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Workers exposed to low levels of benzene present in urban air: Assessment of peripheral blood count variations

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HIGHLIGHTS

- Occupational exposure to benzene in male and female urban workers was evaluated.
- A significant correlation was found between airborne benzene and benzene in the blood.
- A significant correlation was found between blood benzene levels and white blood cells.
- Benzene in the blood can affect the immune system.

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ABSTRACT

Background: Few studies in the literature have examined the effects of benzene on blood cells.
Aim: The aim of this study was to evaluate the possible correlation between the blood benzene levels and the blood cell counts.
Materials and methods: From a population of 2658 workers, we studied a group of 215 subjects. Each worker underwent blood sampling for the assessment of the blood benzene levels and the blood cell counts. The Mann–Whitney *U* test for two-mode variables and the Kruskal–Wallis test for more-than-two-mode variables were performed on all subjects. We estimated the Pearson correlation index between the variables in the total sample and the subgroups divided according to sex, the smoking habit, and job. After the main confounding factors were evaluated, multiple linear regression was performed on both the total sample and the subgroups.
Results: A significant inverse correlation was found among the blood benzene levels and the white blood cells, lymphocytes, and neutrophils in traffic policemen, motorcyclists, and other outdoor workers. We did not find any significant correlation with any other parameters of blood cell count.
Discussion and conclusions: Our results, which must be considered preliminary, indicate that increased blood benzene levels in outdoor workers lead to decreased counts of white blood cells, neutrophils, and lymphocytes, because of possible immune effects. These are worth investigating in the future by specific immune tests.

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1. Introduction

To date, benzene has been an important and widespread environmental pollutant. Exposure to benzene occurs via the inhalation of contaminated air, particularly in areas of heavy traffic and near gas stations, or inhalation of cigarette smoke. Benzene also originates from evaporation during refueling and carburetors, fuel tanks, and other parts of vehicles when the engine is switched off.

Low-level inhalation of benzene over long periods poses a significant threat to human health (ATSDR, 2007; Sancini et al., 2011; Miraglia et al., 2014).

The hematopoietic system is significantly affected by the presence of environmental pollutants, as shown in many studies on humans and animals (Horiguchi et al., 2011; Robert Schnatter et al., 2010; Serrani et al., 1997).

The International Agency for Research on Cancer (IARC) classifies benzene as a "known human carcinogen" (group 1), with "sufficient" evidence of causing different types of leukemia, particularly, the acute myeloid form (Arnold et al., 2013), both in humans and in animals (IARC, 1987).

Chromosomal aberrations (hypo- and hyperdiploidy, deletions, breaks, and gaps) in peripheral lymphocytes and bone marrow cells are predominantly seen in humans (ATSDR, 2007). Prolonged and repeated exposure to low doses of benzene leads to a hemotoxic effect involving all blood cells, which results in anemia, leukocytopenia, thrombocytopenia, pancytopenia, and aplastic anemia (ATSDR, 2007; Lan et al., 2004).

Blood benzene concentration is a suitable marker for evaluating occupational exposure, due to the strong correlation between its concentrations in the air and in the blood of exposed subjects (ACGIH, 2012; Brugnone et al., 1998; Fustinoni et al., 1995).

The assessment of the blood benzene concentration at the end of a working shift is a sensitive and specific method, as it reflects the exposure to benzene (ACGIH, 2012).

The study aims to estimate the levels of individual exposure to benzene at the low doses present in the urban air and to assess the correlation between the blood benzene levels and the peripheral blood counts in a group of outdoor workers in Rome, Italy.

2. Methods

2.1. Studied population

From an initial population of 2658 outdoor employees of the Municipal Police of Rome (occupationally exposed to urban pollutants), we randomly selected 280 workers, approximately 35 from each of the eight different areas of the city; these areas were considered representative of the traffic in order to reduce the confounders.

We included workers who had been living for at least 5 years in the same urban area they were working in and who had similar dietary habits and water consumption (from the water supply and/or mineral water). Moreover, these workers were living in houses with similar furniture, carpet, etc., which are known to produce low and negligible amounts of benzene.

The traffic policemen were assigned to traffic control in streets and areas with high and medium traffic density, and at intersections, parking areas, and areas with limited traffic; they were required to carry out this assignment on foot (Ciarrocca et al., 2012).

The drivers and motorcyclists were assigned to controlling the traffic and intervening in traffic accidents, as well as driving the car, as a driver or as a "second on patrol" (Crebelli et al., 2001; Pancheri et al., 2002).

The other outdoor activities included Core Support Marginalized, external activities of Judicial Police, Environmental Police, and others (Ciarrocca et al., 2012).

All of these activities were performed outdoors, and the drivers spent at least 80% of the total working time (7 h/day for at least 5 days a week) in the car. These activities were performed in the morning so the workers were monitored during the morning session (07:00–14:00) at the end of the workweek. For inclusion in the study and to reduce the confounders, each worker completed a clinical–anamnestic questionnaire in the presence of a physician, covering the following items: age, area of residence in the last 5 years, physiological anamnesis (especially diet and any exposure to smoke), past and current jobs held, past and current pathological anamnesis with a focus on disorders of the hematopoietic system, and information on exposure to benzene during holidays.

To determine the exposure to smoke, we used the World Health Organization (WHO) classification (2014), considering smokers as those who reported having smoked at least 100 cigarettes in their lifetime, who were currently smokers, or who had stopped smoking <6 months ago. All workers who reported having stopped smoking >6 months ago were considered nonsmokers (WHO, 2014).

To avoid the effect of confounders, 65 workers were excluded from the initial sample for the following reasons: exposure to solvents, detergents, and lubricants during their leisure activities (Arnold et al., 2013); disorders of the hematopoietic system in their anamnesis; drug use and habitual drinking (alcohol consumption exceeding two units of alcohol per day for men and one unit of alcohol per day for women; one unit of alcohol corresponds to about 12 g of ethanol) (Saunders et al., 1993); shift work and/or night shifts (Touitou et al., 1990) or outdoor jobs held for <1 year (very short exposure time). The final sample consisted of 215 workers (137 men and 78 women; 59 smokers and 156 nonsmokers). These included 112 traffic policemen, 69 drivers, nine motorcyclists, and 25 workers with other outdoor tasks.

Each subject underwent biological monitoring (assessment of blood benzene concentration) and tests for peripheral blood counts (red blood cells, RBCs; hemoglobin, HGB; hematocrit, HCT; mean corpuscular volume, MCV; average concentration of hemoglobin, MCH; mean corpuscular hemoglobin concentration, MCHC; platelets, PLTs; reticulocytes, RETs; white blood cells, WBCs; lymphocytes, LYMs; neutrophils, NEUs; monocytes, MONOs; eosinophils, EOSs; and basophils, BASOs) using an electronic cell counter (Coulter Counter Model S Plus IV).

Individual air samplings were carried out for eight traffic policemen selected from each of the eight areas considered representative of the geographical distribution of the workers, and on four car drivers when at least two workers were present for each shift. Thus, even if just one worker wore the dosimeter, the results were representative of the coworker in the same car. The air sampling was performed for the entire duration of the experiment.

Air and blood samples were collected on the same day, to avoid the effect of weather and seasonal conditions on individual exposure to benzene. Subjects were equipped with a passive–diffusive air sampler attached as a badge at the neck of each worker, at the beginning of the work day, in order to measure the concentrations of benzene in the breathing area.

After the sampling process, the passive–diffusive air sampler was desorbed by adding CS_2. Benzene was measured by gas chromatography using a Dani gas chromatograph 1000 equipped with a flame ionization detector (FID). The detection limit (LoD) was 0.001 ppm (3.19 $\mu g/m^3$).

The detected concentrations of benzene were expressed as mean values weighted in time, for a period of 8 h.

Each worker underwent blood sampling after five continuous working days, at the end of the shift, on the same day of the individual's air sample. Before assessment of the blood benzene