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Human Biomonitoring of food contaminants in Spanish children: Design, sampling and lessons learned

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ABSTRACT

Human Biomonitoring (HBM) studies are highly useful for evaluating population exposure to environmental contaminants and are being carried out in increasing numbers all over the world. The use of HBM in the field of food safety, in a risk assessment context, presents a growing interest as more health-based guidance values (HBGV) in biological matrices are derived, and can be used in a complementary way to the external exposure approaches such as total diet studies or surveillance programmes. The aims of the present work are: i) to describe the methodological framework of the BIOVAL study, a cross-sectional HBM program carried out by the Health Department of the Regional Government of Valencia (Spain), that is linked to the food safety official control, and is focused on children from 6 to 11 years of age ii) to explain and discuss the pre-analytical results iii) to report and discuss on lessons learned from its design and implementation. The study population included 666 children from whom urine and hair were taken in order to analyse different biomarkers of exposure to food pollutants.

1. Introduction

Health can be jeopardised by exposure to a wide variety of chemicals through different routes, such as ingestion, inhalation and dermal absorption. Traditionally, the risk due to this kind of hazard has been assessed by determining the concentration of pollutants in specific matrices such as food, water and air. The main drawback of this method is that an accurate result for human exposure via multiple pathways requires both quantitation of pollutant levels in different matrices and data on individual behavioural patterns affecting exposure, such as the consumption of contaminated foods. In addition, these determinations do not provide data about real quantities absorbed by the human body (body burden), which depend on different factors such as the physicochemical properties of pollutants and their concentration in a specific environmental medium, time of exposure, as well as individual factors such as metabolism or excretion ratio characteristics (WHO, 2015).

Human Biomonitoring (HBM) is commonly understood as a method for assessing human exposure to natural and synthetic compounds based on the analysis of biomarkers (BM), which are defined as chemical substances or their metabolites measured in human biological matrices such as blood, urine, hair, adipose tissue, teeth, saliva, breast milk or nails (CDC, 2005; EFSA, 2015). Although HBM studies have been used for a long time in occupational health they are currently recognised as an appropriate tool for risk detection or trend controls in other fields such as public health, environmental health and food safety (Casteleyn et al., 2009).

The great advantage of HBM is that it permits an integrated measurement of the amount of a contaminant absorbed by the human body, through the different routes of exposure, from all sources of contamination and takes into account inter-individual variability such as metabolism, ratios of excretion and lifestyle (Angerer et al., 2007; Joas et al., 2012). In particular, cross-sectional HBM studies provide a snapshot of the exposure of a population at a specific time (Knudsen et al., 2012).

Abbreviations: HBM, Human Biomonitoring Studies; BM, Biomarkers; BIOVAL, Human Biomonitoring Programme in Children Population of the Valencian Region (Spain); CAPI, CComputer – Assisted Personal Interviewing; COPHES/DEMOCOPHES, Demonstration of a study to coordinate and perform Human Biomonitoring in a European Scale; EFSA, European Food Safety Authority; IBSP- CV, Biobank for the Biomedical Research in Public Health of the Comunity of Valencia; FISABIO, Foundation for the promotion of Sanitary and Biomedical Research of the Valencian Community; PCH, Public Health Centres; SCALE, European Strategy for Environment and Health; RV, Reference Values; BE, Biomonitoring equivalents; HBMI, HBM II Health-related values derived from the German Human Biomonitoring Comission

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In 2003, the European Commission adopted the "European Strategy for Environment and Health" (SCALE Initiative), whose ultimate objectives were: to reduce the disease burden caused by environmental factors, to identify and prevent new health threats caused by environmental factors and to favor the development of health policies in the EU. One of the main goals of this strategy is to protect children against adverse health effects due to their vulnerability to environmental risks (EC, 2003). The SCALE Initiative was followed by the European Action Plan on Environment and Health from 2004 to 2010 (EHP, 2004–2010), where the need to develop a proper database to collect information was emphasised. The commission underlined the need to apply a coordinated approach to human biomonitoring (HBM) to increase the effectiveness of environmental impact assessments, including the effect of food. In this context, the EU promoted a human biomonitoring programme at a European level (COPHES/DEMOCOPHES) in which 17 European countries (including Spain) participated to create an HBM framework, harmonizing HBM procedures and creating a common baseline of results (Joas et al., 2012).

Likewise, the European Food Safety authority (EFSA, 2015) has emphasised that HBM provide an added value for exposure and risk assessment in food safety areas. This require the derivation of HBGV such as HBM values (Apel et al., 2017) and Biomonitoring Equivalents (BE) (Angerer et al., 2011).

The Public Health Department of the Valencian region (Spain) carries out an evaluation of the external exposure to food contaminants through a total diet study (Marin et al., 2017) and also using data from surveillance programmes (Quijano et al., 2016). To gain more insight into population and sub-populations exposure to food contaminants, and following the EFSA criteria on the usefulness of HBM in this field, we have developed a cross-sectional HBM study (BIOVAL), whose main objective is to evaluate the exposure and risk assessment of children (from 6 to 11 years of age) to the contaminants present in the diet.

In this work we review some methodological options for the design of a HMB study, and focus our attention on achieving the following aims: i) to describe the methodological framework of the BIOVAL study (Fig. 1), ii) to explain and discuss the pre-analytical results, and iii) to discuss the lessons learned from its design and implementation.

2. Study design

2.1. Objective

Following the international experience, provided by many relevant HBM programs such as those implemented in Canada (Haines and Murray, 2012), USA (Calafat, 2012), Germany (Schulz et al., 2011; Kolossa-Gehring et al., 2017), France (Fréry et al., 2014) or Czech Republic (Černa et al., 2012), the BIOVAL programme aims to achieve the following objectives: i) to establish reference values (RV) for the different biomarkers of exposure to the main food contaminants, focusing on the population of the Valencian region (ii) to determine the exposure to the selected substances for the general population, (iii) to evaluate the temporal evolution of the biomarkers of exposure and analyse the geographical differences in relation to the exposure (iv) to provide internationally comparable data; (v) to offer data for risk assessment; vi) to evaluate the effectiveness of different programmes, focused on the reduction of exposure to pollutants and vii) to provide recommendations for risk reduction.

The majority of the environmental chemicals of interest can be incorporate to the human body through different routes (i.e. oral, dermal and inhalation). However, BIOVAL focuses on chemicals whose main pathway of exposure is the diet. Consequently, we have integrated HBM as a new tool in the Food Safety Plan of the Valencian Region (Spain), complementing the classical approach to exposure assessment (external exposure), that combines levels of contaminants on food and food consumption. (EFSA, 2011; Dorne and Fink-Gremmels, 2013)

2.2. Study population

The target population varies in the different HBM studies. The national studies are mainly focused on the general population or some subpopulations (Cerna et al., 2012). However, in other more specific studies, mother-child pairs (Wihelm et al., 2005), pregnant women (Llop et al., 2017) workers (Mercadante et al., 2013), the highly exposed (e.g. hot spots) (Aguilera et al., 2010) are also frequent target populations.

In a comprehensive review made by the University of Copenhagen (EFSA, 2015) based on thirty-seven HBM studies carried out in different countries in recent years, different examples of study populations can

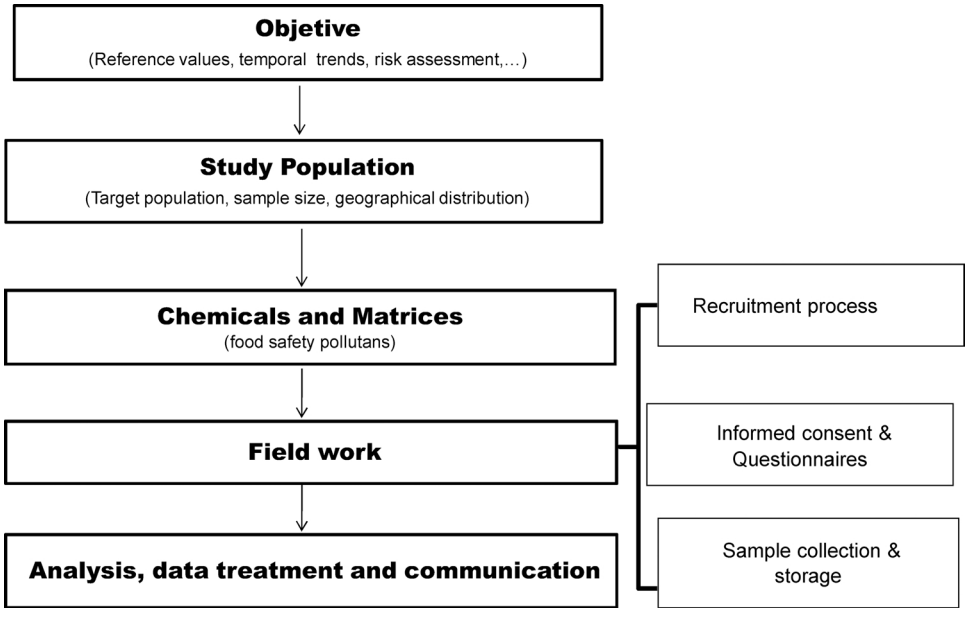

Fig. 1. Methodological framework of the BIOVAL study.