Environmental Health Information Management:  
Selected Developments of Potential Relevance for the  
European Perspective

Rainer Fehr¹

Abstract
The science and practice of Environmental Health aims to promote and protect health via environmental pathways. Programmatic documents, e.g. from the European Ministerial Conferences on Environment and Health 1989-99, leave no doubt about the strategic role of information management. This paper outlines Environmental Health reporting and Health Impact Assessment as two complex examples. The role of an adequate structure model (here: WHO’s DPSEEA) as an integrative tool across individual tasks is underlined. As for reporting, the temporal trends concerning groups of regions can usefully support benchmarking; efforts towards standardization are worth-while. In Health Impact Assessment, a major challenge refers to making best use of available information for predicting and assessing exposures and health effects prospectively. Other fields of information management include inquiry systems, visualization, and derivation of quantitative health targets. Generic concepts and specific solutions of Environmental Health information management in a European perspective deserve in-depth exploration.

1. Context
Globally and locally, the environment and human health are interacting in numerous ways, some of them being straightforward and others highly complex (cf. Wichmann et al. 1992, Seidel 1996). The science and practice of Environmental Health aims to investigate these interrelations, to understand the dynamics, and to promote and protect health via environmental pathways.

Practitioners of Environmental Health face a multitude of tasks which can conveniently be structured according to the Public Health triad (IM 1988), i.e. assessment, policy development, and assurance (Fig. 1). Environmental Health poses a major challenge to interdisciplinary cooperation. Under the headline of „Ecologic health

promotion an attempt was made to provide a comprehensive framework for the multitude of diverse tasks and activities (Fehr 2001).

<table>
<thead>
<tr>
<th>Environment</th>
<th>Assessment</th>
<th>Policy development</th>
<th>Assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental monitoring, surveillance; Environmental impact assessment (EIA)</td>
<td>Environmental protection, environmental plans and programs</td>
<td>Environmental information management, environmental education &amp; training</td>
<td></td>
</tr>
</tbody>
</table>

| Environmental Health (EH) | Assessment: EH monitoring, surveillance; EH impact assessment (EHIA) | Policy development: EH protection and promotion; national EH action plans (NEHAPs) | Assurance: EH information management, EH education & training |

| Health | Assessment: Health monitoring, surveillance, Health impact assessment (HIA) | Policy development: Health protection and promotion; health plans and programs | Assurance: Health information management, health education & training |

Fig. 1: Overview of ecologic health promotion (shaded area), located at the intersection of environmental vs. health-related activities

A number of international conferences has addressed, inter alia or exclusively, Environmental Health concerns, e.g. the UN Conference on Environment and Development in Rio 1992 and the European Ministerial Conferences on Environment and Health in Frankfurt 1989, Helsinki 1994 and London 1999. **Agenda 21**, the main document resulting from the Rio conference (UN 1993) explicitly deals with human health, prominently in chapter 6, “Protecting and Promoting Human Health” and also throughout the document. The Helsinki conference agreed that the European countries would prepare and implement national Environmental Health Action Plans (NEHAPs). These and related documents leave no doubt about the strategic role of information management.

2. **Environmental Health information management and the DPSEEA structure model**

Environmental information is often structured into the components pressure – state – response (PSR). Extensions of this model include driving forces (D) and/or impact (I) as, e.g., in the DPSIR model. The prerequisite for any health-related effects, however, to occur is exposure. In the mid-1990s, the World Health Organisation (WHO) therefore developed a simple but powerful structure model including the six elements
Driving force, Pressure, State, Exposure, Effect, Action (Fig. 2) and named it DPSEEA (Corvalán et al., 1996).

<table>
<thead>
<tr>
<th>D = Driving force</th>
<th>Population growth, economic development, technology, globalisation</th>
<th>Economic &amp; social policy, clean technologies</th>
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<tbody>
<tr>
<td>P = Pressure</td>
<td>Production, consumption, waste release</td>
<td>Hazard management, clean technologies, recycling</td>
</tr>
<tr>
<td>S = State</td>
<td>Natural hazards, resource availability, pollution levels</td>
<td>Environmental improvement, clean-up and remediation procedures</td>
</tr>
<tr>
<td>E = Exposure</td>
<td>External exposure, absorbed dose, target organ dose</td>
<td>Education awareness raising, exposure mitigation and avoidance</td>
</tr>
<tr>
<td>E = Effect</td>
<td>Well-being, morbidity, mortality</td>
<td>Treatment, detoxification</td>
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<tr>
<td>A = Action</td>
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Fig. 2: DPSEEA model (modified after Corvalán et al. 1996, 28)

From the universe of Environmental Health information management, this paper outlines two current strands of development: Environmental Health reporting, and impact assessment. A few remarks on other developments are added.

3. Environmental Health reporting

The Public Health laws of several German states require local status analyses to be prepared on a regular basis. Such reports can include Environmental Health issues. The challenge is – with limited resources – to accurately observe and analyze the current situation, to prioritize problems and to derive conclusions which will support (and possibly help to evaluate) local policy-making. Typically, the reporting is largely based on existing information from both the environmental and the health sector. From this background, an expert status report was prepared on behalf of the Office of Technology Assessment of the German Bundestag (Fehr & Vogt 2001). Several recent examples of reporting are available, espec. on transport, environment and health (Hellmeier & Huhmann 2002).
A recent project investigated the opportunities and limitations of local environmental health surveillance and reporting, and prepared a generic concept (Vogt 2001) which was then applied to transport-related impacts on health and environment in the city of Bielefeld (pop. 321,000). Methods include the spatial and temporal analysis of selected quantitative indicators concerning "pressures" originating from the local transport system, the state of the environment, human exposures to noise, pollutants, and hazardous physical energy, and health events / health status of the population. Following an example of WHO (1997), the DPSEEA model was used to structure the whole analysis in a novel way. We hold that this approach is universally applicable and should be useful for supporting policy-making in widely different administrative and political contexts.

<table>
<thead>
<tr>
<th>D = Driving force</th>
<th>City population dynamics; selected programs incl. health coordination, environmental programs, Agenda 21</th>
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<tbody>
<tr>
<td>P = Pressure</td>
<td>Local transport development, transport-related emissions, consumption of resources</td>
</tr>
<tr>
<td>S = State</td>
<td>Outdoor air, ground &amp; drinking water, soil, food, noise; aspects of health care system</td>
</tr>
<tr>
<td>E = Exposure</td>
<td>Exposure to chemicals in air, water, soil, food; noise; exposure to uncontrolled mechanical energy (crashes); hazardous goods</td>
</tr>
<tr>
<td>E = Effect</td>
<td>Health effects of noxious agents; school health; injuries; morbidity and mortality</td>
</tr>
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</table>

Fig. 3: DPSEEA model and Environmental Health reporting: Contents of a report on transport & health for the City of Bielefeld (Stadt Bielefeld et al. 2001)

One of the report’s key features is to provide systematic, quantitative comparisons of the city of Bielefeld with 22 comparable other cities located in the same state.

Taking the example of Diesel soot emissions, Bielefeld, with 121 metric tons, occupied rank no. 8 in 1994. Three years later, emissions were remarkably lower everywhere. The reduction of Diesel soot emission in Bielefeld over this 3-year period was 51%. This value represented rank no. 16 of the 23 cities, i.e. 15 cities were more successful in emission reduction (up to 67%) while 7 cities were less successful than Bielefeld.

Other examples refer to non-fatal (Fig. 4) and fatal injury rates (Fig. 5). For a period of 11 years, the data for 23 large cities in this state were compared. Using non-fatal injuries as a starting point, we identify Cologne as a priority region with a critical time trend, and Mülheim as a low-risk region. As for non-fatal injuries, the situation in Bielefeld (not emphasized in the diagram shown here) compared to the 23 cities' average has slightly improved over time, and the most current data show the rate
in Bielefeld to coincide with the mean value. Fatal injury rates, due to small overall numbers, are generally rather unstable in the 23 cities.

Fig. 4: Non-fatal injuries in 23 cities in North Rhine-Westphalia. Injured persons / 100 000 pop, by year 1988-98. Emphasized lines: top = Cologne; mean; bottom = Mülheim/Ruhr

Fig. 5: Fatal injuries in 23 cities in North Rhine-Westphalia. Deaths / 100 000 pop, by year 1988-98. Emphasized lines: top = Cologne; mean; bottom = Mülheim/Ruhr
An important lesson learnt refers to the DPSEEA structure model which was perceived as advantageous by the participating institutions. The model helped to integrate the different transport impacts on air, water, soil and food as well as subsequent exposures and potential health effects into a unified framework. Benchmarking information was identified as important input for priority-setting; this tool deserves efforts towards (moderate) standardization.

The report contains specific recommendations concerning policy-making, and additional ones on the further development of regional Environmental Health analyses. The former set includes the following recommendations: Existing outdoor air limit values for diesel soot, benzene, and ozone should be enforced locally; it seems advisable to implement a monitoring program of food items sold in gas stations; transport-related soil pollution needs further investigation; noise abatement should receive priority consideration in city planning; the "modal split" should be influenced towards public transport.

Selected conclusions and recommendations for the further development of Environmental Health analyses include the following: The DPSEEA structure model was found useful, especially for integrating the work of different sectors and disciplines; and there is a need to improve the linkage of environmental & health reporting activities with the city’s planning authorities.

Approaches towards supporting policy-making by local Environmental Health analyses can only be successful if there is continuity of reporting efforts. While the city’s existing programs such as Local Agenda 21 and their respective indicator systems were taken into account for the current analysis, there is still room for closer coordination of related efforts.

4. Health Impact Assessment

For the protection of human health it is useful not only to analyze past and current trends but also to predict and assess the impact of future developments (Kobusch et al. 1997). For environmental issues, this is routinely done in the framework of Environmental Impact Assessment (EIA). In theory this should include human health effects, but in practice this is often not the case. Recent efforts, mostly coordinated by the World Health Organization, therefore aim at the development of Health Impact Assessment (HIA) which should – depending on circumstances – be implemented both within EIA and as an independent procedure.

According to a recent consensus paper, HIA is a combination of procedures, methods and tools by
which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population (WHO-ECHP 1999). Projects to be subjected to HIA include extensions of airports, highways, and waste facilities. There is increasing focus on “strategic” HIA of plans, programs, policies, e.g. transport planning or agricultural policy. According to Art. 152 of the Amsterdam Treaty of European Union, “a high level of human health protection shall be ensured in the definition and implementation of all Community policies and activities”.

Main components of HIA are: screening (where is HIA needed?), scoping (what aspects to include?), prediction (“what - if” analyses), value judgement, participation, communication, and evaluation. As for prediction, HIA methods include: educated guesses, informed opinion, expert opinion, rating; analogy (similar situations); meta-analysis, systematic review; modeling, risk assessment, and computer simulation. A selection of HIA tools includes the following: checklists, matrices, mathematical models, PC programs for risk assessment, geographic information systems (GIS), inquiry systems, factual databases, reference data, and exposure factors compendia.

<table>
<thead>
<tr>
<th>D = Driving force</th>
<th>Projected waste disposal trends; affected populations incl. vulnerable persons (young, sick)</th>
<th>Anticipated future transport &amp; traffic needs; affected populations incl. vulnerable persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = Pressure</td>
<td>Discharges of (in)organic gas incl. carcinogens, of odors, noise (from trucks delivering waste), microbes, fungi; leachate</td>
<td>Emissions of chemicals (benzene, soot, NO₂, CO, etc.), noise, vibrations; injury hazard from traffic crashes</td>
</tr>
<tr>
<td>S = State</td>
<td>Rural county with four villages in the vicinity of the waste disposal site; land-use mostly agricultural; contaminated sites</td>
<td>Study area A: mixture of agricultural use and residential area; study area B: inner-city area, to be partially relieved from traffic</td>
</tr>
<tr>
<td>E = Exposure</td>
<td>Predicted air pollution concentrations for receptor points, additional noise burden and numbers of persons exposed</td>
<td>Using various receptor points, increased noise exposure in area A, incl. senior citizens' home; moderate reduction in area B</td>
</tr>
<tr>
<td>E = Effect</td>
<td>Risk assessment (pathways: air, soil, dermal, meat, milk, water, fish): additional lifetime cancer risk, estimated cancer burden</td>
<td>Simplified analysis (benzene, Diesel soot): no noticeable increase of cancer risk in area A, potential slight reduction in B</td>
</tr>
</tbody>
</table>

Fig. 6: DPSEEA model and HIA: Selected aspects covered in two examples of project HIA (Fehr 1999)
Again, the DPSEEA model offers an appropriate framework to structure the multitude of informations involved in HIA. Some selected aspects are summarized in Fig. 6; this is based on two examples of a 10-step procedural approach being applied to project HIA (Fehr 1999).

In England, the Department of Health funded a series of case studies across the country, and the Scottish Office’s Department of Health supported a research programme on HIA (Abrahams 2002, 57). An audit of HIA activity across the United Kingdom in 1999 showed that 15 out 123 (12%) health authorities had either undertaken or were planning to undertake an HIA. In the Netherlands, HIA so far is a rather loosely defined concept with different meanings among different groups of professionals (Lebret 2002, 64-5). For public health professionals it is primarily associated with the so-called “Gezondheid Effect Screening” of (govermental) policy. A special form of HIA is emerging from the proactive approach of health care development for victims of large scale (man-made) disasters. The different forms of HIA vary considerably but share the forward-looking perspective and the orientation toward the support of policy decisions.

In Germany, the Federal Institute for Consumer Protection and Veterinary Medicine initiated an HIA workshop under the National Environmental Health Action programme (NEHAP) (Welteke & Fehr 2002). This German NEHAP is supported both by the Federal Ministry of the Environment, Nature Conservation and Reactor Safety and by the Federal Ministry of Health; one major objective is to improve the dialogue and joint actions between the environmental and health sector.

With HIA still being at an early stage of development, preliminary quality criteria include the following: transparency making it possible to follow the various steps of the assessment; objectivity implying that different investigators would reach similar results; model validity confirming that the models used in the assessment have been evaluated and have been found to perform well; integration of agents, media, pathways, effects, risk & benefits. The latter goal would profit, e.g., from integration of impact of various agents; integration of environmental media and exposure pathways for a given noxious agent; integrated coverage of complete life-cycle of projects, etc.; and adequate summarization of different health effects.

5. Other fields

An important routine field of information management refers to the systematic, ongoing provision of Environmental Health information, as exemplified by the Noxious Agents Information System “NIS” (Kohn-Schulze et al. 2001). Quality criteria for such inquiry systems include data quality (assured by peer-review procedures), timeliness, breadth and depth of information, user-friendliness, and appropriate cost-benefit ratio (Fehr 1993, 182-3). Advanced information management is required to
support the specialized methodology of Quantitative Risk Assessment (QRA) (Nolte et al. 1998).

Challenges continue to arise in the field of adequate visualization of Environmental Health information. In a joint project with the Artificial Intelligence as well as the Visualization Laboratory at the University of Bielefeld, a project sought to create a highly interactive virtual environment of modelled acoustic data in order to sensitize and improve human decision-making (Börner 1997; Fehr et al. 1998). Ideally, regional fluxes of matter and energy (cf. Baccini & Bader 1996) and the subsequent exposures and impacts on human health would be visualized, e.g. to support HIA procedures as outlined above.

A final example refers to the derivation of Environmental Health targets from empirical geo-socio-demographic data (Fehr 2001, 75-82). The variables included in this analysis were geographic latitude, population density, mortality rate, fraction of students graduating from highschool, and regional economic status. Based on data for 445 cities and counties in Germany, we conducted a regression analysis using all-cause mortality as an outcome variable of high Public Health significance. The residuals served as a basis for identifying „good performers“ vs. „problem areas“. Results contrasting the predicted rates vs. observed rates are shown in Fig. 7.

Fig. 7: Observed vs. predicted mortality rates for German cities and counties, 1994; residuals serving as a basis for identifying quantitative health targets
6. Conclusions

As explored in the EU-funded pilot project on Environmental Health Information Management (EHIM) (Prätor et al. 1997), a wide range of challenges is still unmet. A topic of special concern is the role of information management as a key factor for success or failure of „integrated programs“ such as Agenda 21, „Healthy Cities“, and National Environmental Health Action Plans (NEHAPs) (cf. http://www.uni-bielefeld.de/gesundhw/ehp/home.html). In this context and beyond, the quest for generic concepts and specific solutions of Environmental Health information management in a European perspective deserves in-depth exploration.

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Bibliography


