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The effects of atmospheric factors on daily intensive care unit cases in Germany - A Time Series Regression Study

Katharina Sasse[1], Christian Merkenschlager[1], Michael Johler[1], Till Baldenius[2], Patrik Dröge[2], Christian Günster[2], Thomas Ruhnke[2], Pablo Escrihuela Branz[3], Lucas Pröll[3], Bastian Wein[3], Saskia Hettich[4], Yevgeniia Ignatenko[4], Taner Öksüz[4], Iñaki Soto-Rey[4], and Elke Hertig[1]

[1]Regional Climate Change and Health, Faculty of Medicine, University of Augsburg, Augsburg, Germany
[2]AOK Research Institute (WIdO), Berlin, Germany
[3]Cardiology, Pneumology, Intensive Care Medicine and Endocrinology, University Hospital of Augsburg, Augsburg, Germany
[4]Digital Medicine, University Hospital of Augsburg, Augsburg, Germany

The effects of climate change can be observed globally, and the hazards will rise in frequency and intensity. Modified atmospheric conditions affect morbidity and mortality rates and increase the pressure on healthcare systems. Especially, the intensive care unit (ICU) is vulnerable due to low buffer capacity and high utilization rate. Thus, this study analyzed the impact of regional atmospheric conditions on daily ICU in hospitals in Germany, identifying key factors as well as regional and age-gender differences.

Daily ICU cases for the period 2009-2023 were determined using secondary health data from a German health insurance. Cases were stratified by age and gender. Thirteen intensive care relevant diseases, that provide a comprehensive overview of the ICU, were analyzed using disease-specific predictor sets. A set of 31 predictor variables with predictor-specific time lags was used. Analyses were conducted for regions derived from a human-biometeorological characterization of Germany. Generalized additive models were used to investigate the associations, including the selection of disease-relevant predictors, lags, smoothing functions, variables for temporal trends, seasonality and days of the week. Model quality and performance were assessed using explained deviance and cross-validation.

Over the 15-year study period, 9,970,548 ICU patients were recorded (56% men, 44% women), 74.3% aged ≥60 years. Trauma was the most common ICU-related disease, followed by non-ST elevation heart attacks (NSTEMI), pneumonia and ischemic stroke. ICU demand was most sensitive ($p \leq .05$) to pressure-related factors, thermo-physiological parameters and ozone concentration. In terms of gender and age differences, atmospheric factors affected men more frequently, while women were more impacted by cold weather and particulate matter (PM_{10}). Heat was more relevant for patients aged 60 years and over. In total, at least one atmospheric factor influences the ICU cases despite regional, age and gender-specific differences. The model that best fit the data was for NSTEMI in central eastern Germany (weighted explained deviance of 49.3%).

The strong association between pressure-related factors and the ICU has already been

investigated in literature. Therefore, the results of this study underscore the impact of air pressure on health. Gender differences could indicate that women are less susceptible to the influence of atmospheric factors due to health-conscious behaviour and thus lower exposure levels. The vulnerability of the elderly during heat periods affects not only the demand for ICU beds, but also general hospital admissions. Model performance improved for diseases or regions with a higher number of daily ICU cases. Overall, the study identified key atmospheric factors relevant to ICU, enabling the German healthcare system to prepare better for short-term impacts of atmospheric and air quality factors.