



Review

A review of Human Biomonitoring studies of trace elements in Pakistan



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HIGHLIGHTS

- Human Biomonitoring of trace elements.
- Current picture of the trace elements biomonitoring/cross sectional surveys in Pakistan.
- Comparison of available data with other international Human biomonitoring programs.
- Heavy metals are found mostly higher in blood, urine, hair and nails than most of the countries.

ARTICLE INFO

Article history:

Received 9 April 2016

Received in revised form

10 July 2016

Accepted 1 August 2016

Handling Editor: Martine Leermakers

Keywords:

Human biomonitoring

Trace metals

Physiological fluids

Case-control studies

ABSTRACT

Human biomonitoring (HBM) measures the concentration levels of substances or their metabolites in human body fluids and tissues. HBM of dose and biochemical effect monitoring is an effective way of measuring human exposure to chemical substances. Many countries have conducted HBM studies to develop a data base for many chemicals including trace metals of health concern for their risk assessment and risk management. However, in Pakistan, HBM program on large scale for general population does not exist at present or in the past has been reported. Various individual HBM studies have been reported on the assessment of trace elements (usually heavy metals) from Pakistan; most of them are epidemiological cross sectional surveys. In this current review we tried to develop a data base of HBM studies of trace elements namely arsenic, cadmium, copper, chromium, iron, lead, manganese, nickel, and zinc in biological fluids (blood, urine) and tissues (hair, nails) in general population of Pakistan. Studies from all available sources have been explored, discussed and presented in the form of tables and figures. The results of these studies were critically compared with large scale HBM programs of other countries, (US & European communities etc). It was observed from the present study that the most of the toxic metals in biological fluids/tissues in general population of Pakistan, have higher background values comparatively. For example the mean values of toxic metals like As, Cd, Cr, Ni, and Pb in blood of general population were found as 2.08 µg/L, 4.24 µg/L, 60.5 µg/L, 1.95 µg/L, 198 µg/L respectively. Similarly, the urine mean values of 67.6 µg/L, 3.2 µg/L, 16.4 µg/L, 6.2 µg/L and 86.5 µg/L were observed for As, Cd, Cr, Ni, and Pb respectively.

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1. Introduction

Human biomonitoring (HBM) can be defined as “a systematic continuous or repetitive activity for collection of biological samples for analysis of concentrations of pollutants, metabolites or specific non adverse biological effect parameters for immediate application, with the objective to assess exposure and health risk to exposed subjects, comparing the data observed with the reference level and if necessary leading to corrective actions” (Zielhuis, 1984; Angerer et al., 2011). HBM can provide valuable information on environmental exposures and also helps in identifying potential health risks and it can give very precise information on the total internal exposure of an individual at a given time (Wilhelm, 2014). For the evaluation of chemical exposure to general population or specific groups, human biological material i.e., commonly body fluids blood, urine, milk, or tissues i.e., hair, nails, bones etc. is collected for assessment purpose. For HBM studies, biological materials should easily be accessible in adequate amounts under normal conditions and without causing discomfort and health risk for the individual during sampling. Blood and urine are the far most used biological matrices for this purpose. Blood as the central compartment is in steady state with all organs. Urine is more accessible and available in large volumes and can be used for the monitoring of very low level concentrations of chemicals. Apart from blood and urine; Hair, teeth, and nails also have been used for HBM purposes for long term exposure of environmental chemicals. However, these matrices have few drawbacks like no standard operating procedures are available and no external quality assessment schemes for these materials are available (Angerer et al., 2007).

Human biomonitoring of general population started back in USA in early 1960s, when The National Health and Nutrition Examination Survey program (NHANES) was conducted as a series of surveys focusing on different population groups or health topics. In 1999, this survey became a continuous program with changing focus on different health and nutrition measurements to meet the emerging needs (NHANES, 2013–14). At present, many national or international organization started broad general population HBM studies in different countries including Germany, Canada, USA, Belgium, Spain, Czech Republic, France, Sweden, Finland, Norway South Korea, Japan, and China etc. (Choi et al., 2015).

In 1977, Commission of the European Communities enacted the “council directive on biological screening of the general population for lead” (CEC, 1977). Later on, EUROTERVIHT project (Trace Element Reference Values In Human Tissues) was established in the early 1980s to determine, compare and propose reference values for trace elements (TEs) concentrations in body fluids/tissues from the general population living in different regions of the European Union (Hoet et al., 2013). In 2009, Consortium to Perform Human Biomonitoring on European Scale (COPHES) program was started. Under this program, the biomarkers for Hg, Cd, phthalates, bisphenol A as well as environmental tobacco smoke in human hair and urine from 17 participating EU countries was measured (COPHES).

The first German Environmental Surveys for general population studies to determine the exposure of Germany to environmental contaminants was started in 1885 (GerES-I 1985–6). Being first in series; this survey is still going on (GerES-II 1990–92; GerES-III 1997–99; GerES-IV 2003–6 (children), GerES-V-2014-17 (children and adolescents) (UBA).

A comprehensive national direct health-measures survey was conducted in Canada as a part of the Canadian Health Measures Survey (CHMS cycle 1), and presents national baseline data on concentrations of environmental chemicals in Canadians. This report on HBM based on samples collection of two years (March 2007 to February 2009) from approximately 5600 inhabitants and presents national reference values (RVs) for many chemicals (including 13 TEs) in urine and blood. In 2nd report on HBM (CHMS cycle 2) which was published in April 2013 includes the data for 91 environmental chemicals (including metals & TEs). The Data for cycle 2 was collected from 6400 Canadians (aged 3–79 years) between 2009 and 2011. The third cycle of the CHMS included 5800 Canadians (aged 3–79 years), where 48 environmental chemicals measured in individual samples, 33 of which have been measured in previous cycles. Collection for the third cycle of the CHMS took place between January 2012 and December 2013. Planning for future cycles is underway (HC, 2015).

The French National Nutrition and Health Survey (ENNS), was carried out in France between 2006 and 2007 to assess the exposure of the general population to various environmental pollutants (including 11 metals). The HBM was conducted using 42 biomarkers of exposure in blood, urine or hair in approx. 3100 adults and 1700 children (Fréry et al., 2010).

In Belgium, the Flemish HBM program as a part of a health survey network was carried out in 8 different regions. The first Flemish Environment and Health Study (FLEHS I), was conducted between 2002 and 2006, reference values were established for a wide range of biomarkers including trace elements (Cd & Pb). The second study of HBM program was conducted by the same (FLEHS II) between 2007 and 2011, in which the number of environmental chemicals for HBM data was expanded substantially. The goal of the said program was to establish, use and translate the scientific results into policy actions (Baeyens et al., 2014). The third cycle (FLEHS III) started for the period of 2012–2015 and is expected to finish in 2016 (PRC).

In Spain, the program BIOAMBIENTES represents the first Human Biomonitoring study at national level and studied during the period of March 2009 and July 2010. The first results revealed that mercury is higher in the Spanish population and similar to the levels found in other European populations in which consumption of fish and other marine products is high (Pérez-Gómez et al., 2013).

In Italy, the HBM program “PROBE” was managed by the National Centre for Diseases Control and Prevention of the Italian Ministry of Health. A cross-sectional population study design was used to determine the exposure of healthy general population to metals. The study started in 2008 and lasted until 2010 and reports the internal dose for 20 metals (Alimonti et al., 2011).

Arbitrarily designated trace elements are present in tissues in

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