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Risk factors for increased BTEX exposure in four Australian cities

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Abstract

Benzene, toluene, ethylbenzene and xylenes (BTEX) are common volatile organic compounds (VOCs) found in urban airsheds. Elevated levels of VOCs have been reported in many airsheds at many locations, particularly those associated with industrial activity, wood heater use and heavy traffic. Exposure to some VOCs has been associated with health risks. There have been limited investigations into community exposures to BTEX using personal monitoring to elucidate the concentrations to which members of the community may be exposed and the main contributors to that exposure.

In this cross sectional study we investigated BTEX exposure of 204 non-smoking, non-occupationally exposed people from four Australian cities. Each participant wore a passive BTEX sampler over 24 h on five consecutive days in both winter and summer and completed an exposure source questionnaire for each season and a diary for each day of monitoring. The geometric mean (GM) and range of daily BTEX concentrations recorded for the study population were benzene 0.80 (0.04–23.8 ppb); toluene 2.83 (0.03–2120 ppb); ethylbenzene 0.49 (0.03–119 ppb); and xylenes 2.36 (0.04–697 ppb). A generalised linear model was used to investigate significant risk factors for increased BTEX exposure. Activities and locations found to increase personal exposure included vehicle repair and machinery use, refuelling of motor vehicles, being in an enclosed car park and time spent undertaking arts and crafts. A highly significant difference was found between the mean exposures in each of the four cities, which may be explained by differences in fuel composition, differences in the mix and density of industry, density of motor vehicles and air pollution meteorology.

Keywords: Exposure; Volatile organic compounds; BTEX; Risk factors; Community

1. Introduction

In the US, risk assessments of air toxics suggest increased health effects in urban areas (Caldwell et al.,

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1998; Woodruff et al., 1998). There has been increased attention on community exposure to air toxics and in particular the volatile organics compounds and the composite exposure to air toxics from the range of sources and locations (Woodruff et al., 1998; Gordon et al., 1999; Environment Australia, 2002).

Benzene, toluene, ethylbenzene and xylenes (BTEX) are some of the most common air toxics found in urban airsheds (Lee et al., 2002; Bono et al., 2003). BTEX are emitted from a range of sources and monitoring has shown elevated concentrations in Australian cities (Environment Australia, 2002). Sources include combustion products of wood and fuels, industrial paints, adhesives, degreasing agents, and aerosols (Environment Australia, 1999). Traffic, for example is considered an important source of benzene for both indoor and outdoor exposure (Jo and Park, 1999; Crebelli et al., 2001; Kim et al., 2001). Members of the community are therefore exposed to a potentially large number of sources with varying concentrations.

Benzene has been associated with increased rates of leukaemias and solid tumors in the occupational setting, although its role in community health outcomes is unclear (Vigliani and Forni, 1976; Duarte-Davidson et al., 2001; IARC, 2004). There have been some studies suggestive of a link between benzene from traffic emissions and cancer in members of the wider community and in children in particular (Nordlinder and Jarvholm, 1997; Jarvholm and Forsberg, 2000; Steffen et al., 2004). Chronic exposure to toluene and xylenes has been associated with adverse effects on the nervous system, the liver and the kidneys (ATSDR, 2003; USEPA, 2004). Chronic exposure to ethylbenzene has been associated with adverse effects on the respiratory system and the kidneys (NTP, 1999; ATSDR, 2003).

Despite the number of sources of BTEX in urban airsheds there are limited studies measuring personal exposure to BTEX in the general community. Apart from tobacco smoking, traffic and certain occupations which are known to result in benzene exposure (Jo and Park, 1999; Duarte-Davidson et al., 2001; Environment Australia, 2002) there is limited information in relation to the frequency or extent to which people participate in activities that may increase their personal exposure to environmental concentrations of BTEX. Personal exposure data enable a more accurate estimate of exposure for understanding the risk of exposure to these compounds and have been shown to be significantly higher than stationary measures (Payne-Sturges et al., 2004; Serrano-Trespalacios et al., 2004; Phillips et al., 2005). Further, personal exposure studies have shown highly variable concentrations dependent on the characteristics of the population under study and their geographic location (Payne-Sturges et al., 2004). Thus, there is a need for personal exposure measures to understand the magnitude, frequency and sources of community exposure.

Given the lack of information on personal exposure to air toxics and specifically BTEX, we sought to establish personal exposure concentrations in non-smoking, non-occupationally exposed adults and to identify how behaviour and lifestyle activities influence personal exposure to BTEX.

The study was undertaken with the use of activity diaries, questionnaires and personal monitoring which have been used successfully to determine both exposure concentrations and the activities and sources that contribute to personal exposure such as tobacco smoke and vehicle use (Gilli et al., 1994; Miller et al., 1998; Freeman et al., 1999; Hoffmann et al., 2000).

2. Methods

2.1. Study design

This study was a cross sectional study of daily 24-h personal exposure to BTEX of 204 residents in Adelaide, Melbourne, Perth and Sydney. Daily personal exposure was sampled for five days during both summer and winter. Personal exposure was measured over a 24 h time period. It is also considered an adequate time period to collect sufficient sample of BTEX to quantify (Thomas et al., 1993; Miller et al., 1998; Freeman et al., 1999). The study received ethics approvals from all participating institutions and complied with Commonwealth ethics and privacy requirements.

2.2. Study population

Participants were recruited from volunteer respondents to a postal questionnaire sent out to 12000 randomly selected residents of the four major Australian cities requesting lifestyle information related to BTEX exposure such as use of vehicles, time undertaking arts and crafts and time spent indoors (Environment Australia, 2003). Respondents were excluded from further participation if they were smokers, under 18 years of age or were employed in occupations with known elevated BTEX exposure such as chemical mechanical repairs, manufacture or the petroleum/oil industry. From 28.6% of respondents to the postal questionnaire, 5.9% of these volunteered and met the inclusion criteria for this study.

Fifty individuals from Perth, 54 from Sydney, 55 from Melbourne and 44 from Adelaide were recruited, with participation resulting in 197 individuals in winter and 193 individuals in summer. The sample size calculation was based on expected levels of exposure and the ability to conduct subgroup analysis (Environment Australia, 2003). Due to the withdrawal of participants after the winter sampling period, an additional seven participants were recruited in summer using opportunistic recruitment resulting in a total of 204 participants who provided a sample in either winter or summer.

2.3. Data collection

2.3.1. Questionnaire and diary data

Both self and interview administered questionnaires were used to investigate demographic information as well