Health-relevant influences of air substances and meteorological conditions

An investigation of the effects of ozone, nitrogen dioxide and temperature extremes using health data from the area of Augsburg.

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For a long time it has been known that exceptionally strong and long-lasting heat waves have negative health effects on the population, which is expressed in an intensification of existing diseases and over-mortality of certain risk groups. Often associated with heat are stagnant airflow conditions that cause a large increase in the concentration of certain air substances. Many of these air substances have a strong adverse effect on the human organism.

The aim of the project is to investigate the actual hazard potential of health-relevant air pollution- and climatological variables by quantifying the effects on human health of increased exposure to air constituents and temperature extremes. Different multivariate statistical methods such as correlation analysis, regression models and random forests, extreme value analysis and individual case studies are used.
Research Questions and Goal

Research Topic
„Health-relevant influences of air substances and meteorological conditions“

Initial Question:
Are air hygiene and meteorological stress situations evident in the medical records?

- What characteristics and significance do the relationships have?
- Which weather conditions carry an above average high emergency room risk?
- Which factor can be assigned the greatest hazard potential?
- What are the most common environmental emergency cases?
- What are the health risks of climate change?

Ideally: Short-term forecast
Weather forecast → increased likelihood of certain diseases
Answering the research questions requires knowledge from various areas of expertise. Interdisciplinarity is particularly important for working on this subject of cooperation with relevant research institutions.

- **Climate and environmental sciences**
  - Climatology
  - Statistical methods

- **Emergency medicine**
  - Collection of medical data
  - Categorization of medical data

- **Environmental medicine and epidemiology**
  - Intersection of medicine and epidemiology
High concentrations of certain air constituents are created according to an effect chain. Air pollution often arise in the context of certain air pressure constellations that favor the formation and accumulation of air pollutants in the troposphere through heat or low-exchange conditions.

**Air Substances**
- Focus on $\text{O}_3$, $\text{NO}_2$, $\text{PM}_{10}$, $\text{PM}_{2.5}$
- Measured at various stations in Augsburg
- Provided: Bayerisches Landesamt für Umwelt

**Climate**
- Numerous meteorological parameters used
- Provided: Deutscher Wetterdienst

**Synoptic Situations**
- Responsible for current weather events
- Major role in the formation, decomposition process and the distribution of pollutants
- Provided: ECMWF ERA5
Health effects spectrum of air pollutants

- Increased risk of stroke, dementia, Alzheimer's
- Increased mortality from respiratory diseases
- Increased mortality from cardiovascular diseases
- Increased risk of type 1/2 diabetes and gestational diabetes
- Increased risk of pregnancy complications
- Accelerated skin aging and irritation of eyes, nose, throat and skin

Risk groups:
- Babies, toddlers, children
- Pregnant women
- Seniors
- People with pre-existing conditions
- Intense outdoor activities
Methodological approach

Extreme Value Analysis
Multivariate Statistics
Case Studies
Regression Analysis
Correlation Analysis

Further possible approaches:
- Random Forests
- Contingency table
- k-Means-algorithm
First results: Correlations(1)

Legend
red = neg. corr, green = pos. corr, x = not significant (p-value > 0.05)

Illnesses
J Diseases of the respiratory system
J00 Acute nasopharyngitis [common cold]
J02 Acute pharyngitis
J03 Acute tonsillitis
J04 Acute laryngitis and tracheitis
J05 Acute obstructive laryngitis [croup] and epiglottitis
J06 Acute upper respiratory infections of multiple and unspecified sites
J18 Pneumonia, organism unspecified
J20 Other acute lower respiratory infections
J21 Acute bronchiolitis
J22 Unspecified acute lower respiratory infection
J38 Diseases of vocal cords and larynx, not elsewhere classified
J40 Bronchitis, not specified as acute or chronic
J44 Other chronic obstructive pulmonary disease
J45 Asthma
J69 Pneumonitis due to solids and liquids
J96 Respiratory failure, not elsewhere classified
J98 Other respiratory disorders
J00-J06 Acute upper respiratory infections
J09-J18 Influenza and pneumonia
J20-J22 Other acute lower respiratory infections
J30-J39 Other diseases of upper respiratory tract
J40-J47 Chronic lower respiratory diseases
J90-J94 Other diseases of pleura
J95-J99 Other diseases of the respiratory system
R05 Cough
R06 Abnormalities of breathing

Air substances, Meteorology and Synoptic Data
Air substances = daily maximum of NO2, O3, PM10, PM2.5 in Augsburg
Meteorology = FX: wind max, FM = wind mean, RSK = precipitation, NM: cloud cover, VPM = vapor pressure, PM: local air pressure, TMK: temperature mean (in 2m), UPM: relative humidity, TXK: temperature max (in 2m), TNK: temperature min (in 2m), TGK: temperature min (on ground)
PC = Circulation Patterns after Principal Component Analysis of Air Pressure

Tab.: Correlations between Diseases of the respiratory system and air quality, meteorology and synoptic (data: 2017-2018)
First results: Correlations(2)

Early observations and possible explanations

- All infection related respiratory issues show much stronger correlations → spread of infections is related to weather conditions
- Temperature shows major neg. impact → respiratory issues seem to be more likely in cold weather
- Cloud cover → associated with temperature
- Relative humidity show pos. correlations
- Vapor pressure has neg. influence
- Circulation patterns: PC2 stands out with negative correlations → west winds with mild and humid air from the Atlantic Ocean in Germany


References


