



18th November 2009

Human Biomonitoring in Switzerland

Report of the Federal Council from November 18, 2009 on Human Biomonitoring in Switzerland in response to the Moser Postulate 08.3223 on the implementation of a body burden analysis to chemical substances

Summary

In her Postulate of 20 March 2008, National Councillor Moser (Green Liberal, Canton Zurich) requested the Federal Council to consider the introduction of systematic analysis of various groups of chemicals (pesticides, PCBs, UV filters, etc.) to which the Swiss population is exposed. In its response of 6 June 2008, the Federal Council stated that it was prepared to investigate how existing research activities in specific areas could be coordinated and extended. The present report, prepared under the direction of the FOPH, incorporates comments from key actors in the field of **Human Biomonitoring (HBM)** in Switzerland (Federal Office for the Environment (FOEN), Federal Office of the Agriculture (FOAG), Board of the Swiss Federal Institute of Technology (ETH), Institute for Work and Health (IST), State Secretariat for Economic Affairs (SECO), SUVA and Swiss Association of Cantonal Chemists (VKCS). It describes the HBM activities that already exist in Switzerland and sets out the goals that could be achieved via a national biomonitoring programme. The assessment of the current situation indicates that existing HBM activities do not provide a representative picture of the exposure of the Swiss population to chemical substances. It is therefore proposed that further support should be provided for HBM activities in Switzerland. In order to assess the feasibility of a national HBM programme in this country, Switzerland will be taking part in an EU pilot study (2010–2012). Based on this experience, a decision can then be taken concerning the implementation of a full-scale national HBM programme in Switzerland. At the same time, there is also a need to improve the coordination of existing HBM activities in Switzerland.

1. Background

HBM comprises the measurement of chemical substances or their metabolites in human body fluids and tissues, such as urine, blood, breast milk, hair, fat, etc. As well as dangerous substances, HBM may also cover vital substances, such as vitamins and essential trace elements, or involve analysis of biochemical effects (e.g. DNA adducts – contaminants bound to DNA) or biological effects (micronuclei – chromosome fragments). The advantage of HBM is that it directly determines concentrations in the body resulting from overall exposure to a substance. It thus covers all sources (food, air, water, soil), all intake pathways (inhalation, ingestion, dermal intake) and individual factors of all kinds (nutrition,

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individual metabolism, etc.). By contrast, environmental monitoring aims to determine concentrations of substances in air, water, soil, foodstuffs or house dust and then to estimate human exposure arising from these various pathways. This requires numerous assumptions, which may lead to significant inaccuracies in such estimates. In addition, environmental monitoring does not generally permit estimates of individual exposure.

HBM was introduced in occupational medicine to protect workers' health. Effective methods for measuring certain pollutants were developed as early as the 1960s. HBM was first widely used among the general population in the 1970s to determine blood lead concentrations. HBM programmes were subsequently initiated in a number of countries, e.g. the National Health and Nutrition Examination Surveys (NHANES) in the US (from 1976), the German Environmental Surveys (GerES, from 1985), the Environmental Health Monitoring System (EHMS) in the Czech Republic (from 1994), the Flemish biomonitoring programme in Belgium (from 1999) and the Canadian Health Measures Survey (from 2007). The EU decided in 2004 to define a harmonized approach to HBM across Europe and is planning to launch a pilot study in all member states (2010–2012). These activities indicate that HBM is now widely regarded internationally as a promising public health tool.

2. Assessment of the current situation

This assessment summarizes important HBM activities in Switzerland and indicates the laboratories involved. Although it is not exhaustive, it is designed to provide an overview of the current situation in Switzerland.

2.1. HBM activities

1) *Federal Office of Public Health (FOPH)*

For some years, the FOPH has carried out or provided support for HBM studies of certain chemical substances:

- **Contaminants in breast milk** (organochlorine pesticides and PCBs) have been studied since the 1970s. It was shown that average dioxin concentrations in breast milk have declined by more than 50% over the last few decades. Residues of persistent organochlorine pesticides in breast milk have also decreased sharply in recent decades. This demonstrates the effectiveness of the restrictions and prohibitions implemented. Contaminants in breast milk were also measured in three more recent projects (2002–2006) – dioxins and furans, synthetic musk fragrances, brominated flame retardants, chlorinated paraffins, polychlorinated naphthalenes and chemical UV filters. The analyses were performed at the Swiss Federal Laboratories for Materials Testing and Research (EMPA) and in-house FOPH laboratories. In a follow-up project carried out in cooperation with the FOEN (see point 2 below), breast milk samples from the resident Swiss population are being analysed for selected potentially bioaccumulative contaminants. As well as UV filters, other toxicologically relevant (groups of) substances currently used in products are to be studied.
- Since 2008, the FOPH has supported the largest-ever Swiss study of male fertility, launched under the NRP50 programme. In this project, sperm quality is being studied in approx. 3000 military recruits. In order to explore a possible association between sperm quality and the presence of endocrine-disrupting chemicals, concentrations of various **endocrine disruptors** (including phthalates, PCBs and organochlorine pesticides) are being measured in blood and urine samples from about 400 of these recruits. Given the lack of laboratory capacity in Switzerland, the requisite chemical analyses are being performed in Germany (Ruhr University, Bochum: Professors Angerer and Wilhelm).

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- Since 2008, the FOPH has supported a study of toxicokinetic variation between sexes conducted by the Institute for Work and Health (IST). This involves the exposure of 20 subjects to 4 **solvents**, with the concentrations of the solvents or metabolites subsequently being determined in blood, urine and exhaled air.
- At the FOPH laboratory in 2002, **lead concentrations** were measured in blood samples from 25 hunters and 21 controls. The results showed that the consumption of game meat has no effect on blood lead levels. It can therefore be assumed that, as long as game meat is appropriately prepared, lead residues do not pose any health hazard. The study showed that there is no need to introduce a limit for lead in game meat. In connection with possible risks due to lead in domestic water pipes and fittings, a new series of measurements of blood lead concentrations in the Swiss population are to be conducted at the FOPH laboratory in 2009. The aim is to determine whether lead exposure levels in Switzerland are stable or have decreased.
- Between 2005 and 2006, the FOPH laboratory carried out a HBM study on 14 **perfluorinated alkanes** (in particular PFOS and PFOA, substances used in surface coatings and food packagings). These substances are highly persistent in the environment and potentially toxic.
- A national biomonitoring programme concerning **brominated flame retardants** in blood is to begin in 2009. The measurements are to be performed at the FOPH laboratory. The aim of these studies is to estimate current exposure levels among the Swiss population.
- Since the 1990s, the **iodine and selenium status** of the resident Swiss population has been studied at regular intervals because deficiencies can cause serious illness. Urine and serum analyses were conducted at the FOPH laboratory.
- Since the mid-1950s, the FOPH has collected deciduous teeth and vertebrae for a long-term study on the uptake of **strontium-90** (radioactive isotope of strontium). Analyses are carried out on behalf of the FOPH at the Institute of Applied Radiophysics (IRA), Lausanne University. This programme was initiated as a result of concerns about the possible effects of overground nuclear tests, which were banned in 1963. The oldest deciduous teeth samples are from children born in 1950. These long-term measurements make it possible to trace precisely the rise in levels of atmospheric radioactivity up until 1963 and the exponential decline thereafter. The Chernobyl reactor disaster led to a slight but measurable temporary increase in strontium-90 levels. Deciduous teeth provide information on the contamination of maternal blood during pregnancy, while vertebrae reflect individual contamination during the last years of life. As well as strontium-90, **plutonium** was measured in deciduous teeth at the FOPH laboratory in order to study the transfer of plutonium to the fetus from maternal plasma. The mechanisms of plutonium and strontium-90 uptake are fundamentally different. Maximum plutonium activity was observed in deciduous teeth from children who had been born 10 years before the highest plutonium levels were measured in the atmosphere. This surprising finding can be explained by the fact that plutonium, unlike strontium-90, cannot pass the placental barrier. Consequently, plutonium did not pose a significant radiation risk in Switzerland during the nuclear testing period.

2) Federal Office for the Environment (FOEN)

In a project launched at the beginning of 2008, the FOEN is measuring persistent organic pollutants (POPs) in 50 **breast milk samples**. This project is being carried out as part of an evaluation of the effectiveness of the Stockholm Convention on Persistent Organic Pollutants (POPs Convention). This will make it possible to characterize the exposure situation in Switzerland and to identify any need for action. The analysis includes the following substances, mainly found in plant protection products: aldrin, chlordan, dieldrin, DDT, endrin, heptachlor, hexachlor, hexachlorobenzene, hexachlorocyclohexane, toxaphene, PCBs, PCDDs and PCDFs. The FOPH is also analysing these samples for UV filters and other chemicals (see point 1 above).

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3) *EMPA*

In cooperation with the FOPH (see above), Empa studies bioaccumulative **contaminants in breast milk**: PCBs, dioxins, synthetic musk fragrances, brominated flame retardants, chlorinated paraffins, polychlorinated naphthalenes and chemical UV filters. These substances are used in various products, such as perfumes, sunscreens or computers. These groups of substances, as well as the other chemicals covered by the POPs Convention, can also be analysed in serum by Empa. The aim of these studies is obtain better estimates of exposure levels in infants.

In studies of exposure to indoor air pollutants via inhalation, measurements are occasionally also made of **pentachlorophenol** (PCP, formerly used as a wood preservative) in urine, especially if this substance is suspected to be present in buildings (e.g. kindergartens, schools).

4) *Suva*

In accordance with the Ordinance on the Prevention of Accidents and Occupational Diseases (VUV), the Swiss Accident Insurance Fund (Suva) carries out HBM in preventive medical studies to assess indoor pollution or adverse effects in workers exposed to certain chemicals. Health risks can be assessed by comparing the observed blood or urine concentrations with the biological tolerance (BAT) values for workplace substances. BAT values are defined by Suva in consultation with the Threshold Limit Values Commission of the Swiss Association of Professional Societies for Health and Safety at Work (suissepro); they are updated at 2-year intervals in the publication "Grenzwerte am Arbeitsplatz" (which includes BAT and MAK values). HBM is used primarily for workers exposed to **metals** such as lead, mercury, cadmium, chromium compounds, nickel or cobalt. It is also used in cases of relevant exposure to **solvents**. Analyses are carried out, for example, at the IST in Lausanne, the Institute and Outpatient Clinic of Occupational, Social and Environmental Medicine (IPASUM) in Erlangen, and the Viollier and Gubler laboratories in Basel. A preventive medicine HBM programme, involving approx. 2000 employees, is currently being organized at around 150 companies.

5) *IST*

The Institute for Work and Health (IST) in Lausanne has a laboratory which can measure urinary concentrations of several **heavy metals** (e.g. lead and mercury) **and** metabolites of **organic compounds**. Biomarkers of effects (8-OHdG, cholinesterase inhibition, comet assay) and biomarkers of susceptibility (N-acetyltransferase/NAT phenotype) can also be determined. Such studies are used to estimate workplace exposure levels. In 1995, for example, the IST published a large-scale study of blood **lead** concentrations, involving 1700 subjects. This demonstrated a dramatic decrease in lead concentrations following the introduction of unleaded petrol in Switzerland in 1985.

6) *Cantonal Laboratories*

HBM studies have been carried out by a number of Cantonal Laboratories. For example, a study of 33 breast milk samples performed by the Zurich Cantonal Laboratory in 2003 demonstrated the presence of **paraffin** residues in human milk. These results indicate that breast milk can be contaminated by ingredients of cosmetics. At the end of the 1990s, the Basel-Stadt Cantonal Laboratory published a review of studies of **breast milk contaminants** (organochlorine pesticides and PCBs) to permit rough estimates of exposure in infants.

7) *Universities*

As part of the NRP50 "Endocrine disruptors" programme (2001–2007), the working group led by Margret Schlumpf and Walter Lichtensteiger (Zurich University) studied **contaminants in breast**

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milk (including UV filters, musk fragrances, polybrominated diphenyl ethers, DDT). In the past, the Swiss National Science Foundation has supported projects involving the determination of blood protein adducts (Sabbioni, Würzburg University, 1987–1992) and DNA adducts (ETH Zurich). These adducts could be used as markers for mutagenic and carcinogenic effects.

2.2 Laboratory capacity

HBM calls for a high level of analytical expertise. Only a small number of Swiss laboratories have the capacity to determine certain substances in media such as urine, blood or breast milk. Specifically, these include public sector laboratories (FOPH, Empa, IST, some Cantonal Laboratories). Medical/chemical laboratories (e.g. Viollier) often offer determinations of lead and other heavy metals. Private laboratories routinely offering HBM services for typical organic substances do not exist in Switzerland (with the exception of the Gubler laboratory in Basel). Complex analyses have to be carried out abroad (e.g. in Germany or the US).

2.3 Conclusions

Unlike Germany, the Czech Republic, (Flemish-speaking) Belgium, the US and Canada, Switzerland does not have a comprehensive national programme for the analysis of human burden to chemical substances. It is true that certain HBM studies have been and are carried out by various institutions in Switzerland. However, data is generally only collected in a selective and project-related manner and thus cannot normally be used for comparisons across regions or over time. In addition, laboratory capacity is limited in Switzerland, especially in the case of organic pollutants. Biomonitoring of biochemical (e.g. DNA or protein adducts) and biological effects (e.g. micronuclei) has barely been introduced in Switzerland. By contrast, systematic environmental monitoring has been practised in Switzerland for many years – covering the quality of air (NABEL since 1978), groundwater and surface waters (NAQUA and NADUF since 1972/97) and soil (NABO Flux since 1984), as well as foodstuffs, including drinking water (maximum concentrations and tolerance values defined in the Ordinance on Contaminants and Constituents in Foodstuffs).

3. Possible goals of a HBM programme

In principle, a comprehensive national HBM programme opens up the possibility of numerous activities, with the following goals:

- 1) Determination of **background concentrations** (reference values) of certain substances among the Swiss population.
- 2) Determination of **concentrations among risk groups**, i.e. sections of the population that are particularly highly exposed or particularly sensitive: infants, children or the elderly, urban or rural dwellers, people living close to industrial/commercial sites, regular users of biocidal or plant protection products, occupational or socioeconomic groups, etc. It would be possible to identify people showing values significantly higher than background concentrations for certain substances. In these cases, individual risk assessments could be carried out, and individual recommendations could be formulated for risk reduction.
- 3) Assessment of **trends**, i.e. whether concentrations of substances increase or decrease over time. An increase over time can be interpreted as an early-warning signal, leading to preventive measures (prioritization of efforts to reduce exposure). Exposure to emerging contaminants (e.g. acrylamide) can also be taken into account.

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- 4) Assessment of **regional differences**, i.e. whether concentrations are particularly high in certain regions. Comparisons could also be made with levels in other countries (Germany, Czech Republic, Belgium, US, Canada). Such data could help to identify sources or pathways of exposure.
- 5) **Assessment of the effectiveness** of measures adopted or **monitoring** of legal measures. HBM can be used to assess the effectiveness of measures designed to reduce exposure, such as registration or notification procedures, restrictions or bans on chemicals (in chemicals or food legislation and/or in international agreements, e.g. the POPs Convention), training for professional users or recommendations for consumers. With HBM, it has been demonstrated, for example, that the ban on lead in petrol brought about a decrease in blood lead levels among the general population (the same applies to PCBs and dioxins in breast milk, see above).
- 6) Determination of **essential trace elements and substances**; with HBM, it is possible to study not only risks but also benefits.
- 7) Prioritization of **research on the toxic effects** of substances. Investigation of the question of what level of internal burden to a substance actually poses a health risk. Identification of substances that may cause certain toxic effects in humans (e.g. deterioration in sperm quality). Quantification and evaluation of the body burden with regard to these substances can be useful for the interpretation of health data and trends from the health registry (link between HBM and health monitoring).

4. Measures

We recommend the following measures in the area of HBM:

4.1 Coordination of existing activities (from 2010)

Meetings should be held regularly (at least once a year) with Swiss HBM stakeholders in order to coordinate existing and planned HBM activities. Ideally, these events should also involve environmental monitoring experts, so as to take advantage of synergies between projects in the areas of human biomonitoring and environmental biomonitoring. The EU has a database of current HBM projects in EU member states. Switzerland could become a party to this database, thereby linking up all Swiss HBM actors and coordinating their activities. It would also be desirable for all measurements to be entered in this database. Responsibility for coordination could be assumed by the new Swiss Centre for Applied Human Toxicology or by the FOPH unit responsible for the HBM pilot study.

4.2 HBM pilot study (2010–2012)

The gaps existing in the area of HBM are evident from the assessment of the current situation. At present, it is not possible to obtain a representative picture of the exposure of the Swiss population to chemical substances. The implementation of a national HBM programme – as required for this purpose – is an ambitious, medium-term goal, which still involves a number of unresolved questions. It is therefore important, as a first step, to explore the possibilities and limits in more detail through a pilot study.

This way of proceeding is in line with the strategy of the EU Commission for a coordinated European approach to HBM. In the EU pilot study DEMOCOPHES (2010–2012), in which around 20 EU member states (including Germany, France, the UK and the Netherlands) are participating, four markers (methylmercury in hair and cadmium, cotinine and phthalate in urine) are each to be measured in 120 children (aged 6–11 years) and their mothers (a total of 240 subjects).

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The FOPH will be participating in DEMOCOPHES and in the COPHES II network (CONsortium to Perform Human biomonitoring on a European Scale). Participation in DEMOCOPHES will provide an insight into EU activities in this area. In Switzerland and the EU member countries, comparable HBM data will be collected and comparable procedures established. The limited resources available in the HBM area can thus be used efficiently (Swiss budget for the DEMOCOPHES and COPHES II projects: approx. CHF 300,000). In addition, this pilot study should help to clarify the financial implications of a HBM programme and permit conclusions concerning the strengthening of capacity and expertise in Switzerland.

4.3 Decision on a national HBM programme (2013)

In 2013, based on the results and experience of the pilot study, a decision should be taken as to whether and how a national HBM programme can be implemented in Switzerland. Here, the following points will need to be considered:

Study design

Selection of (groups of) substances, types of sample (urine, blood, breast milk, etc.), population groups (age groups, general population or people/workers with specific exposure), frequency of monitoring, questionnaire for subjects, possibly biobank and biomonitoring for biochemical and biological effects, etc. Environmental monitoring conducted in parallel – with measurements in drinking water, house dust and indoor air in the subjects' dwellings – would provide information on possible sources of substances and facilitate risk management measures. This could also include testing of foodstuffs or cosmetics, generating possible synergies with NANUSS (NAtional NUtrition Survey Switzerland).

Possible (groups of) substances are chemicals as defined in the Chemicals Act (biocidal products, plant protection products, dangerous substances, etc.), known or suspected environmental pollutants (dioxins, furans, PCBs, heavy metals, etc.), mycotoxins (e.g. ochratoxins), radionuclides (e.g. caesium-137 and plutonium), or indicators of tobacco use/passive smoking (cotinine, nicotine).

Study design will have a major influence on the costs of a national HBM programme.

Analytical capacity

Switzerland's existing laboratory capacity in the HBM area is inadequate. One option would be to make use of capacity available abroad (e.g. in Germany and the US). Otherwise, Swiss universities and the ETH Domain (including the attached institutes Empa and EAWAG) have expert analytical laboratories which could take on tasks in the HBM area. However, additional financial resources would be required to expand laboratory capacity and to establish an analytical reference laboratory in Switzerland. Various institutions (IST, ETH Board) advocate the strengthening of analytical capacity in Switzerland, pointing out that the trend towards the reduction of chemical analysis at Swiss universities could prove problematic in the future.

Interpretation

Reference values (statistical values for a representative sample, generally the 95th percentile) should be defined for Switzerland. Should health-based limits be derived specifically for Switzerland, or could these values be taken over from Germany (German Human Biomonitoring Commission)?

Communication and ethics

Clear guidelines should be defined for communication and ethics.