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THE CONCEPT OF HEALTH AND ENVIRONMENT GEOGRAPHIC INFORMATION SYSTEMS (HEGIS) FOR EUROPE AND REQUIREMENTS FOR INDICATORS

Report on a WHO Consultation

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ENVIRONMENTAL HEALTH MANAGEMENT

By the year 2000, there should be effective management systems and resources in all Member States for putting policies on environment and health into practice.

ABSTRACT

The participants attending the Consultation on the Concept of Health and Environment Geographic Information Systems (HEGIS) for Europe and Requirements for Indicators confirmed that health and environment information systems can be used as a basic tool to assist decision-makers in deciding on the actions needed to improve policy for the integrated prevention and control of environmental health hazards and to abate their negative impact on humans. The need to develop HEGIS for Europe derives from the spatial variations of population density, health status and exposure of people to various environmental factors which exist at both subnational and local levels in different countries. The prerequisite for an operational HEGIS for Europe is the development of national capacities in Member States for systematic monitoring of environmental exposures, a network of health statistical databases at subnational levels, and capabilities for linking these data in order to identify adverse impacts on health. The cornerstone principles of HEGIS were outlined, and a stepwise approach to its development described. The main principles for the application and use of HEGIS on the regional, national, subnational and local levels were discussed. A conceptual model and system configuration were proposed, employing two categories of indicators – relating to exposure and health effects. The participants emphasized that indicators of health impairment, which are collected by Member States on routine basis and compiled at European georeferenced subnational level, are suitable primarily for comparative purposes. Superimposed geocoded environmental information can in some cases be useful as a means of formulating provisional hypotheses about the possible impact of past and present environmental exposures on the health status of the population. Nevertheless, such hypotheses should be tested by properly designed epidemiological investigations. Participants proposed that a methodology for the application of known exposure–response and exposure–effect relationships, obtained from epidemiological investigations, should be developed and tested for purposes of risk assessment and management on the subnational, national and regional level within HEGIS.

Keywords

INFORMATION SYSTEMS
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INTRODUCTION

Health and environment information systems are basic tools for assisting decision-makers to decide on the actions necessary to improve policy for the integrated prevention and control of environmental health hazards. The development of these systems will facilitate the identification of priority issues and risk factors in Europe, the forecasting of trends and the measurement of the impact and cost-effectiveness of interventions required in the Declaration on Action for Environment and Health in Europe of the Second European Conference on Environment and Health, Helsinki, 20-22 June 1994.

In endorsing the establishment of health and environment information systems, the Environmental Health Action Plan For Europe identified the following objectives:

- To improve the relevance, quality and availability of data on various aspects of the environment related to health (e.g. pollutant level in air, water, soil, food, body fluids and tissues) for purposes of situation, trend and impact analysis, as required for national environmental policy development and evaluation, as well as for research purposes.
- For the same purposes as above, to improve the value of mortality and morbidity data by making them accessible at suitably low levels of geographic aggregation and by facilitating the possibility of relating them to environmental and other factors (e.g. occupation, lifestyle) that may contribute to mortality, morbidity or both.
- To develop country-specific environmental health profiles as the basis for developing national priorities for action and for monitoring progress.

The requirement to develop health and environment geographic information systems (HEGIS) for Europe derives from the sub-national and local variations in population density, health status and environmental exposures within the countries of Europe. The prerequisite for an operational HEGIS for Europe is the development of national capacities in Member-States for systematic monitoring of environmental exposures, a network of health statistical databases at sub-national levels, and capabilities for linking health and environmental data, in order to identify adverse impacts on health.

The paramount aims of HEGIS for Europe are to monitor the results of implementing the national environment health action plans within the framework of Environmental Health Action Plan for Europe (endorsed by the Second European Conference on Environment and Health), and to compare the environmental health situation on sub-national level between different European countries according to "Health for all targets".

Development of HEGIS for Europe began in response to a number of WHO Consultations in 1990 - 1993. The Consultation on the Concept of Health and Environment Geographic Information Systems (HEGIS) for Europe and Requirements for Indicators, held in Bilthoven from 8 to 9 November 1994, was organised as a follow-up to these meetings. It brought together experts in information systems, demography, health and environment from different countries, representatives from international organizations and staff members from WHO regional office and from WHO headquarters. The meeting was chaired by Dr M. Kuijpers-Linde; Professor Dr F. Willekens served as Vice-Chairperson and Mr J. T. Wills as Rapporteur. The working papers and the participants are listed in Annexes 1 and 2, respectively.

The main cornerstone principles of HEGIS consist of:

1. Geographic environmental monitoring and health surveillance.
2. Health risk assessment and management of the main known environmental hazards.

A stepwise approach to the development of HEGIS is recommended, as follows:

1. Description of the current state of the environment in relation to health in Europe, at appropriate geographic scales (regional, national, sub-national, local, etc.).
 - 1.1. Identification of the main environmental pollutants; assessment and analysis of the information on the quantity, duration and routes of exposure of the main hazards.
 - 1.2. Determination and assessment of the demographic and health status of the population.
 - 1.3. Determination and analysis of the main socio-economic and lifestyle factors affecting health.
2. Estimation of the health status of the population at appropriate geographic scales in relation to the environment, life style and other relevant socio-economic factors; and identification of "hot spots" of poor health and/or environmental degradation, which might require the development and implementation of ameliorative actions.
3. Linkage of data relevant to health status, environmental pollution, occupational exposure, socio-economic factors and lifestyle both spatially (i.e. at the sub-national scale) and temporally, in order to detect time trends.
4. Formulation of provisional hypotheses with respect to the impact of the known past and present environmental exposures on the health status of the population.
5. Identification, assessment and management of the main risks to the environmental health status of the population, to mitigate or eradicate their hazardous effects and prevent the uncontrolled introduction of new hazards.

Based on the above principles and stages, the following structure for HEGIS is proposed:

Database 1 - Demographic and Health Indicators;

Database 2 - Quantity and Routes of Exposure to the Main Environmental Hazards;

Database 3 - Social, Environmental and Economic Indicators;

Database 4 - Reliable Data from Epidemiological Studies and National-based Population Surveys.

DISCUSSION

Particular issues of concern about the proposed HEGIS and its implications for indicator development are the following:

- uses and applications

- system configuration
- data availability and quality
- indicators

Uses and applications

Knowing these in advance is vital in order to help specify data requirements, levels of aggregation etc., and to match these against the available data. It is also important to be realistic about the potential uses, so that resources are not wasted in developing unwanted capability, and so that users are not disappointed.

It was recognised, however, that uses and users could not be defined precisely in advance of setting up the system: most GIS develop their own uses and users once they are in operation. In relation to the HEGIS for Europe, potential users could be identified as national authorities dealing with the problems in health and environment, governments and international organisations.

In terms of uses and applications, the following principles were agreed:

On the regional (European) level the main functions of HEGIS will be the spatial and temporal comparison of the current environmental health situation at sub-national levels between European countries, with particular reference to "Health for all targets" (in particular targets 18-25); and monitoring changes in environment and health as a result of the implementation of the National Environment Health Action Plans, within the framework of Environmental Health Action Plan for Europe. It should also be used to identify priority issues and risk factors in Europe, to forecast trends, and to measure the impact and cost-effectiveness of the interventions required by international environment policy developments.

On the national and sub-national level HEGIS will aid the description of country-specific environmental health profiles and the forecasting of trends as the basis for: developing national environmental health priorities; facilitating environment health impact assessment; evaluating the cost-effectiveness of interventions, as part of either national or international environmental policy; and monitoring national progress in implementation of environment health action plans.

On the local ("small area statistics") level HEGIS will contribute to attempts to relate information on adverse health effects (e.g. morbidity and mortality data) to environmental and other factors (e.g. occupation, lifestyle etc.), and will act as a useful tool in epidemiological investigations of exposure-response and exposure-effect relationships and environmental impact assessment.

The primary aspects of health and environment geographic information systems on any level also include:

- - policy support (i.e. facilitation in decision-making at local, sub-national, national or/and international levels).
- - a reference information on environment and health;

In the present phase of development, the ability of HEGIS to elucidate new relationships between environment and health is limited. Instead, HEGIS should be used to highlight "hot-spots" of environmental degradation and/or poor health, and to demonstrate patterns and trends

based upon known cause health response relationships. It can also be used to assess and demonstrate the effects of ameliorative policies on the environment and health - e.g. to determine whether health is improving as a result of improvements in the environment, and, if not, to determine what other possible determinants exist and how are they involved in, or interact with, the process.

System requirements

The proposed conceptual model for HEGIS is depicted in Fig. 1.

Health status is dynamic. It is determined both by endogenous (genetic predetermining, acquired characteristics, etc.) and by biological, physical and chemical exogenous factors (e.g. in the working and general environment). These may change in time under the influence of socio-cultural factors (e.g. education, nutrition, lifestyle) and the effectiveness of the health care system.

Basic knowledge about possible adverse health effects of environmental "stresses" is mainly obtained from toxicological experiments. These typically involve studies at high dose levels, which are then extrapolated by a range of different procedures to predict dose-response relationships for humans. Very often people are subject to exposure to a variety of factors. Synergetic or antagonistic interactions between these may increase or decrease the effects compared to theoretical predictions. The situation is especially difficult as far as the general population is concerned, which typically displays marked variations in sensitivity to the factors of concern and which usually exposed to relatively low levels of environmental contamination. Moreover, these effects are often unspecified and may be ascribed to a number of confounding factors.

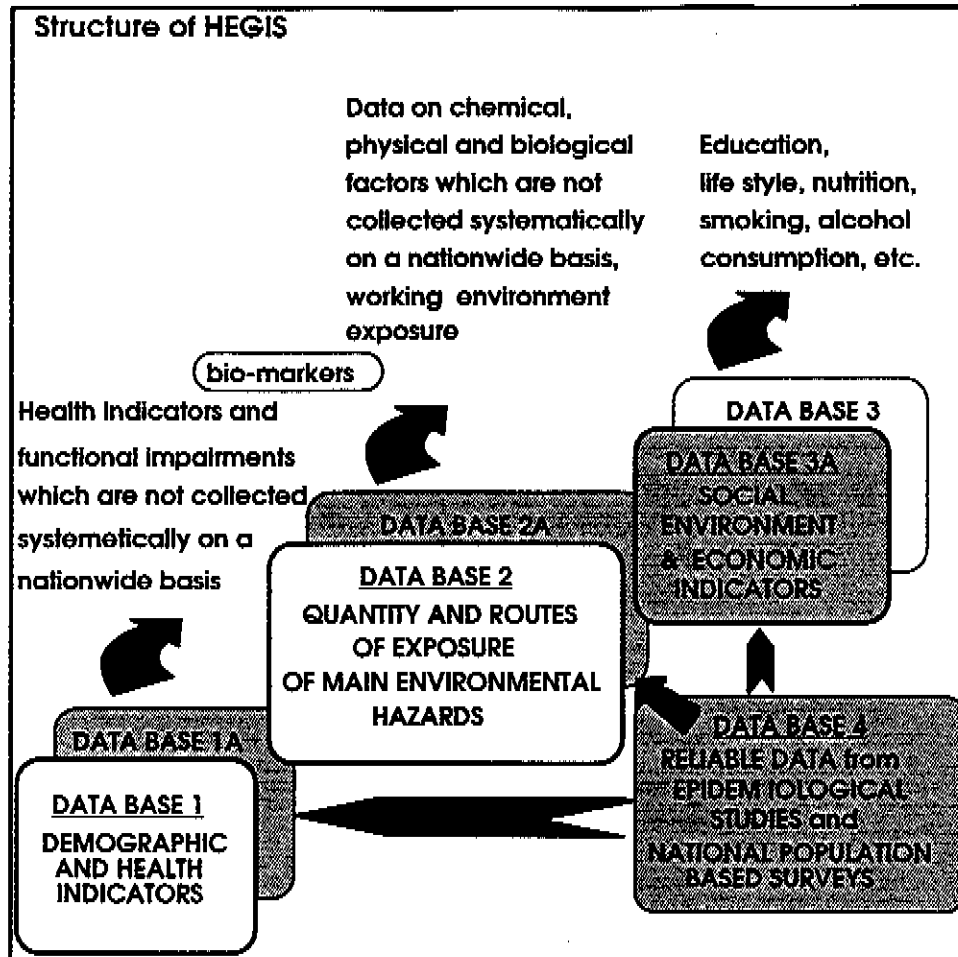
Quantitative risk assessment involves the estimation the risk of a population exposed to a particular hazard at specific doses. Assessments must take account of the uncertainties in both the data and models used. These arise from the many-to-many nature of cause-effect relationships (multiple-cause and multiple-effect cases), and the timeliness of the information (time lags range from almost none to decades).

Health effects in populations represent the end product of a lengthy exposure chain, commencing at the source activity and culminating in exposure in the workplace, residence or general environment. Linkage of environment and health status of a population can be based on information from different points in this exposure chain. Data on biological monitoring provides the key to the estimation of total human exposure by all routes from all sources, and generally gives the early indication of health effect even before functional impairment or diseases occur. Such data are limited in availability, however, so proxies from higher up the exposure chain will often need to be used (e.g. ambient pollutant concentrations, emission rates, etc.).

Data availability and quality

Considerable concern was expressed about the availability and quality of existing environment and health data. Gaps in data availability, inaccuracies in the available data, and lack of comparability of the data all limit what can be achieved with HEGIS.

The quality of data required depends upon the specific application and the level of accuracy needed. Many of the available data are adequate for descriptive applications, but are not suitable for more detailed analytical studies. Full international comparability of data will probably be



achieved in the distant future, but in any case is crucial only in certain circumstances (e.g. for specific comparisons). Generally, different countries can operate in parallel in relation to their own data standards according to their needs.

It is vital, therefore, that the limitations of the data are properly appreciated, and the system not misused for inappropriate purposes with inadequate data. On the other hand, it is important not to become obsessed about the problems of data availability and quality. Often, it is appropriate to do the best one can with the available data, so long as the limitations are borne in mind.

To avoid duplication of effort, it is important that HEGIS is linked into existing procedures and systems for data collection. HEGIS nevertheless needs to be seen within the wider context of work on data collection and environment health initiatives, otherwise there is a danger of duplicating efforts or of running counter to existing trends. There is a need, therefore, to ensure collaboration with relevant partners (e.g. WHO, OECD, UN ECE, EEA). This will help to make more efficient use of the available data, and to encourage new data collection where necessary. On the other hand, it is not feasible or effective to attempt to bring on board all the potential collaborators from the beginning. Instead, if HEGIS is successful, it will attract collaborators who will see the benefits of partnership. Development of the system should therefore start with limited but attainable ambitions and well defined goals. A pilot study - with very specific

objectives - in one or a limited number of countries is likely to be a useful starting point for HEGIS in Europe.

Indicators

Indicators are essential as tools for HEGIS. They provide a means of presenting information in an understandable form, and targeted and interpreted in terms of specific issues. They must have a format which is designed with an explicit target group in mind. An indicator differs from other pieces of numerical information in that it is an element of a specific steering or control process; therefore indicators are specific to the process of which they form a part. The indicators suitable for one function may be totally inappropriate for others.

Because indicators are process-specific, comparability of indicators between countries is only a requirement insofar as the comparison is necessary within the context of an international policy process. For example, without the use of a harmonised core set of health and environment indicators it is impossible to describe actual human exposures as a basis for comparing health status across the European region. In contrast, decision making at the national, sub-national or local level requires more specific data, reflecting the conditions and priorities of the area concerned. Nevertheless, there are likely to be benefits from the use of nationally and internationally comparable indicators at the local level.

Two important characteristics of indicators may be emphasised:

First, an indicator must have a wider significance than its immediate meaning as a measured value.

Second, an indicator is often normative: that is, it is related to an accepted target or reference value and reflects the extent to which policy targets have been achieved. In this way, an indicator helps to provide feedback into the decision-making and control process.

Indicators can be classified in a wide variety of ways. Possibly the most useful distinction, however, is in terms of their intended use, subject and position in the causality (i.e. exposure-effect) chain.

The main uses of indicators in a European HEGIS will be to describe and monitor the environment and health situation in the Region at sub-national level, to forecast trends, to support environment health impact assessment, and to provide information to international programmes for the prevention and control of environmental health hazards.

Identification of indicators by subject or theme of concern should be made according to the priorities laid down in both the Environmental Health Action Plan for Europe and the Declaration on Action for Environment and Health in Europe, adopted at the Second European Conference on Environment and Health (Helsinki, 20-22 June 1994).

The principle priorities are as follows:

1. Contaminated food and water;
2. Ambient and indoor air pollution;
3. Death and injuries from all forms of accidents, including nuclear emergencies;
4. Urban health;
5. Occupational health.

In terms of their *position in the exposure chain*, two sets of indicators for HEGIS may be defined:

Health-Related Environment Indicators (HREIs) - definable environmental conditions or trends which suggest potential harmful health effects. It is desirable that HREIs describe the final phase of a causal chain preceding the health response in question (i.e. biological exposure), though in reality such data are rarely available.

Environment-Related Health Indicators (ERHIs) - health outcomes which suggest an environmental cause, or a contribution from environmental factors. These can be used both to identify the causal factors which require policy intervention, and to assess the health effectiveness of current environmental policy.

On this basis, HEGIS can be used in both directions: to characterise and/or predict health risk, on the basis of available environmental indicators, and/or to identify possible environmental factors responsible for adverse health effects.

Table 1 summarises the tentative list of environment-related health impairments and diseases proposed by the Swedish Environmental Protection Agency in 1993.

Table 1

Tentative list of environment-related diseases (D)	
1.	Cancer (especially lung & skin), group of most interest - children
2.	Respiratory D. (chronic bronchitis, pulmonary emphysema, bronchial asthma, <i>hyperreactivity</i>)
3.	Allergic D. (restricted to atopic allergies and to the symptoms that often occur in connection with atopic diseases, namely asthma, hay fever, conjunctival catarrh and eczema)
4.	Cardiovascular D.
5.	Effects on reproduction (early and late miscarriages, late intrauterine death, neonatal death and combination of these two latter forms, i.e. perinatal death, low and very low weight at birth, various malformations and chromosome abnormalities).
6.	D. of the nervous system (organic psychosyndromes and dementia - Alzheimer D., Parkinson's D., amyotrophic lateral sclerosis, multiple sclerosis, peripheral nervous diseases in combination with polyneuropathy).
Other potentially environment-related diseases (D)	
1.	Skeletal D. (osteoporosis / osteomalatia)
2.	Kidney D. (glomerular & tubular)
3.	Auto - immune D. (glomerulonephritis, rheumatoid arthritis, type I diabetes) and other effects on immune system

Indicators used in HEGIS should reflect the diversity of environmentally-related health effects by quantifying their relative or attributable risks. In this context, the selection of indicators should ideally reflect the environmentally attributable proportion of health outcome.

At the same time, however, the level of uncertainty involved in epidemiologically derived relationships should be taken into account: the duration and levels of exposure, as well as the effect of confounding factors, must all be taken into consideration when estimating impacts of environment on health.

CONCLUSIONS AND RECOMMENDATIONS

It was agreed that there is no single set (or limited group) of indicators which can fully describe environment-health relationships and impacts. Because of the multifactorial nature of health impairment, it was proposed that risk assessment provided the most suitable means of estimating environmental impact on health. This can be based upon both routinely collected demographic and health indicators (e.g. as developed for monitoring 'Health for All' targets) and - where necessary - purpose-built environment health indicators.

It was noted by the participants that HEGIS had undergone a long process of development, and that implementation should now take priority. The joint WHO/ ECEH/EURO- UN ECE- CBS- RIVM project "Spatial Patterns of Mortality at Sub-national Level in Europe" and the Database on the Main Air Pollutants in Europe, available at ECEH (Bilthoven Division) provide a suitable starting point in this respect. These data will be updated every 5 years by collecting relevant data at sub-national level from Member States and/or international organisations.

It is recommended that HEGIS operate on several levels: description of the environment and health situation at the broad, pan-European scale; and through in-depth pilot studies using the HEGIS methodology in smaller geographic areas. It should be noted that the "Trilateral Cooperation for the Application of HEGIS in Assessing Regional Environmental Health Problems" (a transfrontier project between Austria, Hungary and Slovak Republic) is an important example of HEGIS at the latter level.

Because experience with using a geographic information system for superimposing and comparing health and environment data at the international scale is limited, the interpretation of results derived from HEGIS should be undertaken with care. The conclusions and recommendations of the Consultation on Development of a Health and Environment Geographic Information System for the European Region (Bilthoven, 10-12 December 1990) and of the Consultation on Data Requirement and Methods for Analysing Spatial Patterns of Disease in Small Areas (Rome, 20-24 October 1990) should be adhered to.

It was emphasised that routinely collected data on mortality, morbidity other derived indicators of health impairment at the European level should be used mainly for the purposes of description. The integration of these health data with geocoded environmental information may in some circumstances be used to suggest provisional explanations for the perceived variations in health status. It was emphasised, however, that such hypothesis should be based upon known disease aetiology and should be validated through properly developed epidemiological investigations. For the purposes of quantifying the impact of environmental hazards on health, information on population density, duration and intensity of exposure should all be available. This requires the development, evaluation and testing of appropriate methodologies.

In view of the constraints on resources, and to avoid duplication of effort, it was proposed that collaboration should be sought with other United Nations agencies and international organisations (OECD, EEA etc.), in the acquisition of data and the application of the system.

To help establish environment-health priorities, HEGIS should provide for assessments of chronic exposure to hazardous factors, as well as acute and sub acute exposures. In this context, the use of other information systems (e.g. the CARE I, II systems on early response to the outbreak of food-born or communicable diseases) could be useful.

The core set of Environment-Related Health Indicators (ERHIs), to be collected on a routine basis by Member States, should be developed. Appropriate levels of aggregation should be defined for the purposes of assessment of possible environmental health impact, comparison between countries, and further priority setting in the European Region.

The core set of Health-Related Environment Indicators (HREIs) to be used in HEGIS, should similarly be collected on a routine basis by Member States. Appropriate levels of aggregation should also be defined for health impact assessment.

Methodologies for the application of known exposure-response and exposure-effect relationships (obtained from epidemiological investigations) should be developed and tested for risk assessment and management at the sub-national, national and regional levels within HEGIS.

*Annex 1***WORKING PAPERS AND BACKGROUND MATERIAL***Working papers*

ICP/CEH 257/6 Concept: Health and Environment Geographic Information System for Europe (HEGIS).
by Dr Alexander Kuchuk

ICP/CEH 257/7 Requirements to indicators to be used in HEGIS.
by Dr Alexander Kuchuk & Mr Robert Merineau

Background material

ICP/CEH 087/A Consultation on Data Requirement and Methods for Analysing Spatial Patterns of Disease in Small Areas, Rome, 20-24 October 1990

ICP/CEH 090/A Development of a health and environment geographic information system for the European Region, Bilthoven, 10-12 December 1990

EUR/ICP/CEH 246 Environment and Health Indicators for Use with a Health and Environment Geographic Information System (HEGIS) for Europe, Bilthoven, Netherlands 11-13 March 1993

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An Overview of Environmental Indicators. State of Art and Perspectives. Nairobi, UNEP, 1994, by J. A. Bakkes et al.

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