Ultrafine Particles: What Progress Have We Made and What Questions Remain?

Lidia Morawska
Queensland University of Technology
The Team:
Thinking outside the box


**Exposure:**
- Lidia Morawska, QUT
- Aneta Wierzbicka, Lund U
- Aurelio Tobias, IDÆA
- Xavier Querol, IDÆA
- Giorgio Buonanno, U Cassino
- Hicran Altug, U Hospital Düsseldorf
- Josef Cyrys,
- Jürgen Schnelle-Kreis, CMA Munich
- Karin Hougaard, APHA
- Michal Kowalski, EPI Munich
- Micheal Riediker, SCOEH
- Per Schwarze, NIPH
- Regina Pickford, EPI Munich
- Wolfram Birmili, UBA, Germany

**Toxicology:**
- Flemming Cassee, RIVM
- Ali Önder Yildirim, HMGU Munich
- Alison Elder, URMC
- Dietrich Plaß, UBA, Germany
- Je Yu, KEMTI
- Johan Øvrevik, NIPH
- Otmar Schmid, ILBD
- Steffen Loft, U Copenhagen
- Tobias Stöger, U Copenhagen

**Epidemiology:**
- Annette Peters, EPI Munich
- Susanne Breitner, EPI Munich
- Timo Lanki, NIHW Finland
- Enembe Okokon, NIHW Finland
- Regina Pickford, EPI, Helmholtz Center Munich
- Evangelia Samoli, U Athens
- Tamara Schikowski, IUF Düsseldorf
- Massimo Stafoggia, Lazio Region Health Service
- Alexandra Schneider, EPI Region Health Service
- Siqi Zhang, EPI Munich
- Barbara Hoffmann, U Hospital Düsseldorf
- Kai Chen, EPI Munich
- Kathrin Wolf, EPI Munich
- Nino Künzli, Swiss TPH
- Ron Kappeler, Swiss TPH
- Sarah Lucht, U Hospital Düsseldorf
Recommendations: EXPOSURE

Progress:
Recommendations 1, 2 and 3

Future:
Recommendations 4 and 5
Recommendation 1

Recommendation to quantify ambient quasi-UFP in terms of particle number concentration (PNC) in a range at least down to 10 nm, with no restriction on the upper limit.

From toxicology: For practical reasons, using particle number as a predictor may be preferred above mass and surface area, especially if the particle size distribution is known.
Significance

This is an essential criterion for:

• Design of exposure/epi studies
• Carrying out the meta analysis
ISO/TC 146/SC 2/WG1 N 320 defines:

…an **ultrafine particle** as “A particle sized about 100 nm in diameter or less”

1. The recommendation means that SMPS and CPC data can be used

2. An error/uncertainty due to missing the first few nm:
   - Could be calculated/corrected for lower size limit up to 10 nm.
   - Negligible for lower size limit less than 5-6 nm
Background 1b

The impact of the lower cut off

**Number of particles < 10 nm**
- Morning traffic: ~ 1% (orange)
- During the day: about 4% (blue)
- During NPF: higher (grey)

**Number of particles < 20 nm**

- Initial stages of NPF -blue curve) ⇒ 65%
- Fully developed NPF-red curve) ⇒ 42%
Recommendation 2

The following daily (24 hours) mean PNC can be considered as *typical*, based on the scientific literature:

- **Clean environments** < $10^3$ particles cm$^{-3}$
  (not affected by anthropogenic emissions)
- **Urban background** < $10^4$ particles cm$^{-3}$

In *typical* clean urban microenvironments **hourly mean concentrations** < $2 \times 10^4$ particles cm$^{-3}$

The uncertainty in the calibration of PNC measuring instruments varies:
- ~ 30% for < $10^3$ particles cm$^{-3}$
- ~ 10% for ~$10^4$ particles cm$^{-3}$ (typical urban background concentrations)
Significance

At the moment that are no reference or guideline values for exposure to UFP

“... the existing body of epidemiological evidence is insufficient to conclude on exposure/response relationship to UFP”. (WHO 2005)

Typical values can serve as a comparative reference
Background 2a

Clean environments: < $10^3$

Urban background: $\sim 10^4$

Near roads/tunnels: > $10^5$

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**Measurement Location**

- Tunnel (3)
- On Road (2)
- Road Side (18)
- Street Canyon (7)
- Urban (24)
- Urban Background (4)
- Rural (8)
- Clean Background (5)

**10^3 particles/cm^3**

1000

100

10

1

99.09

71.45

47.00

48.18

34.58

39.13

10.76

8.83

7.29

8.10

4.83

2.91

2.61

3.20

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De Jesus et al. *Ultrafine particles and PM$_{2.5}$ in the air of cities around the world: how similar or different are their drivers?* *Environment International, 129, 118-135, 2019*
Recommendation 3

The following should not be used as proxies of UFP:

• PM$_{2.5}$
• CO
• NO$_x$
• BC
Significance

Using other pollutants as proxies of exposure to UFP leads to exposure misclassification.

Very little/no relationship between PNC and PM$_{2.5}$.

The existence/degree of the relationship between PNC and traffic emitted gases and BC vary → specific to the environment.
De Jesus et al. *Ultrafine particles and PM$_{2.5}$ in the air of cities around the world: how similar or different are their drivers?* Environment International, 129, 118-135, 2019
Background 3b

- PNC decreased in all cities
- PM$_{2.5}$ to lesser extent
- The years in which the reduction in concentration occurred do not coincide for PM$_{2.5}$ and PNC

De Jesus at al., Long-term trends in PM2.5 mass and particle number concentrations in urban air: the impacts of mitigation measures and changing climates. Env Pollution, 263, 114500. doi:10.1016/j.envpol.2020.114500
Regulatory air quality monitoring strategy should be extended by integration of UFP for reporting purposes.

Parameters monitored should allow quantification and characterization of primary versus secondary particles and their source contribution.
Mean UFP concentration similar in all 3 cities
BC higher in Barcelona and Tenerife

Association with daily mortality:
- In Barcelona and Tenerife with N1
- In Huelva with N2 (none were significant)

Recommendation 5

Efforts should be stepped up to utilize the emerging science and technology to advance approaches to the assessment of exposure to UFP for application in epidemiological studies and management.

- Modelling tools
- Increasing the number of monitors
- Utilise mobile platforms
Not outside of the box yet, but on the way!

Thank you!

Thinking outside the box team, Munich, Germany, February 2019