Universität Augsburg
Medizinische Fakultät

gefördert durch
DBU
Deutsche
Bundesstiftung Umwelt
www.dbu.de

DFG Deutsche Forschungsgemeinschaft

# 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.

Stephanie D. Koller[1], Christa Meisinger[2], Markus Wehler[3], Elke Hertig[1]

[1]Regional Climate Change and Health, Faculty of Medicine, Augsburg University
[2]UNIKA-T, Chair of Epidemiology, Ludwig-Maximilians-Universität München and Independent Research Group Clinical Epidemiology, Helmholtz Zentrum München
[3]University Hospital Augsburg, Central Emergency Department and Medical Clinic IV

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?

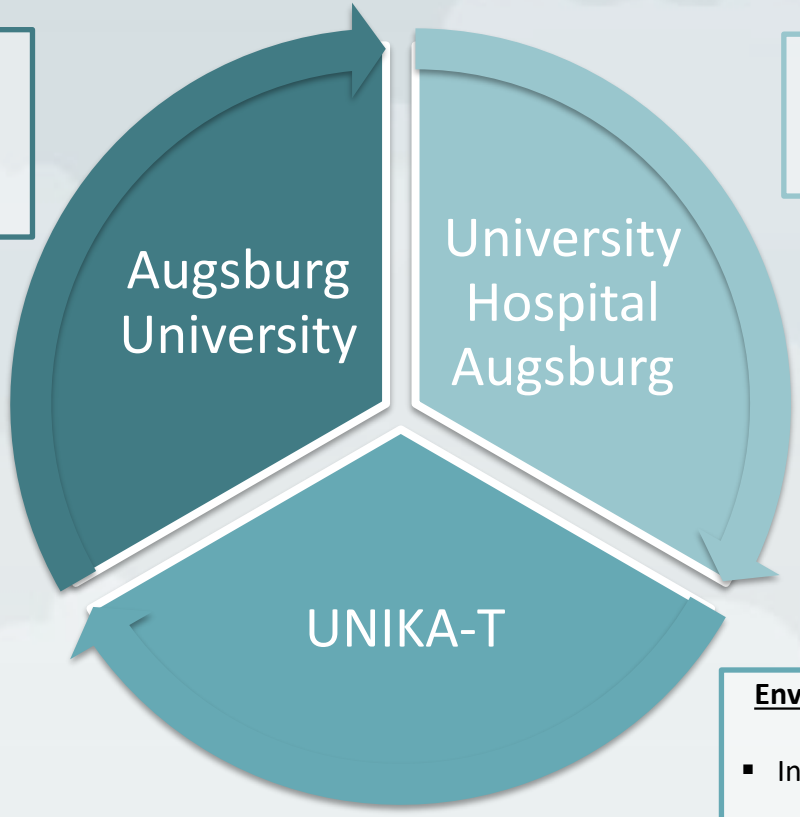
**Ideally: Short-term forecast**

Weather forecast → increased likelihood of certain diseases

# Interdisciplinary cooperation

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

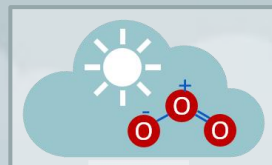


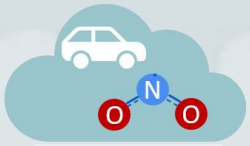

**Emergency medicine**
- Collection of medical data
- Categorization of medical data

**Environmental medicine and epidemiology**
- Intersection of medicine and epidemiology

# Air substances, climate and circulation patterns

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 $O_3$, $NO_2$, $PM_{10}$, $PM_{2,5}$
- Measured at various stations in Augsburg
- Provided: Bayerisches Landesamt für Umwelt



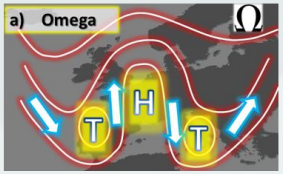


**Climate**

- Numerous meteorological parameters used
- Provided: Deutscher Wetterdienst

**Example**
**Blocking weather conditions:**

- Temperature extremes
- Low exchange conditions
- Dry spells




**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

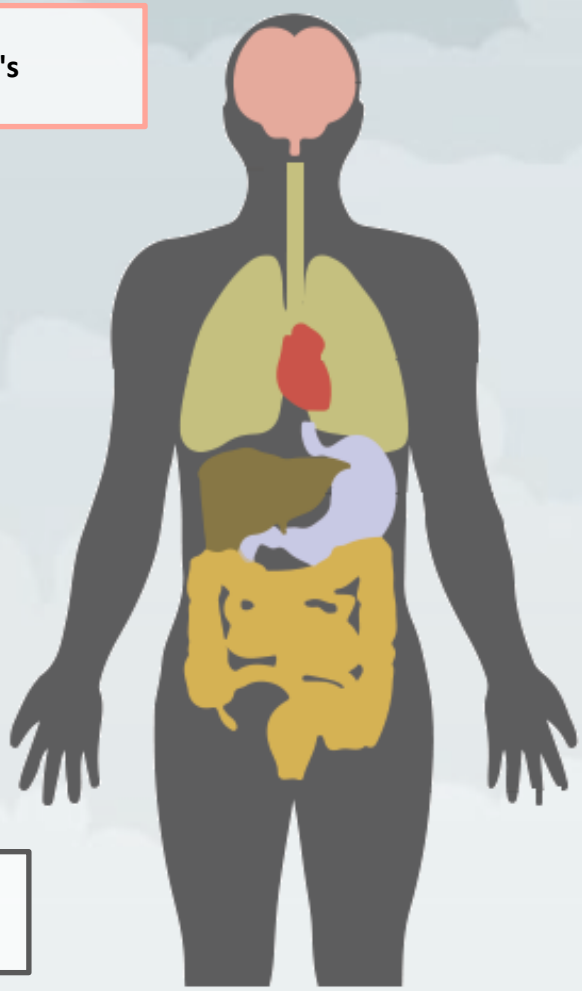
Increased mortality from respiratory diseases

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

Correlation Analysis

Regression Analysis

Further possible approaches:
Random Forests
Contingency table
k-Means-algorithm

# First results: Correlations(1)

| | J | J00 | J02 | J03 | J04 | J05 | J06 | J18 | J20 | J21 | J22 | J38 | J40 | J44 | J45 | J69 | J96 | J98 | J00–J06 | J09–J18 | J20–J22 | J30–J39 | J40–J47 | J90–J94 | J95–J99 | R05 | R06 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO2_8hmax_Königsplatz | 0.1 | 0 | -0.1 | -0.1 | 0 | x | 0 | 0.1 | 0.1 | 0.1 | 0.1 | x | 0 | x | x | 0.1 | x | 0 | x | 0.1 | 0.1 | 0.1 | x | x | 0.1 | x | 0.1 |
| NO2_8hmax_Bourges_Platz | 0.2 | 0 | x | -0.1 | 0 | x | 0 | 0.2 | 0.1 | x | 0.1 | 0 | x | x | x | 0.1 | x | 0 | x | 0.1 | 0.1 | 0.1 | 0 | x | x | x | 0.1 |
| NO2_8hmax_LfU | 0.2 | 0.1 | x | -0.1 | x | x | 0.1 | 0.2 | 0.1 | 0.1 | 0.2 | 0 | 0.1 | 0.1 | x | 0 | x | 0 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | x | x | x | 0 |
| Ozon_8hmax_LfU | -0.4 | -0.1 | 0 | x | -0.2 | -0.1 | -0.3 | -0.3 | -0.2 | -0.1 | -0.2 | -0.1 | -0.2 | -0.1 | 0.1 | x | -0.1 | -0.1 | -0.3 | -0.3 | -0.3 | -0.1 | -0.1 | x | -0.1 | -0.1 | -0.1 |
| Ozon_8hmax_Bourges_Platz | -0.4 | -0.1 | 0 | x | -0.1 | -0.1 | -0.3 | -0.3 | -0.2 | -0.1 | -0.2 | -0.1 | -0.2 | -0.1 | 0 | x | x | -0.1 | -0.3 | -0.3 | -0.3 | -0.1 | -0.1 | x | -0.1 | -0.1 | -0.1 |
| PM10_8hmax_Königsplatz | 0.1 | 0 | x | -0.1 | x | 0 | 0 | 0.1 | 0.1 | 0.1 | 0.1 | x | 0 | 0 | x | x | 0 | 0.1 | 0 | 0.1 | 0.1 | 0.1 | 0 | x | 0.1 | x | 0.1 |
| PM10_8hmax_Bourges_Platz | 0.1 | 0 | x | -0.1 | x | x | 0 | 0.1 | 0.1 | 0.1 | 0.1 | x | 0 | x | x | x | 0 | 0.1 | 0 | 0.1 | 0.1 | 0 | 0 | x | 0.1 | x | 0.1 |
| PM10_8hmax_Karlstraße | 0.1 | 0 | x | -0.1 | x | x | 0 | 0.1 | 0.1 | 0.1 | 0.1 | x | 0 | 0 | x | x | 0 | 0.1 | x | 0.1 | 0.1 | 0 | 0 | 0.1 | x | 0 |
| PM10_8hmax_LfU | 0.1 | 0 | x | -0.1 | x | x | 0 | 0.1 | 0 | 0 | 0.1 | x | 0 | x | x | x | 0 | 0.1 | 0 | 0.1 | 0.1 | 0 | x | 0 | x | x | 0 |
| PM25_8hmax_Bourges_Platz | 0.2 | 0.1 | x | -0.1 | x | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0 | 0.1 | 0 | x | x | x | 0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | x | 0.1 | x | 0.1 |
| PM25_8hmax_LfU | 0.2 | 0.1 | x | 0 | x | x | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | x | 0.1 | 0 | x | 0 | x | 0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0 | 0.1 | 0 | 0.1 |
| DWD_FX | x | x | x | 0.1 | 0 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| DWD_FM | 0.1 | x | x | 0.1 | x | x | 0.1 | 0.1 | 0.1 | 0.1 | x | x | 0.1 | x | x | 0 | x | x | 0.1 | 0.1 | 0.1 | x | x | x | x | 0 | 0 |
| DWD_RSK | x | x | x | x | x | -0.1 | x | x | x | 0 | 0 | x | 0 | x | x | x | 0.1 | x | x | x | -0.1 | x | x | x | 0 | x | x |
| DWD_NM | 0.2 | x | 0 | 0.1 | 0.1 | x | 0.2 | 0.2 | 0.1 | 0 | 0 | x | 0.1 | x | 0 | -0.1 | 0 | 0.1 | 0.2 | 0.2 | 0.2 | x | x | x | 0.1 | 0.1 | x |
| DWD_VPM | -0.6 | -0.2 | 0 | x | -0.2 | -0.1 | -0.4 | -0.3 | -0.3 | -0.3 | -0.3 | 0 | -0.3 | -0.1 | 0 | x | -0.1 | -0.1 | -0.4 | -0.4 | -0.5 | -0.1 | -0.2 | x | -0.1 | 0 | -0.1 |
| DWD_PM | -0.1 | x | x | 0 | x | 0 | -0.1 | -0.1 | x | x | 0 | x | x | 0 | 0 | x | 0 | 0 | 0 | -0.1 | x | x | -0.1 | x | -0.1 | x | -0.1 |
| DWD_TMK | -0.6 | -0.2 | 0 | x | -0.2 | -0.1 | -0.4 | -0.3 | -0.3 | -0.3 | -0.3 | 0 | -0.3 | -0.1 | 0.1 | x | -0.1 | -0.2 | -0.4 | -0.4 | -0.5 | -0.1 | -0.2 | x | -0.2 | 0 | -0.1 |
| DWD_UPM | 0.3 | 0 | 0 | x | 0.1 | x | 0.2 | 0.2 | 0.2 | 0 | 0.1 | x | 0.1 | 0 | -0.1 | x | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0 | 0 | x | 0.1 | x | x |
| DWD_TXK | -0.6 | -0.2 | 0 | x | -0.2 | -0.1 | -0.4 | -0.3 | -0.3 | -0.3 | -0.3 | 0 | -0.3 | -0.1 | 0.1 | x | -0.1 | -0.1 | -0.4 | -0.4 | -0.4 | 0 | -0.2 | x | -0.2 | 0 | -0.1 |
| DWD_TNK | -0.6 | -0.2 | 0 | x | -0.2 | -0.2 | -0.4 | -0.3 | -0.3 | -0.3 | -0.3 | 0 | -0.2 | -0.1 | x | x | -0.1 | -0.2 | -0.4 | -0.4 | -0.5 | -0.1 | -0.2 | x | -0.1 | 0 | -0.1 |
| DWD_TGK | -0.5 | -0.2 | x | x | -0.2 | -0.2 | -0.4 | -0.3 | -0.3 | -0.3 | -0.2 | 0 | -0.2 | -0.1 | x | x | -0.1 | -0.2 | -0.4 | -0.3 | -0.4 | -0.1 | -0.2 | x | -0.1 | 0 | -0.1 |
| Year_PC1 | 0.1 | x | -0.1 | 0 | 0.1 | x | 0.1 | 0.1 | 0 | x | 0 | x | 0 | x | x | x | x | x | 0.1 | 0 | 0 | x | x | -0.1 | x | x | 0 |
| Year_PC2 | -0.5 | -0.2 | 0 | x | -0.2 | -0.2 | -0.3 | -0.3 | -0.3 | -0.2 | -0.2 | 0 | -0.2 | -0.1 | 0.1 | x | x | -0.1 | -0.4 | -0.3 | -0.4 | -0.1 | -0.1 | x | -0.1 | 0 | -0.1 |
| Year_PC3 | 0.1 | x | x | -0.1 | 0 | x | 0.1 | x | 0.1 | 0 | 0 | x | x | x | x | 0 | x | x | 0.1 | x | 0.1 | 0.1 | x | x | x | x | x |
| Year_PC4 | x | x | x | x | x | x | x | x | -0.1 | 0 | 0 | x | x | x | x | x | 0 | x | x | x | x | x | x | x | x | x | -0.1 |
| Year_PC5 | -0.2 | x | x | x | x | -0.1 | -0.2 | 0 | -0.1 | -0.1 | x | x | x | x | 0 | x | x | x | -0.2 | 0 | -0.1 | x | 0 | x | x | x | x |
| Year_PC6 | 0.1 | x | x | 0 | x | 0 | 0.1 | 0 | 0 | 0 | x | x | 0.1 | 0 | x | 0 | 0.1 | x | 0.1 | 0.1 | 0 | x | 0.1 | x | 0.1 | x | 0 |
| Year_PC7 | -0.1 | x | x | -0.1 | 0 | x | -0.2 | x | -0.1 | -0.1 | x | x | x | x | x | 0 | 0 | x | -0.1 | x | -0.1 | x | x | x | 0 | x | x |
| Year_PC8 | x | 0 | x | x | x | x | 0 | x | x | x | x | x | x | x | 0 | x | 0 | x | 0.1 | x | x | 0 | 0 | x | x | x | 0 |

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

**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 $No_2$, $O_3$, $PM_{10}$, $PM_{2,5}$ 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

# 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

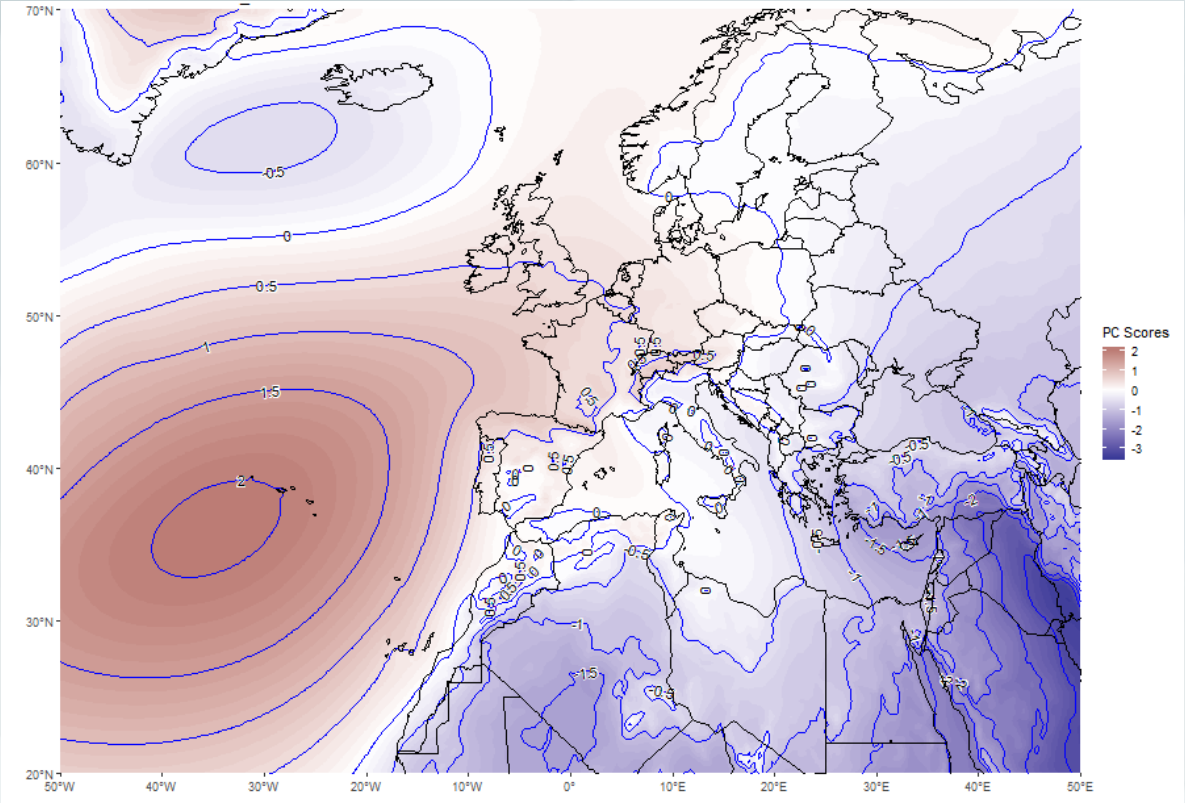



Fig.: PC2 Circulation Pattern

# References


Deutsche Gesellschaft für Pneumologie und Beatmungsmedizin [Hrsg.] (2018): Atmen: Luftschadstoffe und Gesundheit. Berlin.

Eis D., Helm D., Laußmann D., Stark, K. (2010): Klimawandel und Gesundheit. Ein Sachstandsbericht. In: Robert Koch-Institut Berlin [Hrsg.]. https://edoc.rki.de/bitstream/handle/176904/877/29ETCuO6ZOtk.pdf?sequence=1&isAllowed=y (12.01.2019).

Fann N., Lamson A., Anenberg S., Wesson K., Risley D., Hubbell B. (2012): Estimating the national public health burden associated with exposure to ambient PM2.5 and ozone. In: Risk Anal. 2012; 32(1):81-95. doi: 10.1111/j.1539-6924.2011.01630.x.

Gryparis A., Forsberg B., Katsouyanni K., Analitis A., Touloumi G., Schwartz J., Samoli E., Medina S., Anderson H., Niciu E., Wichmann H., Kriz B., Kosnik M., Skorkovsky J., Vonk J., Dörtbudak Z. (2004): Acute effects of ozone on mortality from the „air pollution and health: a European approach“ project. In: American journal of respiratory and critical care medicine 2004, 170(10):1080-1087. doi: 10.1164/rccm.200403-333OC.

Hertig E., Meisinger C., Schneider A., Peters A., von Scheidt W., Kuch B. (2019): Meteorologische Faktoren gesundheitsrelevanter troposphärischer Ozonkonzentrationen am Bespiel täglicher Herzinfarktfälle in der Region Augsburg (in Review).

Int Panis L., Provost E., Cox B., Louwies T., Laeremans M., Standaert A., Dons E., Holmstock L., Nawrot T., De Boever P. (2017): Short-term air pollution exposure decreases lung function: a repeated measures study in healthy adults. In: Environ Health 2017, 16(1):60. doi: 10.1186/s12940-017-0271-z.

# References


Kampa M., Castanas E. (2008): Human health effects of air pollution. In: Environ Pollut. 2008; 151(2):362-7. doi: 10.1016/j.envpol.2007.06.012.

Nolde M., Küster D., Wehler M., Linseisen J., Meisinger C. (2018): Patienten der Notaufnahme am Klinikum Augsburg im Jahr 2017.

Peters A., Hoffmann B., Brunekreef B., Künzli N., Kutlar M., Probst-Hensch N., Ritz B., Schulz H., Straif K., Wichmann E. (2019): Die Rolle der Luftschadstoffe für die Gesundheit.

Plass D., Vos T., Hornberg C., Scheidt-Nave C., Zeeb H., Krämer A. (2014): Entwicklung der Kranheitslast in Deutschland. Ergebnisse, Potenziale und Grenzen der Global Burden of Disease-Studie. In: Deutsches Ärzteblatt Int. 2014; 111: 629–38. DOI: 10.3238/arztebl.2014.0629.

Robert Koch-Institut [Hrsg.] (2004): Hitzefolgekrankheiten: Bericht zu einer Stellungnahme der Kommission „Hitzetote" der Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften (AWMF). In: Epidemiologisches Bulletin 2004, 24:189–91.

Wichmann H. (2018): Expertise zu gesundheitlichen Risiken von Stickstoffdioxid im Vergleich zu Feinstaub und anderen verkehrsabhängigen Luftschadstoffen – Bewertung durch internationale Expertengruppen. München.