Assessment of environmental tobacco smoke and respirable suspended particle exposures for nonsmokers in Prague using personal monitoring

Abstract
Objective: Exposures to respirable suspended particles (RSP) and environmental tobacco smoke (ETS) were assessed in Prague, Czech Republic, to determine the range and degree of personal exposure by means of personal monitoring over a 24-h period. Design: Self-reported nonsmokers were randomly selected from a representative sample of the population of Prague. Housewives were recruited into one group, primarily for assessment exposures in the home, and office workers were recruited into a second group for assessment of the contribution from the workplace. Methods: A total of 238 randomly selected nonsmoking subjects collected air samples near their breathing zone by wearing personal monitors for 24 h. Samples collected were analyzed for RSP, nicotine, 3-ethenylpyridine, and ETS particles (using ultraviolet absorbance, fluorescence, and solanone measurements). Saliva cotinine analyses were also undertaken to confirm the nonsmoking status of the subjects. Results: The most highly exposed subjects in this study were office workers both living and working with smokers. Median time-weighted average exposure concentrations of 60 lgm⁻³ RSP, 16 lgm⁻³ ETS particles, and 1.6 lgm⁻³ nicotine were determined for these subjects, who also had the highest median saliva cotinine level of 2.4 ng ml⁻¹. Housewives living in nonsmoking households were the least exposed subjects in this study, showing levels of 32 lgm⁻³ RSP, 0.17 lgm⁻³ ETS particles, and 0.15 lgm⁻³ nicotine. As based upon median levels of ETS particles and nicotine, no group would potentially inhale or be exposed to more than 10 cigarette equivalents per year (CE/y) and the least exposed would inhale less than 1 CE/y. The most highly exposed (90th percentile levels) nonsmokers in this study, who both worked and lived with smokers, would potentially inhale up to 29 CE/y. Overall, the workplace was estimated to contribute between 45% and 49% of the annual exposure to nicotine and ETS particles, respectively. On the basis of determined saliva cotinine concentrations, a misclassification rate of between 1.7% and 2.5% was calculated. Conclusions: Highest exposures were apparent for office workers both working and living in smoking environments, and our findings suggest a significant contribution to overall ETS particle and nicotine levels from the workplace where smoking takes place. Overall, the rates at which subjects were determined to have misclassified their smoking status in this study were the lowest observed in any of the European cities investigated to date. Clearly, a more sensitive method of analysis for cotinine in body fluids is needed for more accurate determination of the levels expected for nonsmokers.

Key words Personal exposure · Respirable suspended particles · Environmental tobacco smoke · Nicotine · Cotinine

Introduction

Prague was the eighth successive major European city studied by these authors with regard to air quality, following on from investigations conducted in Stockholm (Phillips et al. 1996), Barcelona (Phillips et al. 1997a), Turin (Phillips et al. 1997b), Paris (Phillips et al. 1998a), Bremen (Phillips et al. 1998b), Lisbon (Phillips et al. 1998c) and Basel (Phillips et al. 1998d). Situated on the river Vltava in the heart of continental Europe, Prague is the capital of the newly formed Czech Republic and has a population of approximately 1.2 million.
Personal monitoring was chosen for this study in preference to static or ambient measurements so as to obtain a more accurate representation of personal exposures to selected pollutants. The study involved subjects monitoring the air close to their breathing zone over 24-h periods in Prague, Czech Republic, during October/November 1995. Environmental tobacco smoke (ETS) particles were estimated using ultraviolet absorbing particulate matter (UVPM), fluorescent particulate matter (FPM) and solanesol-related particulate matter (SoPM). Vapour phase ETS exposures were also assessed by simultaneous measurement of nicotine and 3-ethenylpyridine (3-EP) concentrations. For the evaluation of exposures to ETS and respirable suspended particles (RSP), households and workplaces were classified as smoking or nonsmoking. Subjects also provided saliva samples for cotinine analysis and self-reported activities using diaries and questionnaires. Similar methodologies have been used in other recent studies (Heavner et al. 1996; Jenkins et al. 1996; Sterling et al. 1996; Back et al. 1997).

The study was designed to assess the exposure of housewives and office workers to RSP and ETS particles by obtaining accurate measurements of air concentrations. The information collated herein should provide some meaningful data to allow informed and objective debate on issues related to passive smoking and exposures to RSP overall. The results should also provide the opportunity to compare and contrast a city from a former “Eastern Block” country with major cities in Central Europe. The main objectives of this study were:

1. To recruit random subjects, who were representative of the population of Prague, into six separate lifestyle “cells”
2. To determine the range and degree of personal exposure within these cells of selected subjects to RSP and ETS constituents by means of personal air sampling over a 24-h period
3. To assess the contribution of the workplace to overall ETS and RSP exposure

### Methods

#### Recruitment of subjects

Recruitment was performed by GfK, a leading direct marketing company in the Czech Republic that possesses the most complete personal data base in the country. A representative population was selected from the data base to be compliant with the following criteria:

1. All subjects were to be nonsmokers living within 15 km of the Prague city centre.
2. Equal proportions were recruited from three age groups: 20–34, 35–49, and 50–64 years.
3. Subjects’ life styles were to be representative of the population living within 15 km of the city centre.
4. Subjects were to be distributed between six “cells” as indicated in Table 1, cells 3–6 being targeted at office workers.

#### Table 1 Cell categorisation by home and workplace status (Prague)

<table>
<thead>
<tr>
<th>Cell</th>
<th>Study type</th>
<th>Smoking status</th>
<th>Planned number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single monitor</td>
<td>Smoking</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>Single monitor</td>
<td>Nonsmoking</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Dual monitor</td>
<td>Smoking</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>Dual monitor</td>
<td>Smoking, Nonsmoking</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Dual monitor</td>
<td>Nonsmoking</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Dual monitor</td>
<td>Nonsmoking</td>
<td>30</td>
</tr>
</tbody>
</table>

Subjects were recruited from this representative population using randomly selected telephone numbers and were screened to confirm their eligibility to participate in the study. Suitable volunteers were given an appointment to attend an information/training session organised either at the Renaissance Prague Hotel or at the Hotel Hilton Atrium, also in Prague.

The assignment of subjects into cells as depicted in Table 1, households were classified as “smoking” if a smoker of cigarettes, pipes or cigars was resident and also normally smoked within communal areas of the household. The smoking status of a workplace was defined by the absence/presence of smoking co-workers within 30 m of the subject’s workstation. These definitions were chosen for the best representation of “real world” situations and for consistency across the different cities under study, where the attitudes of residents may vary considerably from country to country. The regulations governing air quality in the workplace were also different in each country at the time the studies were undertaken.

#### Monitoring session

Subjects were required to wear a personal monitor designed to collect particulate and vapour phase components present in the air close to the subject’s breathing zone (Ogden et al. 1996). RSP and ETS particles were collected onto a Fluoropore membrane filter, and nicotine and 3-EP were adsorbed onto XAD-4 resin beads. The personal monitoring methodology has been described in detail elsewhere (Phillips et al. 1996) and is briefly described below.

#### First visit to the study centre

On arrival, subjects were shown an instructional video, dubbed into Czech, explaining the objectives of the air quality survey and were given further instructions regarding use of the equipment and completion of the documentation by locally recruited interpreters. Subjects were issued Czech language questionnaires and diaries for recording of exposures and observations over the 24-h collection period and were supervised during completion of a “first visit” questionnaire. For avoidance of misinterpretation and possible errors in translation, all questionnaires and diaries were designed for either numeric or tick-box answers. Nonworking subjects recruited for participation in cells 1 and 2 were provided with a single personal monitor for use over the collection period (single monitor study). Working subjects recruited for participation in cells 3–6 were provided with two personal monitors for use over the same period (dual monitor study). All subjects were required to provide a saliva sample prior to the monitoring period (pre-sample).

#### Last visit to the study centre

Following completion of the 24-h monitoring period, subjects returned their personal monitors and associated documentation to the study centre. Subjects also provided a second saliva sample (post-sample) and completed a “last visit” questionnaire.