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Human Biomonitoring:

Scientific assessment of human exposures to chemicals at Public Health England and potential health impacts

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Contents

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Exposure and risk assessment of environmental substances

Detection, assessment, management, control and reporting of new and emerging threats to public health

Protect and improve health by controlling and reducing risks to health from environmental hazards

Environmental monitoring of air, water and land to compare with environmental standards and guidelines

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Human biomonitoring: makes it personal

The collection of biological samples

Measurement of indicators of chemical/elemental uptake (biomarker)

Biomarkers: the chemical or element, a metabolite, a DNA or protein adduct or a protein, biochemical or microRNA

HBM accounts for all sources and routes of exposure making it an invaluable tool for risk assessment

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Exposure-effect continuum for environmental chemicals

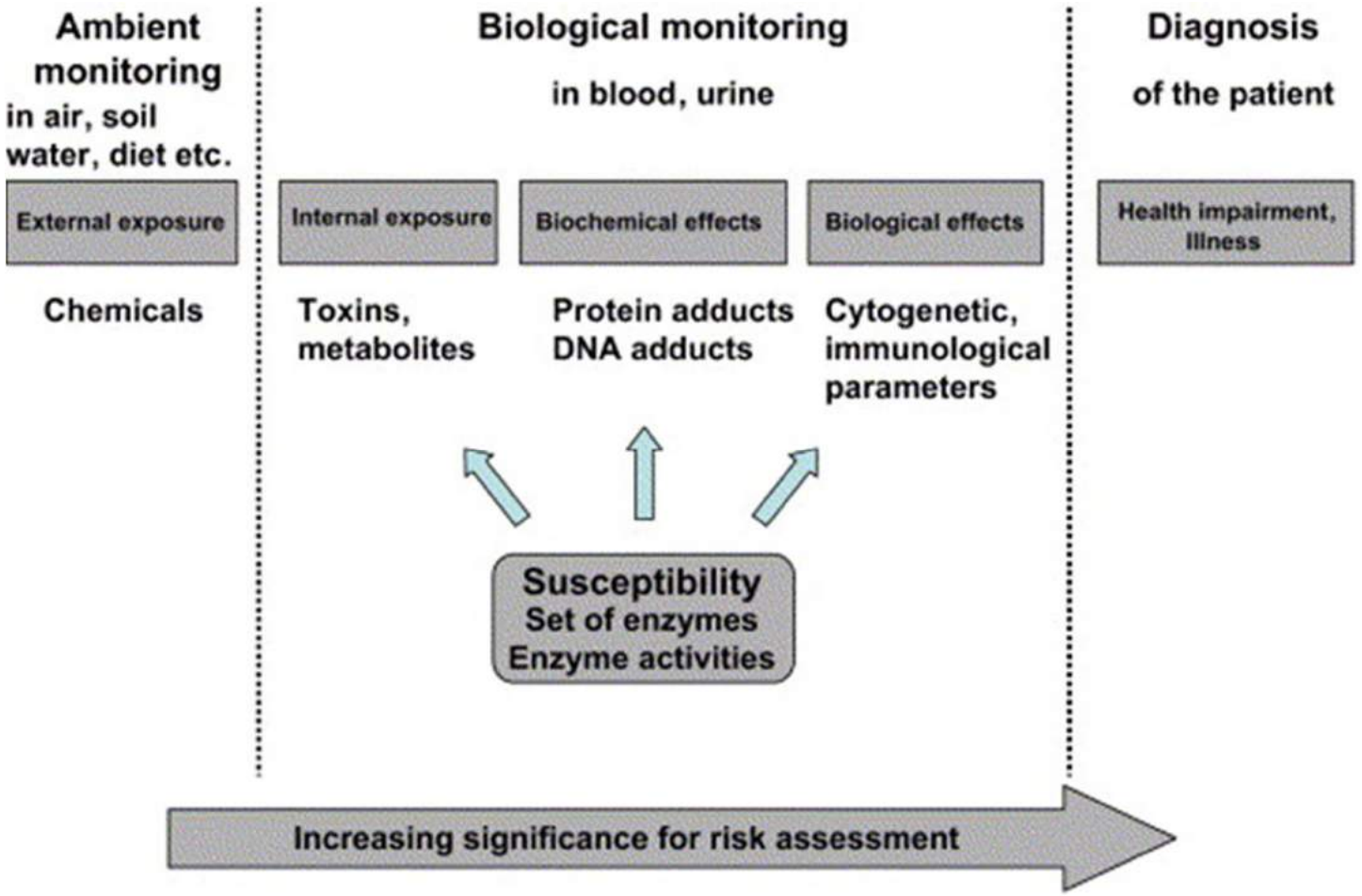

Figure 1 from Angerer, Ewers and Wilhelm (2007) International Journal of Hygiene and Environmental Health, Volume 210, Issues 3–4, 201–228

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Uses and benefits of human biomonitoring

To improve exposure assessment & provide risk management strategies for environmental substances

- Identify priority chemicals and concentrations
- Determine who has levels associated with health effects
- Identify vulnerable groups
- Track trends in exposures to current and emerging chemicals
- Assess effectiveness of public health efforts
- Set priorities for research & policy action to reduce exposure

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Issues and limitations

- Lack of toxicological and epidemiological information to interpret the results
- Lack of meaningful reference levels
- Exposure biomarkers can be difficult to relate to possible health outcomes
- Effect biomarkers can be difficult to relate to exposure
- Does not define sources or route of exposure
- No information about the source or history of exposure
- Snapshot of substances present in the body at a single point in time
- Or accumulation of exposure from many sources and routes over a period of time

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What is needed?

Reliable and comparable data

Reference levels

Validation of analytical techniques and Laboratory quality assurance

Correct choice of biomarker for study design and question

Improved interpretation

Establishing correlation between biomarker levels and health risk

Coordination with related research – epidemiology, toxicology, statistics, pharmacokinetic modeling, exposure assessment

Harmonisation across Europe

A European HBM pilot study was recommended as an action within the European Environment and Health Action Plan 2004

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Harmonising approaches for comparable data

HBM framework – COPHES

European pilot study - DEMOCOPHES

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Human Biomonitoring on a European scale

Perform HBM in a coherent and harmonised approach throughout Europe

- Framework & standardized protocols
- Recruitment strategy
- Fieldwork and sampling
- Chemical analyses
- Data analysis and interpretation
- Communication

COPHES
Consortium to Perform Human Biomonitoring on a European Scale

SEVENTH FRAMEWORK PROGRAMME

Challenges - differences in: political and health priorities, threats to health, levels of analytical capacities, cultural, ethical issues

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Pilot Study

DEMOCOPHES

Cross-sectional study across Europe

- Children aged 6-11 years old and their mothers
- Urine and hair samples
- Measuring exposure to : cadmium, phthalates, environmental tobacco smoke and mercury
- Questionnaire data – home environment, diet, use of personal care products, smoking status
- >1800 mother-child pairs in 17 European countries

Fig. 1. Countries implementing the pilot study (in green): BE, CH, CY, CZ, DE, DK, ES, HU, IE, LU, PL, PT, RO, SE, SI, SK, UK.

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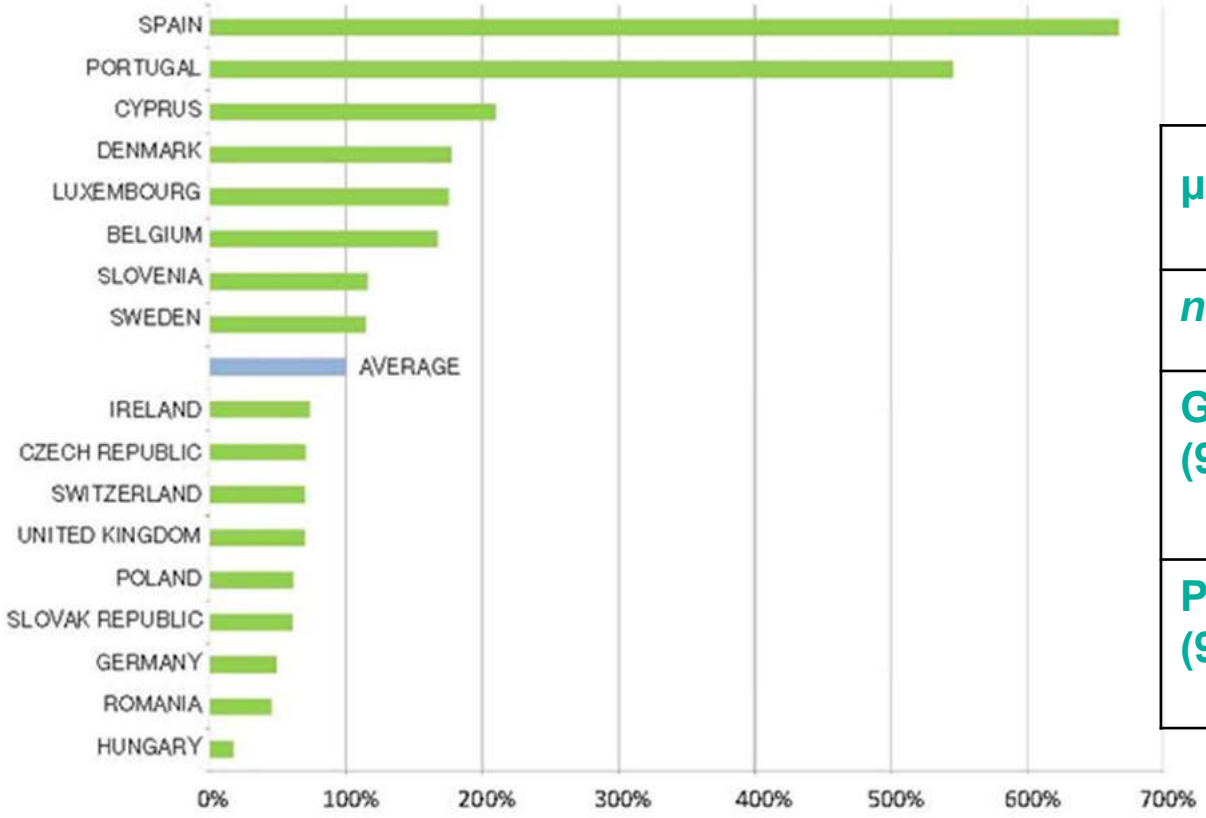
Mercury in hair



µg/g	Mothers	Children
n	1839	1836
GM (95%CI)	0.23 (0.22,0.23)	0.15 (0.14 0.15)
P90 (95%CI)	1.20 (1.07,1.34)	0.80 (0.70, 0.92)

Mercury in children's hair, % of the DEMOCOPHES countries average, adjusted for age and gender

DEMOCOPHES (2013). "Layman's report."www.eu-hbm.info

Castano, A., et al. (2015). "Fish consumption patterns and hair mercury levels in children and their mothers in 17 EU countries." Environ Res **141**: 58-68.

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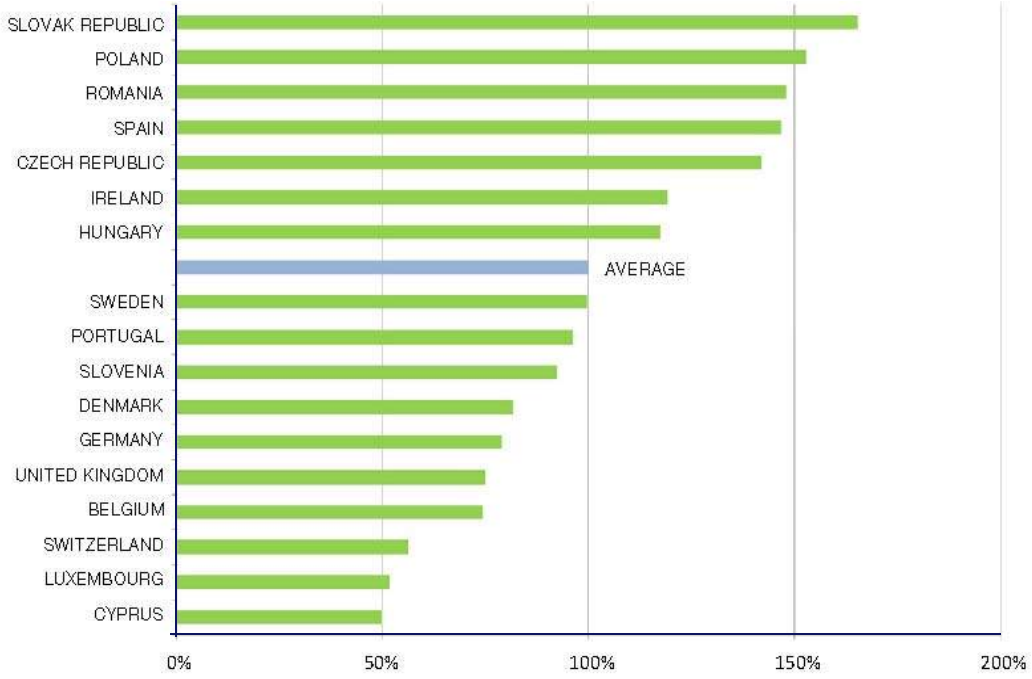
Urinary phthalate metabolites

Higher in children than mothers except MEP (cosmetics)



Sum of DEHP metabolites in urine of children, % of the DEMOCOPHES countries average, adjusted for urinary creatinine, age and gender

DEMOCOPHES (2013). "Layman's report."www.eu-hbm.info

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Urinary cotinine levels and smoking legislation

Levels in children reflect the smoking habits of the adults in the household

Children exposed had 5x higher levels compared to non-exposed children

a)Children
b) Mothers
(average± standard deviations)

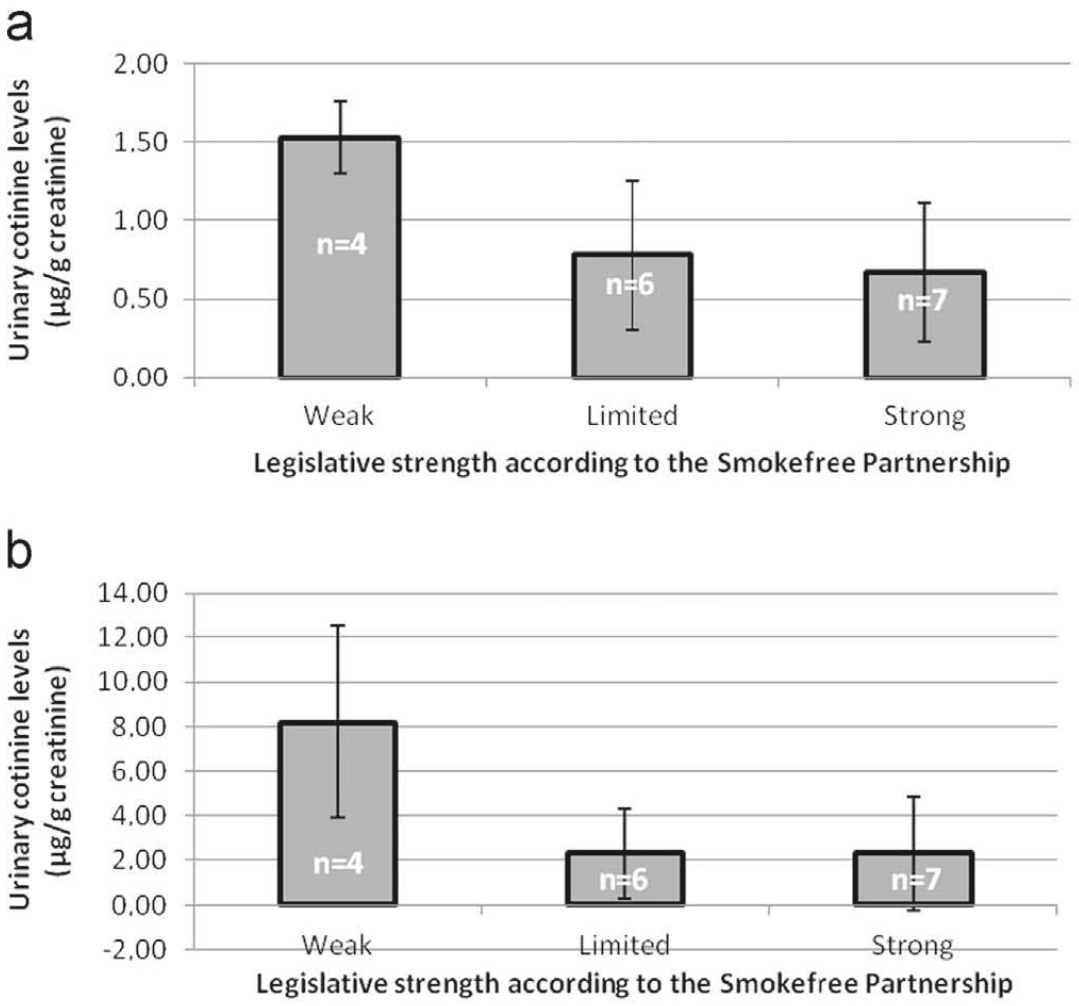

Figure 3 from Smolders et al 2015 Environmental Research Interpreting biomarker data from the COPHES/DEMOCOPHES twin projects: Using external exposure data to understand biomarker differences among countries 141 (2015) 86-95

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Urinary cadmium in smokers and non-smokers

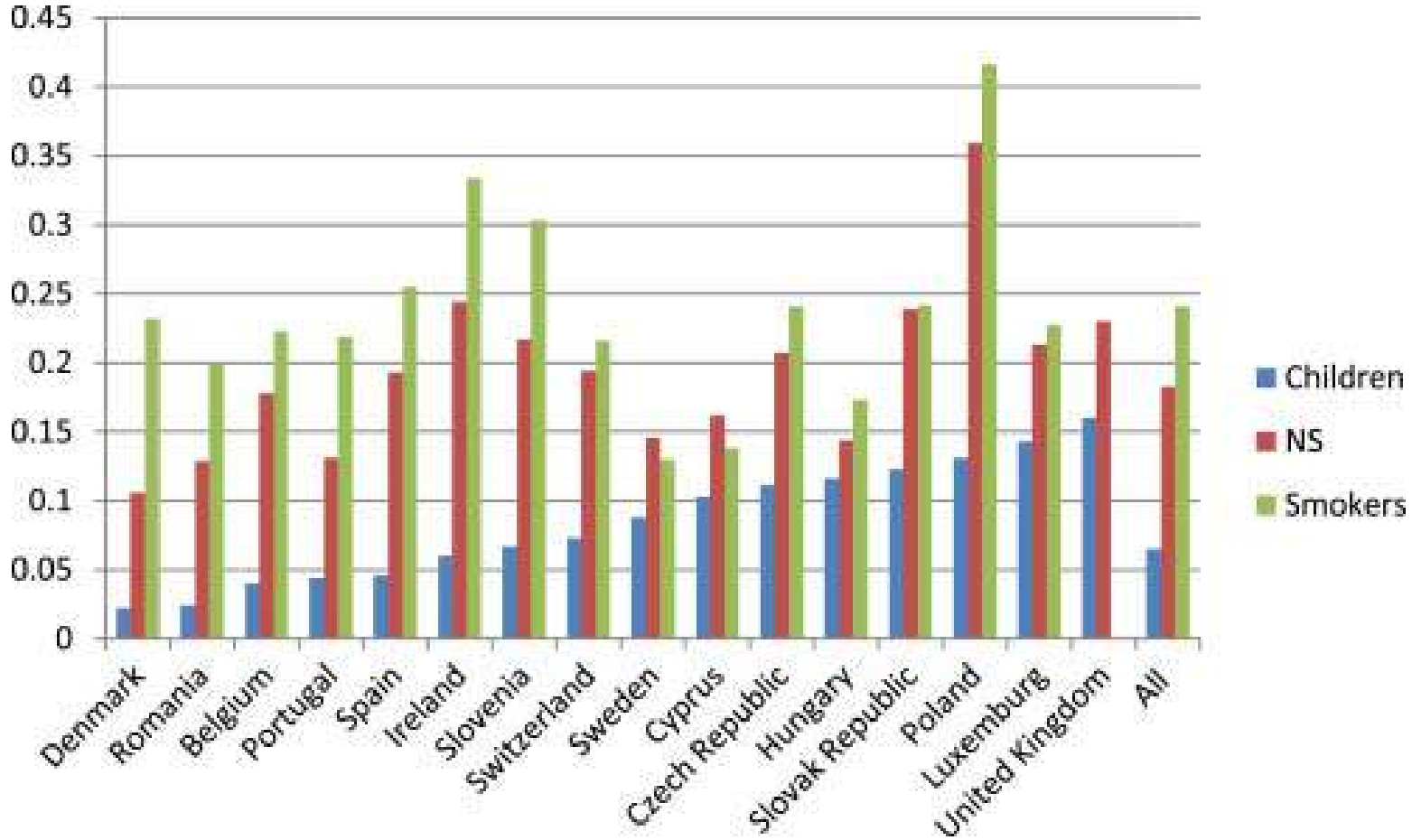

Fig. 1. Urinary Cd (µg/g crea; geometric mean) in smokers, non-smokers (NS) and children in 16 European countries (sorted by children's UCd).

Figure 1 from Berglund et al Environmental Research Exposure determinants of cadmium in European mothers and their children (2015) 141 69-76

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Urinary cadmium and cadmium emissions to air

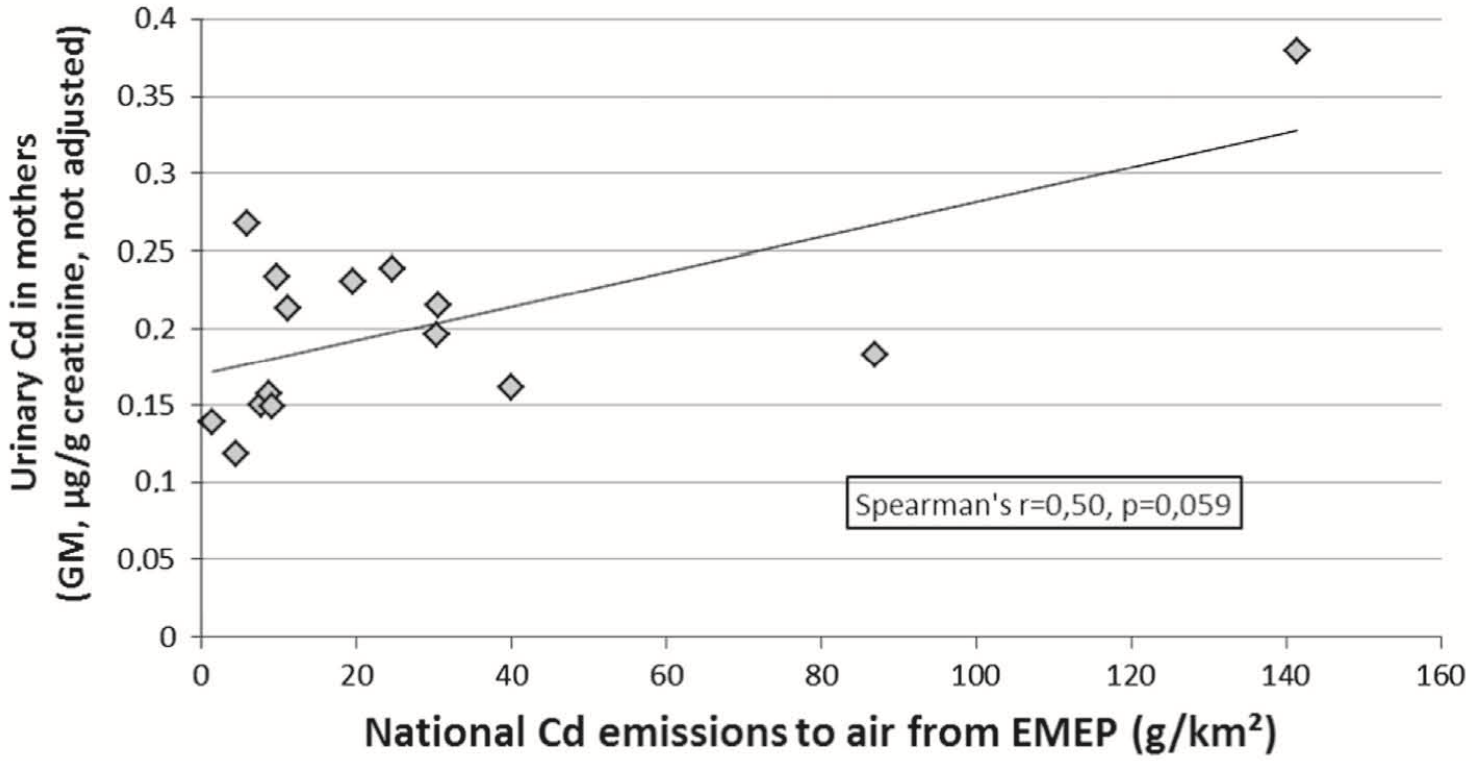

Fig. 2. Relation between nationally reported annual cadmium-emissions and urinary cadmium levels in mothers (most recent EMEP-CEIP data from 2010; no data for Luxemburg).

Figure 2 from Smolders et al 2015 Environmental Research Interpreting biomarker data from the COPHES/DEMOCOPHES twin projects: Using external exposure data to understand biomarker differences among countries141 (2015) 86-95

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COPHES

DEMOCOPHES

Results

Biomarker levels in children and mothers were highly correlated, especially for mercury and cotinine.

Younger children (5-8 years) have higher levels of mercury, cotinine and most phthalates compared to older children (9 - 11 years)

UK results were similar to or below population based reference values published by the US NHANES and Germany's GerES surveys

UK Results were below health guidance values and were of no concern with regards to health.

Den Hond, E., et al. (2015). "First steps toward harmonized human biomonitoring in Europe: demonstration project to perform human biomonitoring on a European scale." Environ Health Perspect 123(3): 255-263

Exley, K., et al. (2015). "Pilot study testing a European human biomonitoring framework for biomarkers of chemical exposure in children and their mothers: experiences in the UK." Environ Sci Pollut Res Int **22**(20): 15821-15834.

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COPHES

DEMOCOPHES

Harmonisation

Tested framework and biomonitoring protocols

Strict quality assurance and control required to guarantee comparable and reliable results

Adaptations to suit national needs without influencing comparability of results

Targeted communication with social science strategies

Capacity building, Training, helpdesk

Environmental Research Volume 141, Pages 1-132 (August 2015) **Harmonized human biomonitoring on a European scale: experiences in seventeen countries** Edited by Dominique Aerts and Ludwine Casteleyn

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Impact

Standardised protocols - Protocols and advice for HBM studies

Database of background exposures - Requests for data

Drive policy-relevant evaluations and recommendations - HBM Framework for policy

World Health Organization
REGIONAL OFFICE FOR Europe

efsa European Food Safety Authority
Committed to ensuring that Europe's food is safe

ECHA
EUROPEAN CHEMICALS AGENCY

European Commission
RESEARCH & INNOVATION

Population exposure assessment validated by biomonitoring

Daniel Middleton

Middleton, D. (2016) Unpublished PhD, University of Manchester, in prep

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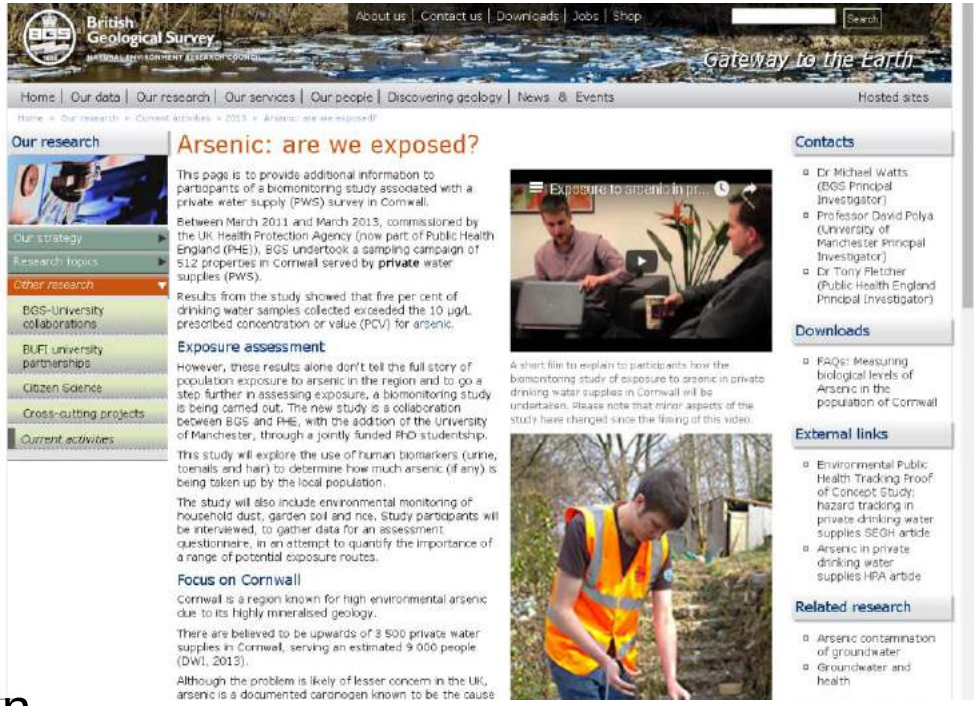
Arsenic in private drinking water supplies

Phase I

Water samples from 497 properties in Cornwall

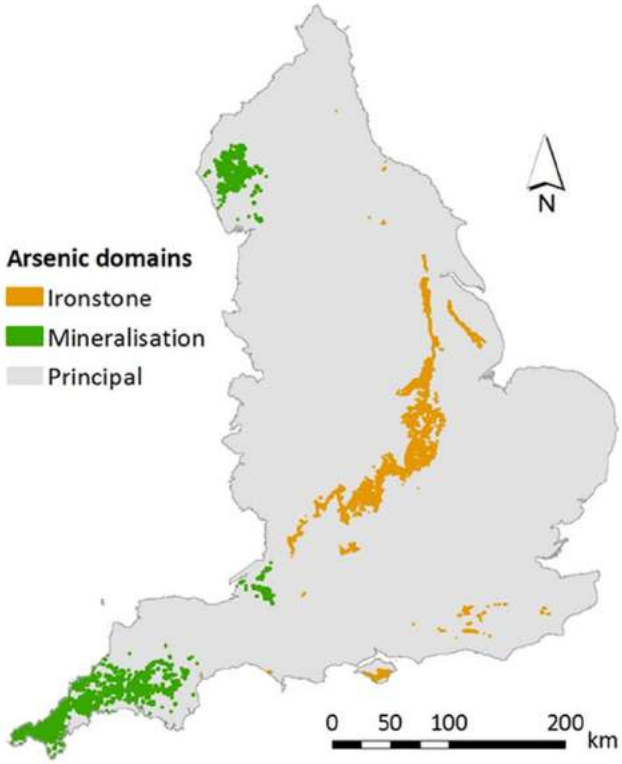
5.5% of tap water samples exceeded the arsenic PCV of 10 µg/L

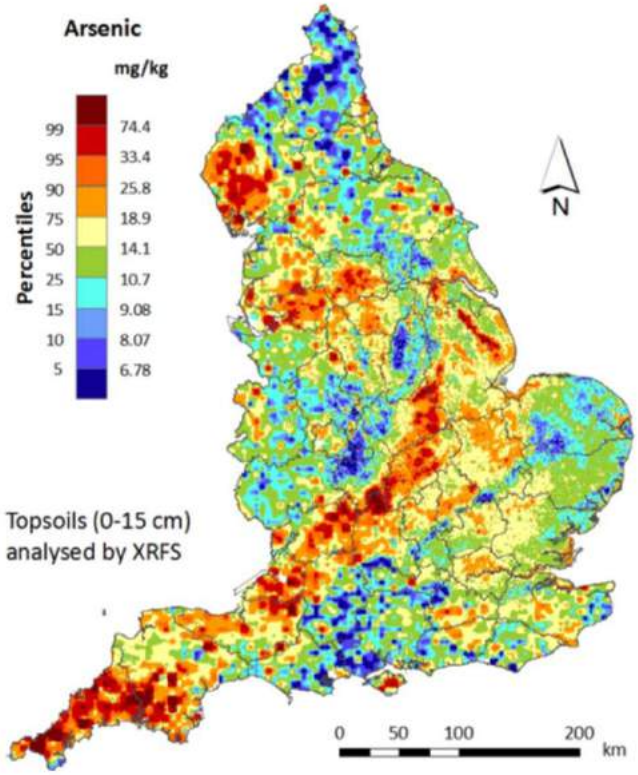


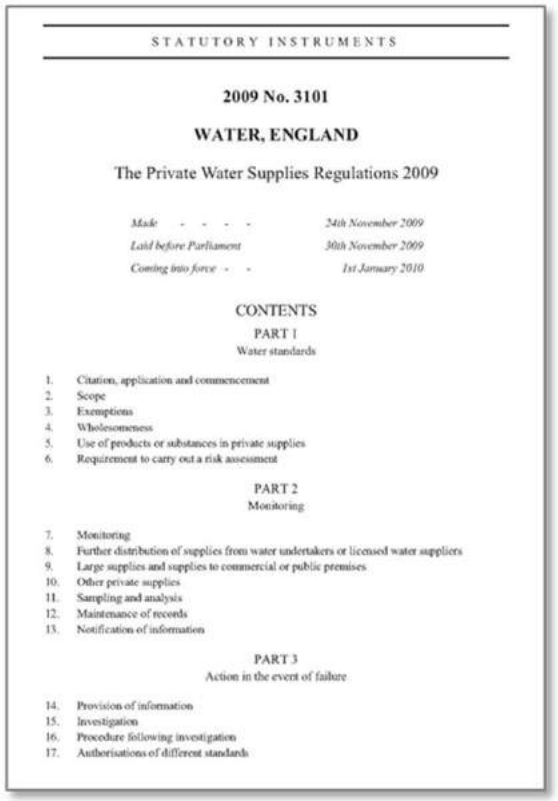
Phase II

Assess the association between arsenic consumption from PWS and biological levels in the study population

http://www.bgs.ac.uk/sciencefacilities/laboratories/geochemistry/igf/Biomonitoring/arsenicSW.html







STATUTORY INSTRUMENTS

2009 No. 3101

WATER, ENGLAND

The Private Water Supplies Regulations 2009

Made - - - - *24th November 2009*
Laid before Parliament *30th November 2009*
Coming into force - - *1st January 2010*

CONTENTS

PART 1
Water standards

1. Citation, application and commencement
2. Scope
3. Exemptions
4. Wholesomeness
5. Use of products or substances in private supplies
6. Requirement to carry out a risk assessment

PART 2
Monitoring

7. Monitoring
8. Further distribution of supplies from water undertakers or licensed water suppliers
9. Large supplies and supplies to commercial or public premises
10. Other private supplies
11. Sampling and analysis
12. Maintenance of records
13. Notification of information

PART 3
Action in the event of failure

14. Provision of information
15. Investigation
16. Procedure following investigation
17. Authorisations of different standards

Elevated environmental As in Cornwall: mineralised geology exacerbated by historical mining.

High PWS usage relative to rest of UK, estimated 2,463 single domestic supplies -5% local population (DWI, 2015).

5.5% Drinking water samples >10 µg/L UK As PCV (2011-2013).

The University of Manchester

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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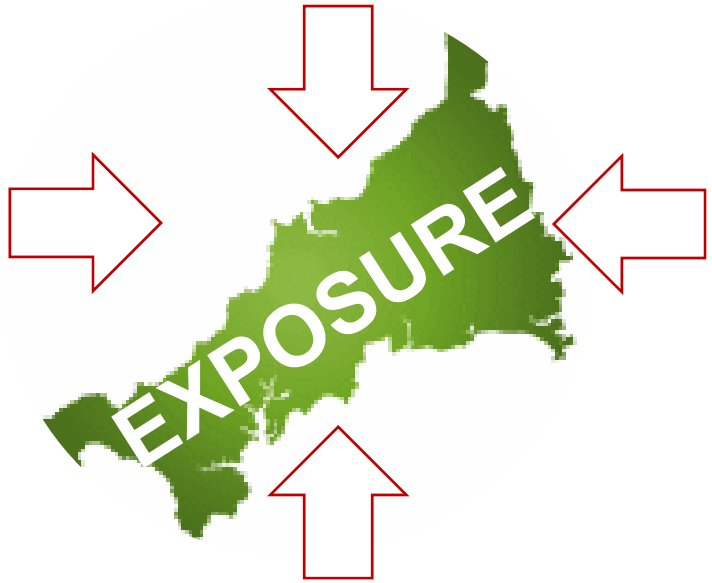
Groundwater consumption

Dust Ingestion/inhalation

Soil ingestion



Rice consumption

Study details

Ethical approval granted by University of Manchester and NHS ethics committees

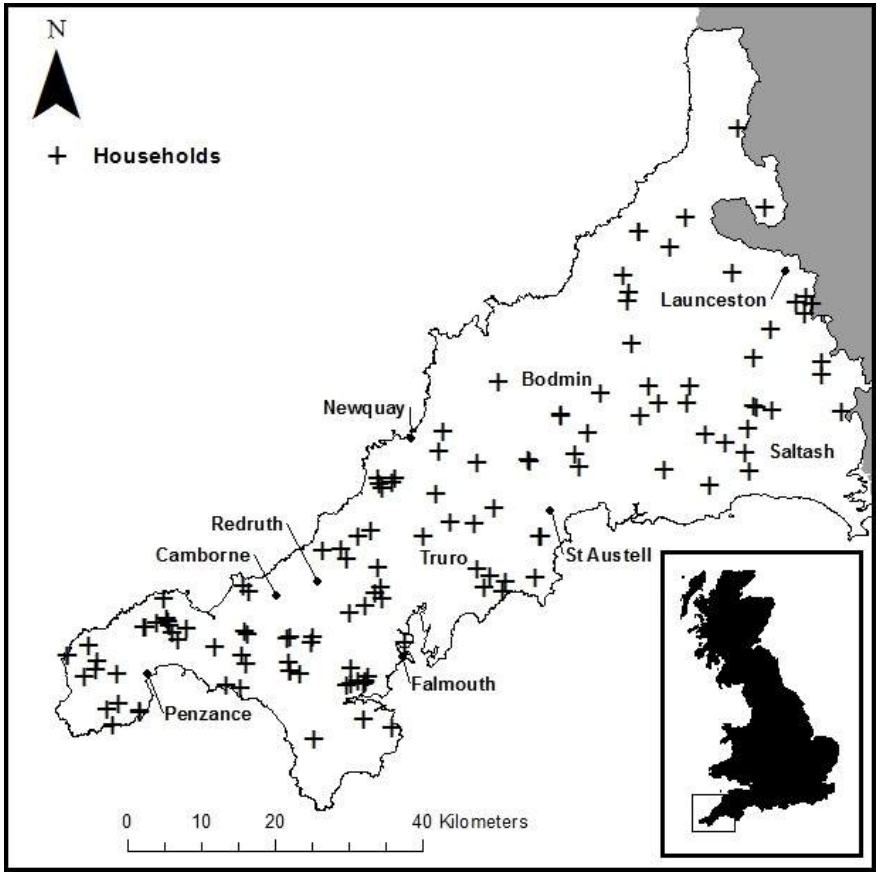
Previous involvement in PWS survey

215 Volunteers recruited via information letter + phone call

Sample collection packs mailed to participants

Biological samples – Urine, hair, toenails

Environmental samples -Point of use drinking water, veg patch/garden topsoil, rice, household dust



Levels of arsenic measured in PWS drinking water

Arsenic speciation in urine samples

Correlation between arsenic levels in urine and drinking water samples

Temporal variation of arsenic in point-of-use drinking water

Summary

PWS users in Cornwall (and likely elsewhere in UK) are exposed to high concentrations of As in drinking water

Geological and population based hazard and exposure modelling will reveal true extent of exposure

Toenail/Hair biomarkers for longer term exposure

Analysis of soil and dust and multivariate statistics will allow quantification of alternative routes of exposure

Long term

Identify at-risk groups – demographically and spatially

Assess the public health burden of As exposure from PWS and other exposure routes in Cornwall

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Linking research to evidence-based policy making

The European Human Biomonitoring Initiative

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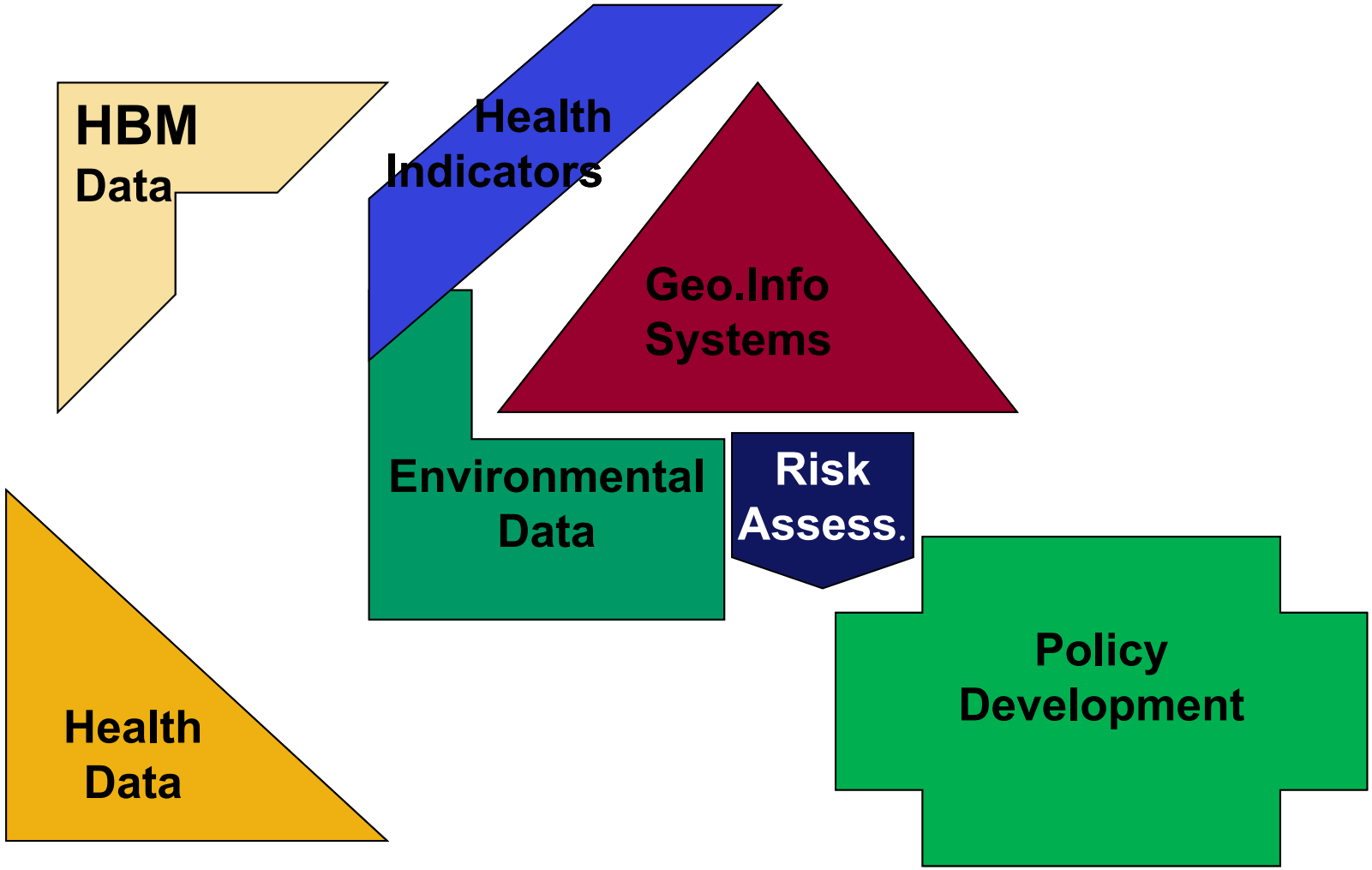
Present- Fragmented approach



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The European Human Biomonitoring Initiative (EHBMI)

Horizon 2020 work programme 8: Health, demographic change and wellbeing

Sub call: SC1-PM-05-2016

Aim:

To create a European joint programme for monitoring and scientific assessment of human exposures to chemicals and potential health impacts

Building on previous activities undertaken at EU and national levels

To create a sustainable and permanent framework

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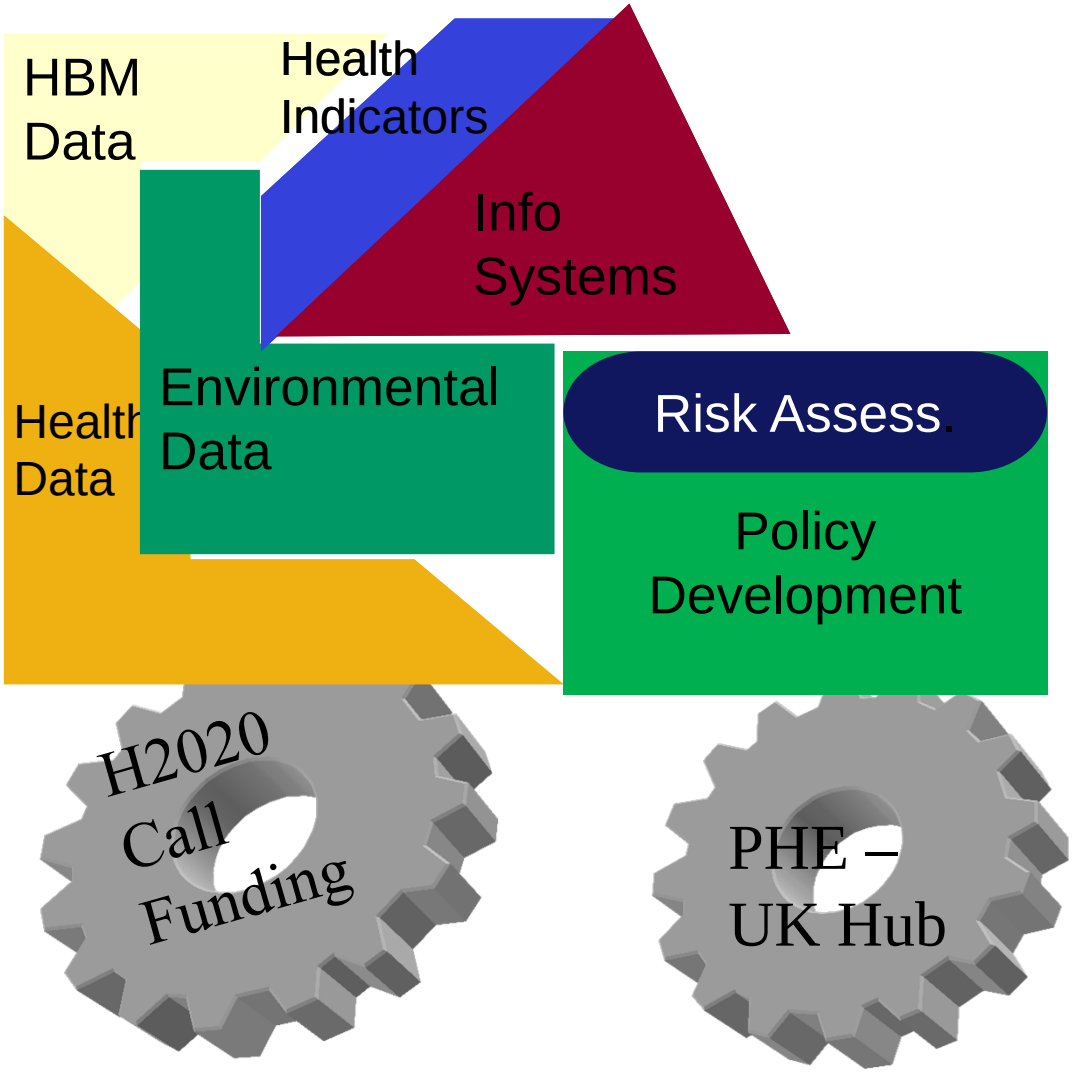
VISION - Integrated Approach - EHBMI



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EHBMI
Science to Policy: Integrated Approach

Coordination of national and EU activities

Focus on linking research to evidence based policymaking

Build on European excellence

Promote capacity building and spread of best practice

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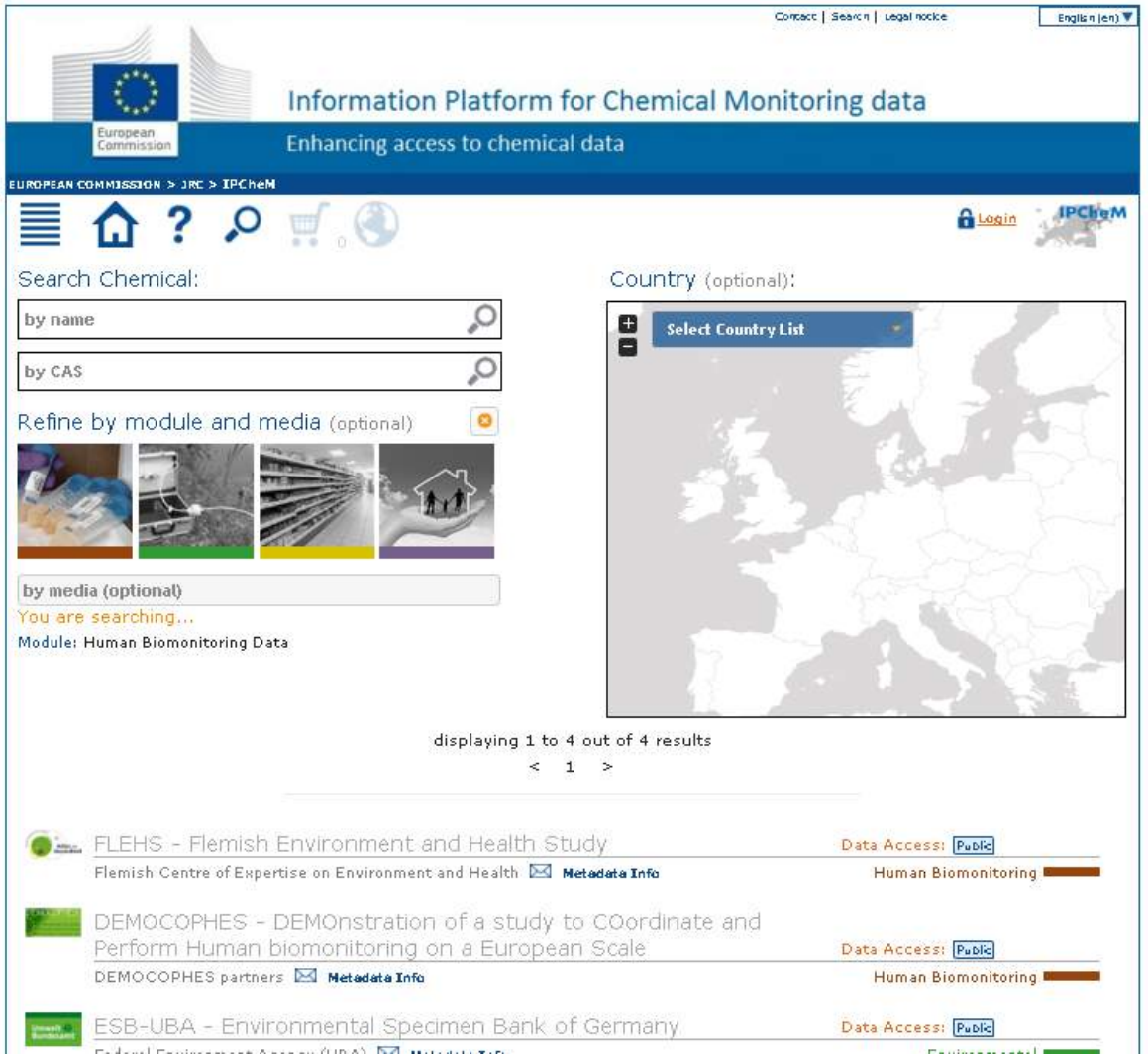
EHBMI Science to Policy: Integrated Approach

Making use of existing data



https://ipchem.jrc.ec.europa.eu/

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EHBMI Science to Policy: Integrated Approach

Support Research and Innovation

Improving methods and procedures

e.g. for sampling, sample analysis, data management and analysis

Understanding the impact of chemical exposures on human health

Development of validated exposure and effect biomarkers

Establishing correlation between biomarker levels and health risks

Improving the use of HBM data in risk assessment of chemicals and mixtures

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EHBMI Science to Policy: Integrated Approach

Integrating environmental and human health data

Integrating many HBM programmes across Europe, National cohorts, epidemiological studies, and health surveys

Evidence for supporting policy makers

Reference values / Background levels
Geographical distribution
Trends – temporal and spatial
Social / ethnic differences
Emerging issues
Monitor existing policies

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First set of prioritised chemicals

Phthalates and DINCH

Bisphenols

Flame retardants

MOCA (used to make polyurethane)

Perfluorinated compounds

Cadmium

Chromium VI

Polycyclic aromatic hydrocarbons (concerning air pollution)

Chemical mixtures and emerging substances

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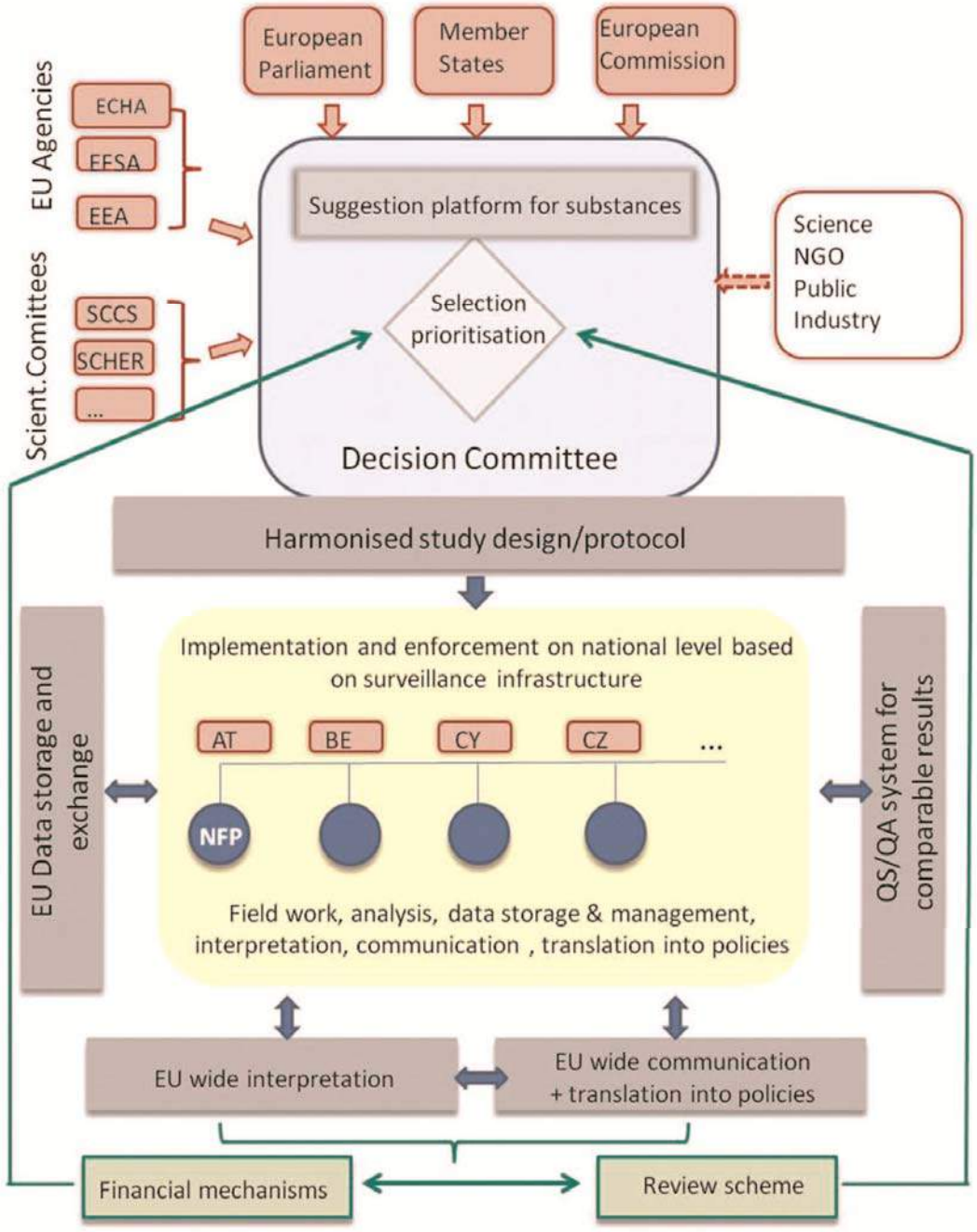
Concept for sustainable HBM in Europe



Joas et al Environmental Research 141 (2015) 42-57

EHBMI - UK involvement

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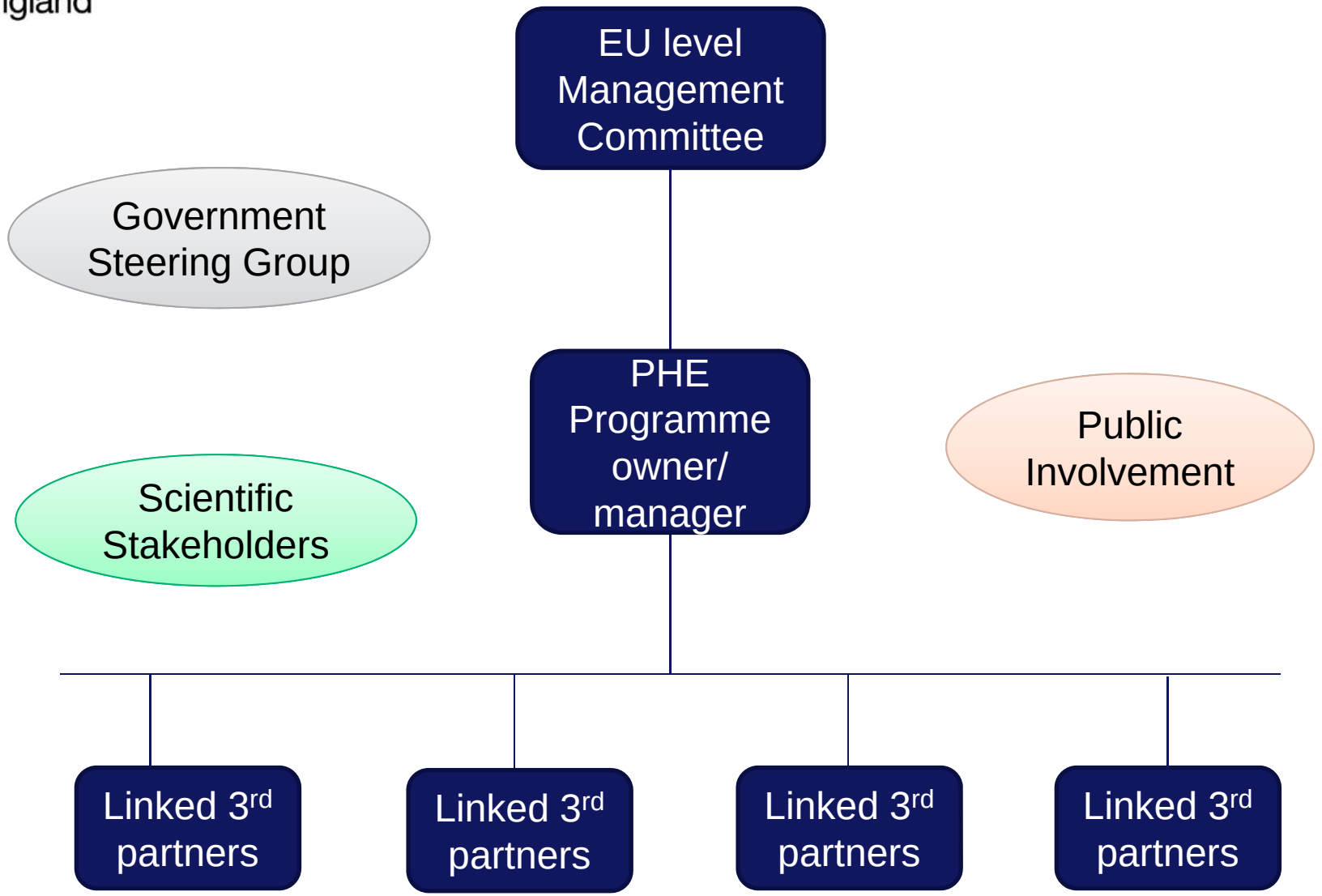

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Summary

- COPHES/DEMOCOPHES demonstrated that a harmonised approach to produce comparable biomonitoring data on a European scale is possible
- In >1800 participants across 17 European countries levels of exposure to cadmium, phthalates, environmental tobacco smoke and mercury was assessed
- Biomonitoring is able to measure integrated exposures within the human body but the presence of a chemical doesn't necessarily mean ill-health
- Biomonitoring alone cannot explain where or how the exposure occurred or the toxic potential for that exposure

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Summary

- An integrated approach is required that uses all data types along the environmental disease continuum for a complete understanding of the public health impact of exposure to environmental chemicals

- The EHBMI will build on the COPHES/DEMOCOPHES experience, and aims to create a more integrated approach to create a sustainable and permanent framework for HBM that will make better use of HBM data in policy legislation and regulation.

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PHE Toxicology department - Ovnair Sepai (COPHES, DEMOCOPHES, EHBMI lead)

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