as well as cardiovascular mortality [4]. Due to its antioxidative properties acute ozone exposure is known to cause protracted changes in small airway function along with inflammation even in healthy individuals [5].

* Corresponding author. Tel.: +49 9131 85 44773; fax: +49 9131 85 34105.
E-mail address: teresa.biermann@uk-erlangen.de (T. Biermann).

0306-9877/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.mehy.2008.09.042

Several potential mechanisms of pollutants in cardiovascular diseases have been proposed [6]. Firstly, there is evidence of direct effects of air pollution on the human body. These occur through their systemic circulation after crossing the alveolar barrier leading to haemo-dynamic disturbances such as elevated viscosity of the blood [7], increased heart rates and changes in heart rate variability and therefore to arrhythmia, congestive heart failure and cardiac arrest, especially in the elderly [8–10]. Even ischemic stroke mortality was found to be elevated in accordance to values of air pollution [4]. Secondly, indirect effects of air pollution on mortality are represented by pulmonary inflammation triggering systemic inflammation due to oxidative stress, endothelial dysfunction, and leukocyte as well as platelet activation [11].

Effects of air pollution on animals in general as well as on their central nervous system are widely discussed. A direct and adversarial effect of ozone on the serotonin system with a decline of the 5-HTA could be found [12]. Long-term exposure to ozone is able to alter peripheral as well as central catecholamine activity in rats [13]. Furthermore, some evidence could be provided for a disturbed sleep and even EEG-alterations in animal experiments due to exposure to air pollution with special emphasis on ozone [14].

Nevertheless, the literature on the association between ambient air pollutants and psychiatric disorders concerning the human being is scarce. Some studies link cardiovascular and psychiatric disorders through the 5-lipoxigenase thereby creating an indirect link to the influence of air pollution [15]. Focussing on depressive symptoms, results of multivariate time-series analyses yielded decrements of emotional well-being with elevated sulphur dioxide levels. Further analyses of variance suggested a pollution-induced neuropsychological impairment in healthy residents of polluted areas [16]. In a prospective longitudinal study on the effects of carbon monoxide (CO), CO poisoning was discussed as a contributing factor for depression and anxiety [17]. Recently, a significant short-term effect of ambient air pollution exposures on the amount of daily visits to an Emergency Department due to depression has been described [18].

Generation of the hypothesis

Approximately one million people die from suicide worldwide per year. The mulitfactorial process (main factor: mental disease) of suicide is amongst others associated with an imbalance of the brain chemistry which can be triggered by stressful conditions (life events as well as a manifold combination of biological, psychological as well as social factors, some of them being possibly due to elevated air pollution levels). Nevertheless, there is no single cause of suicide nor has it been thoroughly elucidated.

A seasonal variation of suicide with a peak in spring and early summer months has been well established in literature [19]. As air pollutions by volatile gases are also seasonal-dependent, a contribution to the seasonal variation of suicide might be existing. Therefore, the hypothesis that environmental exposure to ambient air pollutants such as ozone or carbon monoxide play a part for the existence of a suicide peak in spring and early summer emerged.

Experimental evidence

The potential influence of elevated ozone values was tested with preliminary data from a population based register of suicides in Middle Franconia (an administrative district of Bavaria/Germany with approximately 1.7 million inhabitants), from 2004 to 2007. Further details pertaining to this database are documented in our earlier studies [20–21]. To generate tentative evidence for the present hypothesis, 1008 suicides as well as 917 suicide attempts leading to police procedures were analyzed. Data on daily average values for ozone in $\mu g/m^3$ were obtained from the Institute of Chemical Analysis of the City of Nuremberg/Germany.

A higher suicide rate than expected could be observed from July to September (see Fig. 1), whereas the rates of the suicide attempts did not show a seasonality in relation to ozone levels. The ozone levels differed statistically significant ($T = -2.5$; $p = 0.014$) between days where one or no suicide were observed (mean ozone: 79.8 $\mu g/m^3$; SD: 36.3) and days with two or more suicides (mean ozone: 86.4 $\mu g/m^3$; SD: 39.4). There was no significant association between ozone levels and suicide attempts as shown in Fig. 2.

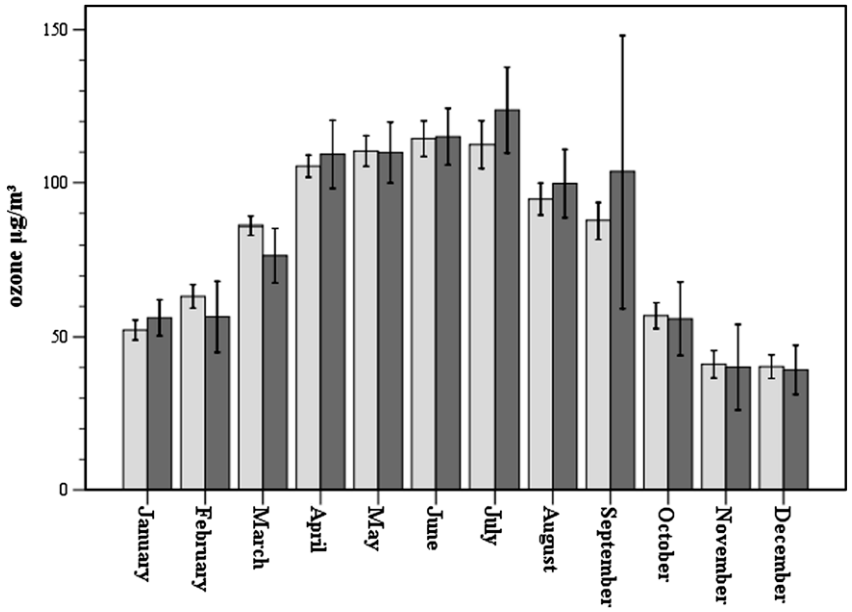

Fig. 1. The monthly distribution of the frequency of suicide in relation to measured ozone values in $\mu g/m^3$. Bars are demonstrating 95% confidence intervals based on standard error. Light grey bars (none or one suicide on each day) are compared to dark grey bars (two or more suicides of each day respectively).