The EXPOlis study was a European representative population based study of adult air pollution exposures, where personal exposure and workplace, indoor residential and outdoor residential environments were measured for participating adults. Objectives of the variable component of the study were to determine background exposures to 30 VOCs selected for their relevance to health or as markers of pollution sources. Due to the highly skewed nature of these distributions, in the current paper we wish to expand on this approach to identify activities and sub-populations with more elevated exposures and examine differences in personal exposures of EXPOlis populations in Athens, Helsinki, Oxford and Prague in relation to questionnaire information and 48-hour time activity diaries.

### Sampling design

- Participants carried an aluminum briefcase, containing VOC sampling apparatus and other self-monitoring equipment, all times during the 48-h sampling period
- VOCs were actively sampled using a modified Buck IH Pump (A.P. Buck Inc. Orlando, Florida) and absorbed onto Perkin Elmer Tenax TA absorbent tubes
- Analysis was performed by VTT (Espoo, Finland) using a Hewlett-Packard 5980 Series II gas chromatograph with flame ionization (FID) and mass selective detection (Hewlett-Packard MD 5972). VOCs were identified from MSD total ion chromatogram by a Wiley 275 software library. Peaks on FID chromatograms were identified on the basis of retention times of standard reference materials (high purity).
- Further details of the VOC sampling and analysis including comparisons of PEM and MEM measurements, duplicates and performance evaluations may be found in Jurvelin et al (2000).

### Step 1: Factor Analysis

- Principal component analysis with VARIMAX rotation on Natural Log transformed VOC and personal exposure measurements.
- Factor analysis is used to identify underlying patterns that explain common variations among a set of variables. Principal component analysis (PCA) relies on a slightly different mathematical model where unique factor loading and scores are left out of the analysis, and uses linear combinations of elements to characterize or account for the variation of each dimension in a multi-variate space.
- Linear combinations of the correlation matrix of element concentrations by applying a VARIMAX rotation produces the source vectors (5). Thus, the rotated factors represent major sources or meteorological effects to explain common variations in VOC concentrations in personal samples.

### Text

### Identification Of Similar Source Factors in Helsinki (Edwards et al., 2001)

### Table: Stepwise Linear regression

<table>
<thead>
<tr>
<th>Source Factor</th>
<th>Identification</th>
<th>n</th>
<th>Adjusted r²</th>
<th>Predictor variables</th>
<th>CHEMICALS</th>
<th>Dependency Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>Traffic/combustion emissions long range transport</td>
<td>123</td>
<td>0.40</td>
<td>Trafic time</td>
<td>VOCs</td>
<td>1.56</td>
</tr>
<tr>
<td>Factor 2</td>
<td>Localized traffic emissions</td>
<td>123</td>
<td>0.32</td>
<td>Time at work indoors</td>
<td>VOCs</td>
<td>1.56</td>
</tr>
<tr>
<td>Factor 3</td>
<td>Cleaning and household products</td>
<td>123</td>
<td>0.22</td>
<td>Time cooking</td>
<td>VOCs</td>
<td>1.56</td>
</tr>
<tr>
<td>Factor 4</td>
<td>Indoor product emissions and mold</td>
<td>123</td>
<td>0.29</td>
<td>Time washing car</td>
<td>VOCs</td>
<td>1.56</td>
</tr>
<tr>
<td>Factor 5</td>
<td>d-limonene indoor source</td>
<td>123</td>
<td>0.27</td>
<td>Time at work outdoors</td>
<td>VOCs</td>
<td>1.56</td>
</tr>
</tbody>
</table>

### Text

### Activities and behaviors related to personal exposures to source factors

**Factor 1: Traffic/combustion long range transport**

- The variables included are comparable with the less volatile components of automobile emissions. In Helsinki this factor was clearly associated with long range transport, as wind vectors showed directional dependency of this factor although participants were spread over the whole metropolitan area and monitored during the whole year (4).
- Prague is the most dominant factor clearly identifying a more exposed population. The second more exposed population is Athens, both showed considerably elevated concentrations of these compounds relative to other countries. This is perhaps not surprising given that the exposure sample from Prague was selected from municipality employees, in other words downtown office workers, and in Athens indoor levels of these compounds were elevated and greater time was spent in the car. This is related to the third factor where more time spent in other indoor (not home or workplace) was related to reduced exposure to this factor.
- Secondary sub-populations with greater exposure and sources appear to be those who spend greater time in a carwash, whose homes have an attached garage and those who live in high-rise suburban neighborhoods. It is interesting to note attached garage appearing as these variables have also been identified as leading to higher exposures to the compounds in this factor in other studies.

**Factor 2: Local traffic emissions**

- This factor was associated with the more volatile components of vehicle emissions and related to localized sources.
- The strongest predictor was the amount of time spent exercising outdoors
- A negative coefficient for those in Helsinki indicated that they were less exposed to this factor (but not because they exercised outdoors less).
- This factor appears to identify different types of homes and socioeconomic levels, associated with apartment buildings, and suburban areas with high-rise buildings. This is related to the third factor where more time spent in other indoor (not home or workplace) was related to reduced exposure to this factor.
- Residential sub-populations with greater exposure and sources appear to be those who spend greater time in a carwash, whose homes have an attached garage and those who live in high-rise suburban neighborhoods. It is interesting to note attached garage appearing as these variables have also been identified as leading to higher exposures to the compounds in this factor in other studies.

**Factor 3: Cleaning and household products**

- This factor appears to identify different types of homes and socioeconomic levels, associated with different product use.
- Helsinki participants were associated with increased exposure to this factor, and demonstrated the largest standard deviation in concentration levels.
- Electric heating - more prevalent in suburban single family homes – was associated with this factor. Interestingly district heating was less associated with this source, which is associated with apartment buildings, and suburban areas with high-rise buildings. This could reflect socioeconomic differences in the use of consumer products.
- Chipboard was also associated with suburban areas with single family homes but not associated with electric heating, which was negatively correlated with this source.
- Time spent in the car was negatively associated with this factor. Although time spent in the car was inversely correlated with time spent home indoors (r=-0.25, p<0.003) and time spent at work indoors (r=-0.19, p<0.03), removal of car did not allow these variables to enter the model.

**Factor 4: (Product emissions and mould)**

- This factor was associated with product emissions from the indoor environment and mould.
- Interestingly Oxford, whose homes were more associated with the periphery and lower traffic, was less associated with this factor. More importantly, however, Oxford homes mostly had central heating, which was negatively correlated with this source.
- Work outdoors was also positively associated with this factor, possibly due to products used or mould.
- Gas heating was also positively associated with this factor, but was mainly associated with homes in Prague (r=0.55,p<0.001). Time using a gas stove, however, was inversely associated with this factor.
- Floor renovation or repairs during the past year were also less associated with this factor, supporting association of this factor with mould.

**Factor 5: d-Limonene source**

- This appears to be a residential indoor source of d-limonene associated with product use. Predictors for this factor were all negative and associated with reduced exposure to this source. Exposures to this factor were negatively associated with participants in Helsinki, time windows were open at home, time spent at work indoors, time spent outdoors exercising and participants in Prague.

## References