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Environmental and occupational exposure to benzene in Thailand

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Abstract

Exposure to benzene in air is a concern in Thailand, particularly since it was observed that the incidence of blood-related cancers, such as leukemia and lymphoma, has increased in the past few decades. In Bangkok, the mean atmospheric levels of benzene on main roads and in schools were 33.71 and 8.25 ppb, respectively, while in gasoline service stations and petrochemical factories the mean ambient levels were 64.78 and 66.24 ppb, respectively. Cloth vendors (22.61 ppb) and grilled-meat vendors (28.19 ppb) working on the roadsides were exposed to significantly higher levels of benzene than the control group (12.95 ppb; $p < 0.05$). Bangkok school children (5.50 ppb) were exposed to significantly higher levels of benzene than provincial school children (2.54 ppb; $p < 0.01$). Factory workers (73.55 ppb) and gasoline service attendants (121.67 ppb) were exposed to significantly higher levels of benzene than control workers (4.77 ppb; $p < 0.001$). In accordance with the increased benzene exposures, levels of urinary *trans,trans*-muconic acid (MA) were significantly increased in all benzene-exposed groups. In school children, the levels of MA were relatively high, taking into account the much lower level of exposure. Blood benzene levels were also significantly increased in Bangkok school children (77.97 ppt; $p < 0.01$), gasoline service attendants (641.84 ppt; $p < 0.05$) and factory workers (572.61 ppt; $p < 0.001$), when compared with the respective controls. DNA damage, determined as DNA strand breaks, was found to be elevated in gasoline service attendants, petrochemical factory workers, and Bangkok school children ($p < 0.001$). The cytogenetic challenge assay, which measures DNA repair capacity, showed varying levels of significant increases in the numbers of dicentrics and deletions in gasoline service attendants, petrochemical factory workers and Bangkok school children, indicating a decrease in DNA repair capacity in these subjects.

Keywords: Bangkok; Benzene; Biomarkers; Children; DNA repair capacity; DNA strand breaks; *trans,trans*-Muconic acid

1. Introduction

Benzene is classified as a human carcinogen, and an association between exposure to benzene and the development of leukemia is well established [1]. Ex-

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posure to benzene in the environment and in certain occupational settings has been a subject of concern in Thailand, particularly since it was observed that the incidence of leukemia has increased in the past few decades [2].

Benzene is an important component of gasoline. In Thailand, the limit for benzene content in gasoline is set at 3.5% [3], while in some industrialized countries, such as the USA, the content is only 1% [4]. Benzene is also used in the petrochemical as well as many other chemical industries. Sources of benzene in the environment, to which the general public may be exposed, are cigarette smoke, burning of coal, and traffic emissions. In many occupational settings, exposure may be from benzene used as a solvent, as a raw material, or in gasoline itself.

Environmental and occupational monitoring of benzene exposure and the use of various biomarkers to study benzene exposure and potential toxicity can help to identify the high-risk groups and to determine whether this risk is due to the relative high exposure levels, as in occupational exposures, or the inherently greater susceptibility of the individual, such as in children.

This study has been undertaken to investigate the exposure to benzene in the environment, i.e. from the traffic-related air pollution in Bangkok, and in various occupations, such as in gasoline service attendants and petrochemical factory workers. Environmental and personal air sampling have been used to assess the exposure. Measurement of blood benzene levels and/or urinary *trans,trans*-muconic acid (MA) provides information on the internal doses as well as individual variation in metabolism. DNA damage as measured by the Comet assay [5], and DNA repair capacity as measured by the cytogenetic challenge assay [6], provide information on possible early biological effects of benzene exposure and may be indicative of health risks.

2. Materials and methods

2.1. Study design

2.1.1. Environmental exposure to benzene

In the study involving traffic-related air pollution, seven heavily congested areas of Bangkok were chosen as study locations for roadside and school levels of benzene, namely the Pratunam, Banglampu, Chakrawad, Pratumwan, Hualampong, Surawongse and Victory Monument areas. Street vendors who set up their stalls directly at the roadside and whose work period was approximately 8 h were recruited as subjects. Temple areas located within 500 m of the selected main roads were chosen as control sites, and monks and nuns who spent most of their time in the temples were selected as the controls. Through information provided in the questionnaires, factors such as age and lifestyle (e.g. non-smoking status, medication, type of diet, etc.) were taken into consideration to ascertain that they were well matched between controls and study groups. Schools in Bangkok located within 500 m of the main roads were selected as study sites, while others situated in Chonburi (a provincial area located approximately 110 km from Bangkok) were used as control sites. Students were age-, gender-, and education level-matched between the control and study groups. An explanation of the study was given to all subjects and an informed consent was obtained from all the participants (or parents in the case of the school children).

2.1.2. Occupational exposure to benzene

Attendants from gasoline service stations in Bangkok and workers in the quality control unit of petrochemical factories involved with the production of aromatic compounds, such as benzene and toluene, were recruited in this study. Gasoline service station attendants worked 8-h shifts and only refuelled gasoline. They were not involved in any other responsibilities during their workday. The control subjects were age-, gender-, and lifestyle (non-smoking status, medication, type of diet, etc.)-matched workers in an occupational setting unrelated to the use of benzene.

2.1.3. Selection of study subjects

All adult subjects were non-smoking, healthy volunteers between the ages of 18–40. Mean levels of urinary creatinine lower than 28 μg/mmol creatinine were used to affirm the non-smoking status [7]. Subjects of both genders were involved in the study of benzene exposures in street vendors, monks and nuns, while subjects selected for the study on occupational exposures were all males. School children were healthy, 10–12 years old boys.