Insights into the Spatial and Temporal Distribution of UFP from Swiss Health Studies

Ming-Yi Tsai, Reto Meier, Marloes Eeftens, Medea Imboden, Inmaculada Aguilera, Alex Ineichen, Mark Davey, Martin Fierz, Regina Ducrest-Stich, Martina Ragettli, Christian Schindler, Harish Phuleria, Nino Künzli, Nicole Probst-Hensch

Questions?

The Studies in brief

The SAPALDIA study

The TRITABS & TAPAS study

EXPOSOMICS study

Several Insights

Next Steps

Acknowledgments

Thank you for your attention!
The Studies in brief

The SAPALDIA study

- SAPALDIA3: Home-Outdoor & Home-Indoor measurements

- Nearly all our work is done with Martin Herr’s MiniDisc
  - Studies done at cohort subjects’ homes (24-hr, 1-2 weeks)
  - Personal measurements (24-hr)
  - Mobile Measurements (24-30 min) on sidewalks
  - Different commute modes

- Much higher levels in Geneva & Lugano
- Highest in winter, generally lowest in summer

TRITABS & TAPAS study

- "Mobile" and Personal measurements

- 39 Tubs study
  - Basel 2011 (simultaneous to SAP3)

- TAPAS study
  - Self-reported in Basel (2011)

EXPOsOMICs study

- Personal, Home-outdoor, & "Mobile" measurements
Nearly all our work is done:
- Studies done at cohort level
- Personal measurements
- "Mobile Measurements"
  - Different commute methods

Much higher levels in Germany.
Highest in winter, generally.
SAP3
Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults

Repeated measurements in 2011 and 2012
3 seasons x 2 weeks

NO₂
8 areas, 40 sites each

PM and Ultrafine particles
4 areas, 20 sites each

Legend
- Cohort participants
- Country border
- Lakes
- Major road

SAPALDIA 3 sampling sites

Pollutants
- NO₂ only
- NO₂+PM
- NO₂+PM+UFP
- REF
TRITABS & TAPAS study
"Mobile" and Personal measurements

Tri-Tabs study
- Basel 2011 (simultaneous to SAP3)

TAPAS study
- Sub-studies in Basel (2011)
Tri-Tabs study
• Basel 2011 (simultaneous to SAP3)

- 20-min UFP (non-rushhour)
- @ 60 sites
- 3 seasons

TAPAS study
• Sub-studies in Basel (2011)

• UFP in different transportation modes
• Contribution of commute route to exposure
- 20-min UFP (non-rushhour)
- @ 60 sites
- 3 seasons
- UFP in different transportation modes
- Contribution of commute route to exposure
EXPOsOMOMICs study

Personal, Home-outdoor, & "Mobile" measurements

Basic Study Design
- Short-term studies (London, Barcelona)
- Long-term studies in Wiikheim (Bauld, London, Amsterdam)
- Questionnaires
- Monitoring: Indoor, personal, home, mobile
- Circadian fresh blood, archived blood

EXPOsOMOMICs consortium:
- REGIOMONTANA (Bauld)
- Wiikheim (Bauld, London, Amsterdam)
- Questionnaires
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- Contribution of commute route to exposure

Kilometers
Basic Study Design

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  - Questionnaires
  - Monitoring: health, personal, home, mobile
  - Omics: fresh blood, archived blood

Parallel OMICs analyses

- agnostic (untargeted) OMICs --> look for signals with 24-hr exposure in EXPOsOMICs blood
- simultaneous agnostic OMICs in nested case-control studies within cohorts --> archived blood samples
Basic Study Design

- Short-term studies (London, Barcelona)
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Parallel OMICs analyses

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- simultaneous agnostic OMICs in nested case-control studies within cohorts--> archived blood samples
Exposure Measurements (in all 5 centers):
- 24hr Personal exposure monitoring (PEM) * 3 seasons
- 24hr Home-outdoor measurements * 3 seasons (Basel+NL)
- 30min UFP measurements at 160 locations * 3 seasons --> LUR models

24hr PEM:

**Health metrics**
- Blood pressure
- Height & weight
- Spirometry
- Buccal swab
- Blood sample

UFP Mobile Monitoring:
- 160 locations in Basel and surrounding areas
- 30 min measurements at each location:
  - PM$_2.5$ (DustTrak)
  - BC (MicroAeth)
  - Particle numbers (CPC & MiniDisc)
  - Traffic counts
24hr PEM:

Health metrics
- Blood pressure
- Height & weight
- Spirometry
- Buccal swab
- Blood sample

PEM Backpack
PEM Backpack
UFP Mobile Monitoring:

- 160 locations in Basel and surrounding areas
- 30 min measurements at each location:
  - PM$_{2.5}$ (DustTrak)
  - BC (MicroAeth)
  - Particle numbers (CPC & MiniDisc)
  - Traffic counts
PEM & Mobile mtg sites

Location of PEM participants
Basel, SAPALDIA cohort

Location of Mobile Monitoring locations
(n=160) Basel, CH
Location of PEM participants
Basel, SAPALDIA cohort

EXPOsOMICS Basel
PEM Participants

- urban traffic
- urban background
Location of Mobile Monitoring locations (n=160)  Basel, CH
Basic Study Design

- Short-term studies (London, Barcelona)
- Long-term studies w/cohorts (Basel, London, Amsterdam/Utrecht/Maastricht, Barcelona, Turin)
  - Questionnaires
  - Monitoring: health, personal, home, mobile
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Parallel OMICs analyses

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- Nearly all our work is done with Martin Herr's Minidisk
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- Personal measurements (24-hr)
- "Mobile Measurements" (20-30 min) on sidewalks
- Different commute modes

Much higher levels in Geneva & Lugano
Highest in winter, generally lowest in summer

TRITABS & TAPAS study
"Mobile" and Personal measurements

- Epik study
  - Basel 2011 (simultaneous to SAP3)

- TAPAS study
  - Self-driven in Basel (2011)

EXPOsOMICs study
Personal, Home-outdoor, & "Mobile" measurements
Several Insights

Insight 1:
- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect.
- Seasonally higher in winter vs. summer
- Expected annual pattern
- Long-term levels can be well modelled (EUR) at cumulative levels

Insight 2:
- Indoor UFP levels are (as with other pollutants) generally lower than outdoors

Insight 3:
- Short-term sidewalk measurements (20-30 min) appear to capture the different site types
- Boreal sidewalk levels are similar between 2013 & 2014
- Sidewalk measurements are about 20% higher than at "locally" residences

Insight 4:
- Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns

Next Steps
- OMK analyses with UFP data to ED marker of exposure
- Real-time data offers a wealth of parameters
- Will be done within a year
- Build seasonal EUR models (EXPOOMICS)
- 20 min at 10 sites * 3 seasons per area
- Explore possibilities for other EUR modelling (e.g. GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb—but need to extend to 4 other SAPALDIA areas
- Extensively nationally

Acknowledgments
- Swiss TPH
- SAPALDIA Team
- EXPOOMICS Consortium
- BAFU - Bundesamt für Umwelt
- EMPA - Eidgenössische Materialprüfungs- Forschungsanstalt - NABCL network
- FHNW Schweiz - University of Applied Sciences
- SNF - Schweizer National Fund
- EU Framework Programme 7 grant #308610

Thank you for your attention!
**Insight #1 (point of view of exposure measurements)**

- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect.
- Seasonally higher in winter vs summer.
- Expected diurnal pattern.
- Longer-term levels can be well modelled (LUR).

High correlations with some pollutants.

<table>
<thead>
<tr>
<th>Area</th>
<th>NO$_2$</th>
<th>PM$_{2.5}$</th>
<th>PNC</th>
<th>LDASA</th>
<th>PM$_{10}$</th>
<th>PNC</th>
<th>LDASA</th>
<th>PM$_{40}$</th>
<th>PNC</th>
<th>LDASA</th>
<th>LDASA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel</td>
<td>0.21</td>
<td>0.35</td>
<td>0.18</td>
<td>0.03</td>
<td>0.47</td>
<td>0.32</td>
<td>0.63</td>
<td>0.25</td>
<td>0.35</td>
<td>0.59</td>
<td>0.08</td>
</tr>
<tr>
<td>Geneva</td>
<td>0.21</td>
<td>0.44</td>
<td>0.39</td>
<td>0.32</td>
<td>0.60</td>
<td>0.64</td>
<td>0.18</td>
<td>0.22</td>
<td>0.13</td>
<td>0.19</td>
<td>0.02</td>
</tr>
<tr>
<td>Lugano</td>
<td>0.11</td>
<td>0.82</td>
<td>0.25</td>
<td>0.13</td>
<td>0.74</td>
<td>0.61</td>
<td>0.16</td>
<td>0.28</td>
<td>0.14</td>
<td>0.48</td>
<td>0.17</td>
</tr>
<tr>
<td>Wald</td>
<td>0.35</td>
<td>0.50</td>
<td>0.62</td>
<td>0.37</td>
<td>0.82</td>
<td>0.80</td>
<td>0.51</td>
<td>0.71</td>
<td>0.44</td>
<td>0.86</td>
<td>0.33</td>
</tr>
<tr>
<td>All areas</td>
<td>0.42</td>
<td>0.80</td>
<td>0.63</td>
<td>0.41</td>
<td>0.81</td>
<td>0.80</td>
<td>0.51</td>
<td>0.74</td>
<td>0.79</td>
<td>0.59</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Diurnal patterns w/ref site

SAP3 UFP LUR models
High correlations with some pollutants

| Area    | NO₂ | PM₂.₅ | PM₁₀ | PM_coarse | PNC | LDSA | PM₂.₅ abs | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA | PM₁₀ | PM_coarse | PNC | LDSA |
|---------|-----|-------|------|-----------|-----|------|----------|------|-----------|-----|------|------|-----------|-----|------|--------|---------|-----|------|------|-----------|-----|------|------|-----------|-----|------|------|-----------|-----|------|------|-----------|-----|------|------|-----------|-----|------|------|-----------|-----|------|------|-----------|-----|------|
| Basel   | 0.21| 0.35  | 0.18 | 0.03      | 0.47| 0.32 | 0.63     | 0.49 | 0.32      | 0.43| 0.50 | 0.25 | 0.25      | 0.35 | 0.36 | 0.01  | 0.71      | 0.59 | 0.08 | 0.19 | 0.63      |      |      |      |            |      |      |      |            |      |      |
| Geneva  | 0.21| 0.44  | 0.39 | 0.32      | 0.60| 0.64 | 0.18     | 0.63 | 0.24      | 0.17| 0.33 | 0.22 | 0.13      | 0.07 | 0.19 | 0.83  | 0.10      | 0.17 | 0.02 | 0.03 | 0.92      |      |      |      |            |      |      |      |            |      |      |
| Lugano  | 0.11| 0.82  | 0.25 | 0.13      | 0.74| 0.61 | 0.16     | 0.75 | 0.16      | 0.10| 0.38 | 0.28 | 0.14      | 0.61 | 0.48 | 0.51  | 0.27      | 0.50 | 0.17 | 0.12 | 0.75      |      |      |      |            |      |      |      |            |      |      |
| Wald    | 0.35| 0.90  | 0.62 | 0.37      | 0.82| 0.80 | 0.51     | 0.45 | 0.20      | 0.34| 0.30 | 0.71 | 0.44      | 0.86 | 0.84 | 0.30  | 0.69      | 0.72 | 0.33 | 0.34 | 0.98      |      |      |      |            |      |      |      |            |      |      |
| All areas | 0.42| 0.80  | 0.63 | 0.41      | 0.81| 0.80 | 0.51     | 0.74 | 0.21      | 0.40| 0.58 | 0.68 | 0.41      | 0.74 | 0.79 | 0.59  | 0.62      | 0.76 | 0.42 | 0.40 | 0.90      |      |      |      |            |      |      |      |            |      |      |

![Box plot of PNC concentration for different areas](image-url)
Diurnal patterns w/ref site

Basel

Geneva

Lugano

Wald

Particles/cm³

Midnight 6am Noon 6pm

Midnight 6am Noon 6pm

Midnight 6am Noon 6pm

Midnight 6am Noon 6pm

Residential sites PNC 10th to 90th percentile
Reference site PNC 10th to 90th percentile
# SAP3 UFP LUR models

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>N</th>
<th>Model</th>
<th>Model</th>
<th>Measures of spatial autocorrelation</th>
<th>LOOCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$ (µg/m³)</td>
<td>74</td>
<td>PM$<em>{2.5} = -13.2 + PM25</em>{2010} * 1.81 + MAJROADLENGTH$<em>{25} * 0.0478 + URBGREEN$</em>{5000} * -0.000000521 + TRAFMAJOR * 0.0000515$</td>
<td>0.55</td>
<td>0.57</td>
<td>2.0</td>
</tr>
<tr>
<td>PNC (particles/cm³)</td>
<td>67</td>
<td>PNC = 7805 + Area$<em>{GE} * 4270 + Area$</em>{LU} * 5895 + Area$<em>{WA} * ‘2388 + TRAFLOAD$</em>{250} * 0.000110 + ROADLENGTH$<em>{100} * 4.26 + MAJROADLENGTH$</em>{50} * 19.9 + UGNL$_{1000} * -0.00273$</td>
<td>0.85</td>
<td>0.87</td>
<td>1991</td>
</tr>
<tr>
<td>LDSA (µm²/cm³)</td>
<td>67</td>
<td>LDSA = 29.9 + Area$<em>{GE} * 9.17 + Area$</em>{LU} * 17.3 + Area$<em>{WA} * 0.502 + MAJROADLENGTH$</em>{250} * 0.00317 + ROADLENGTH$_{100} * 0.0094 + TRAFNEAR * 0.000199 + ALT * -0.0257$</td>
<td>0.89</td>
<td>0.91</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Insight #2

- Indoor UFP levels are (as with other pollutants) generally lower than outdoors

![Graph showing particle number concentration (PNC) and UFP mean diameter](image)

![Graph showing PM_{2.5}, PM_{10}, NO_{3} concentrations](image)

**Figure 2.** Scatter plots of co-located indoor and outdoor levels of particle number concentration, PM_{2.5}, PM_{10}, and NO_{3} from 1–2-week-long measurements without tobacco smoke influence. Lines show linear regressions for each area (colored) and all areas combined (black).
Insight #2

- Indoor UFP levels are (as with other pollutants) generally lower than outdoors
Scatter plots of co-located indoor and outdoor levels of particle number concentration, PM\textsubscript{2.5}, PM\textsubscript{absorbance}, and NO\textsubscript{2} from different cities.
## Measurements without smoking influence

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Sites</th>
<th>I/O ratio median (10th; 90th percentile)</th>
<th>I/O Pearson correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PNC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All areas</td>
<td>90</td>
<td>48</td>
<td>0.72 (0.27; 1.54)</td>
<td>0.38</td>
</tr>
<tr>
<td>Basel</td>
<td>1</td>
<td>1</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>Geneva</td>
<td>21</td>
<td>13</td>
<td>0.52 (0.26; 1.30)</td>
<td>-0.07</td>
</tr>
<tr>
<td>Lugano</td>
<td>31</td>
<td>15</td>
<td>0.70 (0.28; 1.47)</td>
<td>0.29</td>
</tr>
<tr>
<td>Wald</td>
<td>37</td>
<td>19</td>
<td>0.98 (0.28; 2.13)</td>
<td>0.26</td>
</tr>
</tbody>
</table>

| **PM$_{2.5}$** |    |       |                                        |                        |
| All areas      | 156| 64    | 0.73 (0.37; 1.28)                      | 0.61                   |
| Basel          | 33 | 17    | 0.54 (0.29; 1.14)                      | 0.43                   |
| Geneva         | 35 | 14    | 0.86 (0.50; 1.38)                      | 0.57                   |
| Lugano         | 36 | 14    | 0.65 (0.34; 0.98)                      | 0.71                   |
| Wald           | 52 | 19    | 0.80 (0.40; 1.30)                      | 0.30                   |

| **PM$_{10}$** |    |       |                                        |                        |
| All areas      | 155| 64    | 0.70 (0.39; 1.34)                      | 0.46                   |
| Basel          | 32 | 17    | 0.60 (0.34; 1.15)                      | 0.50                   |
| Geneva         | 35 | 14    | 0.76 (0.49; 1.79)                      | 0.21                   |
| Lugano         | 36 | 14    | 0.58 (0.37; 0.98)                      | 0.62                   |
| Wald           | 52 | 19    | 0.76 (0.40; 1.57)                      | 0.24                   |

| **PM$_{coarse}$** |    |       |                                        |                        |
| All areas        | 152| 64    | 0.67 (0.20; 2.13)                      | 0.16                   |
| Basel            | 32 | 17    | 0.77 (0.27; 1.55)                      | 0.51                   |
| Geneva           | 35 | 14    | 0.71 (0.19; 2.65)                      | 0.00                   |
| Lugano           | 36 | 14    | 0.51 (0.15; 1.01)                      | 0.14                   |
| Wald             | 49 | 19    | 0.76 (0.26; 4.41)                      | -0.08                  |

| **PM$_{absorbance}$** |    |       |                                        |                        |
| All areas         | 156| 64    | 0.74 (0.41; 1.12)                      | 0.79                   |
| Basel             | 33 | 17    | 0.63 (0.40; 1.15)                      | 0.39                   |
| Geneva            | 35 | 14    | 0.79 (0.55; 0.99)                      | 0.90                   |
| Lugano            | 36 | 14    | 0.80 (0.45; 1.08)                      | 0.76                   |
| Wald              | 52 | 19    | 0.68 (0.37; 1.23)                      | 0.62                   |

| **NO$_2$**       |    |       |                                        |                        |
| All areas        | 175| 66    | 0.55 (0.21; 0.99)                      | 0.63                   |
| Basel            | 37 | 17    | 0.42 (0.20; 1.03)                      | 0.10                   |
| Geneva           | 40 | 15    | 0.59 (0.30; 0.98)                      | 0.72                   |
| Lugano           | 43 | 15    | 0.64 (0.28; 0.95)                      | 0.36                   |
| Wald             | 55 | 19    | 0.54 (0.15; 1.03)                      | 0.24                   |
**Insight #3**

- Short-term sidewalk measurements (20-30 mins) appear to capture the different site types.
- Basel sidewalk levels are similar between 2011 & 2014.
- Sidewalk measurements are about 20% higher than at 'co-located' residences.

**Characteristic site levels; similar levels**

Co-located sampling between Tri-Tabs & SAPALDIA3 were highly correlated but showed >20% higher cons for the sidewalk.

**Reference Site w/ Mobile Monitoring**

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**Acknowledgements**

Colleagues: Co-authors, M. Schaffarek, S. Jourdain.
Table 2
Summary statistics for median and mean 20-min UFP measurements and total traffic counts by season and site type. The mean UFP concentration of the suburban background station, taken during the same 20-min periods, is shown in italics.

<table>
<thead>
<tr>
<th>Site type</th>
<th>N</th>
<th>20-min median UFP (particles cm⁻³)</th>
<th>Mean (SD) suburban</th>
<th>Min</th>
<th>25th</th>
<th>75th</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street</td>
<td>122</td>
<td>14,700 (9100)</td>
<td>17,800 (10,500)</td>
<td>1600</td>
<td>7800</td>
<td>20,100</td>
<td>53,100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12,000 (7700)</td>
<td>12,200 (7700)</td>
<td>1100</td>
<td>5200</td>
<td>12,100</td>
<td>50,500</td>
</tr>
<tr>
<td>Urban</td>
<td>45</td>
<td>9900 (8600)</td>
<td>11,300 (10,000)</td>
<td>9800</td>
<td>5700</td>
<td>14,300</td>
<td>11,600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10,100 (6700)</td>
<td>10,200 (6700)</td>
<td>2200</td>
<td>5200</td>
<td>12,600</td>
<td>17,800</td>
</tr>
<tr>
<td>Regional</td>
<td>8</td>
<td>9000 (5300)</td>
<td>9800 (5700)</td>
<td>2400</td>
<td>5300</td>
<td>14,300</td>
<td>18,000</td>
</tr>
<tr>
<td></td>
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<td>11,400 (6000)</td>
<td>11,600 (6300)</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>6</td>
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</tbody>
</table>

SD: standard deviation; Min: minimum; 25th: 25th percentile; 75th: 75th percentile; Max: Maximum.
<table>
<thead>
<tr>
<th>Site type</th>
<th>Mean PNC</th>
<th>SD PNC</th>
<th>Min PNC</th>
<th>25th Percentile</th>
<th>Median PNC</th>
<th>75th Percentile</th>
<th>Max PNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street</td>
<td>14,700(9100)</td>
<td>12,000(7700)</td>
<td>1600</td>
<td>7800</td>
<td>20,100</td>
<td>53,100</td>
<td>17,800(10,500)</td>
</tr>
<tr>
<td>Urban</td>
<td>9900(8600)</td>
<td>10,100(6700)</td>
<td>12,100</td>
<td>50,500</td>
<td>1600</td>
<td>5900</td>
<td>12,100</td>
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<tr>
<td>Regional</td>
<td>9000(5300)</td>
<td>2200</td>
<td>5200</td>
<td>12,600</td>
<td>17,800</td>
<td>9800(5700)</td>
<td>11,600(6300)</td>
</tr>
</tbody>
</table>

SD: standard deviation; Min: minimum; 25th: 25th percentile; 75th: 75th percentile; Max: Maximum.
'Co-located' sampling between Tri-Tabs & SAPALDIA3 were highly correlated but showed >20% higher concs for the sidewalk.

Table 3
Comparison of the median and mean 20-min UFP concentrations from SAPALDIA home outdoor measurements with the 20-min median and mean UFP concentrations measured on the sidewalk nearby.

<table>
<thead>
<tr>
<th>Site type</th>
<th>n</th>
<th>SAPALDIA average (sd)</th>
<th>Sidewalk average (sd)</th>
<th>R²</th>
<th>Slope</th>
<th>Intercept (95% CI)</th>
<th>t-test a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
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</tr>
<tr>
<td>All</td>
<td>18</td>
<td>8500 (3800)</td>
<td>10,100 (4800)</td>
<td>0.84</td>
<td>0.73</td>
<td>1100 (−700, 3000)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Urban b</td>
<td>10</td>
<td>8400 (3800)</td>
<td>9400 (4900)</td>
<td>0.89</td>
<td>0.73</td>
<td>1600 (−500, 3800)</td>
<td>0.14</td>
</tr>
<tr>
<td>Street b</td>
<td>6</td>
<td>8100 (3000)</td>
<td>10,700 (4000)</td>
<td>0.71</td>
<td>0.64</td>
<td>1300 (−5100, 7600)</td>
<td>0.03</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>18</td>
<td>8700 (3600)</td>
<td>11,100 (4500)</td>
<td>0.78</td>
<td>0.71</td>
<td>900 (−1500, 3300)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Urban b</td>
<td>10</td>
<td>8700 (3700)</td>
<td>10,400 (4900)</td>
<td>0.88</td>
<td>0.70</td>
<td>1400 (−1000, 3900)</td>
<td>0.02</td>
</tr>
<tr>
<td>Street b</td>
<td>6</td>
<td>8200 (2700)</td>
<td>11,600 (3500)</td>
<td>0.47</td>
<td>0.54</td>
<td>2000 (−7500, 11,500)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

13 and 5 concurrent measurements were collected in spring and summer, respectively.

a p-value of paired t-test for the difference between sidewalk and home outdoor concentrations.
b Data for the two regional background sites are not shown.
Insight #4
- Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns

TAPAS study showed large differences in exposure by different commute modes

Exposomics: personal not different by home traffic situation
TAPAS study showed large differences in exposure by different commute modes

Winter commute: 20% of daily UFP exposure

Fig. 5. Contribution of commute to total daily ultrafine particle number exposure. Error bars represent 95% confidence intervals derived using bootstrap with 100 replications.
Winter commute: 20% of daily UFP exposure
Exposomics: personal not different by home traffic situation
UFP 2 subject traces

Seas_2_304, ID: 304, TFLD50: low, DTV10K: low (min–means)

Seas_2_347, ID: 347, TFLD50: high, DTV10K: high (min–means)
Personal >> Home

Mean UFP:
Pers: 18,400
HO: 6,200
Personal<<Home

Mean UFP:
Pers: 4,400
HO: 10,500
Next Steps

- OMICs analyses with UFP data to ID marker of exposure
  - Real-time data offers a wealth of parameters
  - will be done within a year+
- Build seasonal LUR models (EXPOsOMICs)
  - 30-min @ 160 sites * 3 seasons per area
- Explore possibilities for other UFP modelling (eg, GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb
  - but need to extend to 4 other SAPALDIA areas
  - extend nationally
Acknowledgments

Colleagues: Co-authors, Marianne Rutsch, Gregor Fessler, Aliocha Schaffner, Sivi Jeyachandren, Helen Graf, Tobias Heckelmann, Evelyn Fischer, Kevin Esterman, Benjamin Flückiger, Susanna Nussbaumer, Andreas Schwärzler, Gregor Juretzko, Katja Stähli, Sandra Okorga

• Swiss TPH
• SAPALDIA Team
• EXPOMICs Consortium
• BAFU - Bundesamt für Umwelt
• EMPA - Eidgenossische Materialprüfungs-Forschungsanstalt - NABEL network
• Cantonal air monitoring agencies (LHA Beider-Basel, SP-Air Geneva, OstLuft, SP-Environment Valais, InLuft, Abteilung fuer Umwelt des Kantons Aargau, ANU-Graubuenden, SPAAS-Ticino)
• FHNW Schweiz - University of Applied Sciences
• SNF - Schweiz Nationalfonds
• EU Framework Programme 7 grant #308610

Thank you for your attention!
Insights into the Spatial and Temporal Distribution of UFP from Swiss Health Studies

Ming-Yi Tsai, Reto Meier, Marloes Eeftens, Medea Imboden, Inmaculada Aguilera, Alex Ineichen, Mark Davey, Martin Fierz, Regina Ducret-Stich, Martina Raggetti, Christian Schindler, Harish Phuleria, Nino Künzli, Nicole Probst-Hensch

contact: m.tsai@unibas.ch

Questions?

The Studies in brief

The SAPALDIA study

TRITABS & TAPAS study

EXPOSOMICS study

Several Insights

Image 1:

Insight 2:

Insight 3:

Image 4:

Next Steps

Acknowledgments

Thank you for your attention.