AirMonTech



HelmholtzZentrum münchen German Research Center for Environmental Health

A scientific journey from the practice of studying AQ related health effects into the future

Dr. Josef Cyrys

Helmholtz Zentrum München Institut für Epidemiologie II

Universität Augsburg Wissenschaftszentrum Umwelt

3rd International AirMonTech Workshop on Current and Future Air Quality Monitoring. 4 – 6 March 2013, Duisburg, Germany



Annual number of publications in air pollution epidemiology, 1960–2009



Ayala et al., 2012

HelmholtzZentrum münchen

German Research Center for Environmental Health





Overview of epidemiological approaches in air pollution research 1950 - 2010



HelmholtzZentrum münchen

German Research Center for Environmental Health





Overview of epidemiological approaches in air pollution research 1950 - 2010



Time-series studies usually use network monitoring data



Erfurt Krämpferstrasse



Augsburg Bourgesplatz

HelmholtzZentrum münchen

German Research Center for Environmental Health





Time-series studies usually use network monitoring data



Erfurt Krämpferstrasse



Augsburg Bourgesplatz

P. Bruckmann:

"European Supersites" for monitoring PM mass (EC, UFP, ...) as base for health effects related research are needed

K. Katsouyanni:

Set up of "supersites" or "special" sites should be considered

Why do we need special sites for research?







Implausible NO₂ data, Erfurt, April 1994 - February 1995



HelmholtzZentrum münchen

German Research Center for Environmental Health





Missing data at the reference site, Augsburg 2010



HelmholtzZentrum münchen

German Research Center for Environmental Health





Imputation of PM10 values, Erfurt 1992 - 1995



Wissenschaftszentrum Umwelt Universität Augsburg W Z

U



HelmholtzZentrum münchen German Research Center for Environmental Health

Imputation of PM10 values, Erfurt – results



Wissenschaftszentrum Umwelt Universität Augsburg W Z

U



HelmholtzZentrum münchen German Research Center for Environmental Health

Some data still not available



Breitner et al.: Short-Term Mortality Rates during a Decade of Improved Air Quality in Erfurt, Germany. EHP 117(3): 448-454, 2009

HelmholtzZentrum münchen

German Research Center for Environmental Health





Temporal changes in measurement program (Augsburg, 1999 – 2001)



Peters A et al.: Particulate Air Pollution and Nonfatal Cardiac Events - Air Pollution and Myocardial Infarction in a Case-Crossover Study, HEI Research Report 124, 2006

HelmholtzZentrum münchen

German Research Center for Environmental Health





Closing of sites in operation and opening of new sites



HelmholtzZentrum münchen

German Research Center for Environmental Health





Using of regulatory monitoring network for epidemiological time-series studies: summary

- Monitoring networks provides continuous measurement data with high time resolution and high quality
- Those data could be used without additional costs in short term epidemiological studies (assumed high temporal correlation of the given pollutant across study area)
- Only small number of pollutants is measured
- Limited number of locations (in Germany mostly at traffic related sites)
- The measurement program varies during the time (exchange of devices, changing of parameters)
- Different measurement methods are used across cities and countrie
- Closing of monitors and opening at new locations
- Changes in the proximity of the measurement sites (new roads, tunnels, construction works)





Time-series studies usually use network monitoring data, but not only...



Erfurt Krämpferstrasse



Erfurt HMGU monitoring site



Augsburg Bourgesplatz



Augsburg HMGU monitoring site

HelmholtzZentrum münchen

German Research Center for Environmental Health





Overview of epidemiological approaches in air pollution research 1950 - 2010



HelmholtzZentrum münchen

German Research Center for Environmental Health





In long-term studies one or few fixed monitoring sites were used for estimating the city average



This approach could masks any contribution of within-city differences in concentrations

HelmholtzZentrum münchen

German Research Center for Environmental Health





Distribution of annual average concentration of NO_2 and NO_x for each ESCAPE study area separately



Cyrys et al.: Variation of NO₂ and NO_x concentrations between and within 36 European study areas: Results from the ESCAPE study, Atmospheric Environment 62, 374-390, 2012

HelmholtzZentrum münchen

German Research Center for Environmental Health





Long term exposures and spatial variability – evidence for improvement

Level of Exposure to Fine Particulate Matter and the Risk of Death from Cardiovascular Causes in Women



Miller at al.: Long-Term Exposure to Air Pollution and Incidence of Cardiovascular Events in Women, N Engl J Med, 356, 447-58, 2007

HelmholtzZentrum münchen

German Research Center for Environmental Health





Air pollution modelling

- Based on measurements (interpolation across the study area, land-use regression modelling)
- Based on emission, dispersion and meteorological data (dispersion modelling)



From Jerrett et al., 2005

HelmholtzZentrum münchen

German Research Center for Environmental Health





Use of land use regression (LUR) modelling for exposure assessment in epidemiological studies

- It was introduced in the SAVIAH (Small Area Variations In Air Quality and Health) study in the late 90s (Briggs et al., 1997)
- In 2008 already 25 epidemiological studies using LUR modelling were identified (Hoek et al., 2008)
- LUR modelling can be applied to any measurable air pollutant
- However, in most cases, pollutants were included that can be measured easily and inexpensively at a relative large number of locations (usually using passive sampling)

Pollutants	No. samplers	Investment (Euro) ^a	Personnel (person days) ^b	Personnel (Euro)	Consumables (Euro) ^c
$PM_{10} + PM_{2.5}$	12	60,000	110	26,000	2000
NO_x	40-80	3200-6400	30–40	7200–9600	1500-3000

Approximate costs of land use regression monitoring campaigns with 40 sites and four weekly samples per site

Hoek et al., 2008

HelmholtzZentrum münchen

German Research Center for Environmental Health





Land use regression modelling approach

- Air pollution measurements conducted at selected sites
- Collecting of input data (information on land use, address density, traffic intensity etc) for these sites using Geographic Information System (GIS)
- Development of a regression model for the monitoring sites based on the relevant input data
- Estimation of the ambient air concentrations at the homeaddresses based on the regression model





LUR results: an example for the KORA study cohort in Augsburg, Germany



HelmholtzZentrum münchen

German Research Center for Environmental Health





Dispersion modelling approach



HelmholtzZentrum münchen

German Research Center for Environmental Health





Comparison between LUR and dispersion modelling, TRAPCA study, Munich



Cyrys et al.: GIS-Based Estimation of Exposure to Particulate Matter and NO₂ in an Urban Area: Stochastic versus Dispersion Modelling, Environ Health Perspect, 113, 987 – 992, 2005

HelmholtzZentrum münchen

German Research Center for Environmental Health





Comparison between LUR and dispersion modelling

LUR modelling	Dispersion modelling	
Empirical, statistical approach	Based upon physical principles und using assumptions about dispersion patterns	
Spatial variation	Spatial and temporal variation	
A need for specific measurements in space and validation with monitoring data	A need for specific inputs and extensive cross-validation with monitoring data	
Have a limited power to separate different pollutants	Specific inputs may not be readily available	
Unable to model the short-distance spatial variation (in range of tens of meters)	Model operation requires time, resource and expertise	

HelmholtzZentrum münchen







New developments

- Improvement of LUR modelling by adding of emission data (Rosenlund et al., 2008) or wind field data (Arian et al., 2007).
- Adding of time-resolved variables (Maynard et al., 2007, Su et al., 2008).
- Incorporation of dispersion model estimates within a LUR model (Wilton et al., 2010).
- Combination of LUR and air dispersion (Mölter et al., 2010).
- Development of advanced spatiotemporal models (Szpiro et al. 2010).
- GIS-based air pollution dispersion model for city-wide exposure assessment (Guliver and Briggs, 2011).





Conclusions

- Central monitors may supply reasonable proxies over the entire population for time-series studies.
- However, central monitors provide poor estimates of long-term exposure for individuals.
- Exposure assessment approaches for epidemiological studies of air pollution and health have evolved from simple using ambient monitoring data toward more sophisticated land use regression, dispersion and meteorological modelling.
- Cross-validation of the new approaches against personal exposure measurements will be needed.





Future monitoring

- Central monitors should be maintained for reasonable long periods.
- Urban background sites as well as traffic related sites are useful to inform temporal-spatial models.
- In addition, monitoring of population average exposures to other prominent sources may be warranted.
- Besides currently regulated pollutants emerging indicators of health-relevant aerosol constituents and properties is recommended.





Acknowledgement

- A. Peters and H-E. Wichmann, Helmholtz Zentrum München,
- my colleagues from HMGU and WZU,
- and all project partners.

http://www.helmholtz-muenchen.de/epi2/index.html http://www.wzu.uni-augsburg.de/



