CARTOGRAPHIC ASPECTS OF HEALTH DATABASES VISUALIZATION IN GLOBAL CONTEXT

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Abstract

One of the most important visions of Digital Earth is global sharing of knowledge and data. International databases should be accessible to users from the rest of the world and databases should be coordinated to avoid duplication of any data or discrepancy of values among databases. Transformation of the Earth into a "global village" brings advantages and disadvantages. One of possible risks is a pandemic outbreak of a contagious disease. Decision and reaction must be undertaken in short time.
For good decision relevant data and information is necessary. Nowadays, there are many databases of international health data. The following part of the paper describes databases of the most important health data providers. Databases of WHO, OECD, IARC and Eurostat are compared. It is analyzed if they are not in discrepancy and how it is possible to combine data from various databases.
Cartographic visualization can be effectively used for better data analysis, exploration, and for complex understanding of the situation. Spatial analysis is much easier in the map than in the table. But creation of a health map has certain rules which must be accepted to produce a good map. The description of these rules is in the third part.
Selected significant world providers offering cartographic interfaces are further mentioned. There are differences between them in possibilities offered to user, in technology used, and in quality of provided maps. The comparison of attitudes and cartographic techniques is given on the base of aforementioned databases.
The last part of this article is dedicated to description of Global Health Information Infrastructure (GHII) proposal which could fulfil the Digital Earth vision about knowledge sharing in the realm of health care and health status. Potential components, existing initiatives, and future prospects are proposed.

Keywords: *health databases, health cartography, health data infrastructures*

DIGITAL EARTH IN HEALTH SERVICES – SHARING OF KNOWLEDGE AND DATA

"Digital Earth is comprised of a corresponding set of... ...systems, which are fully integrated to provide a framework to support international cooperation for global sustainable development... ...and social wellbeing" (ISDE 2010). One of the most important visions of Digital Earth is global sharing of knowledge. International databases should be accessible to users from the rest of the world and databases should be coordinated to avoid discrepancy of values among databases.

Pandemic danger for a global village

Transformation of the Earth into a "global village" brings advantages and disadvantages. One of possible risks is a pandemic outbreak of a contagious disease. Nowadays it is possible to travel from one continent to another in a few hours. In this situation it is very difficult to stop spreading of any epidemic. In the pandemic situation decisions and reaction must be undertaken in short time. Accessible and accurate data is requirement for an accurate decision.

Dangerous trend of lifestyle diseases

Not only pandemic outbreaks but also lifestyle diseases are the threats for a modern society, economy and wellbeing. The well-known examples are cancer, diabetes etc. It is estimated by the IARC Lyon Globocan database that 10.8 million new cases of cancer were diagnosed worldwide in 2002. In the same year 6.7 million people died. The situation in the Czech Republic is no brighter. Data from the Czech National Cancer Registry predict that the number of cancer cases will increase year to year. In 1989 the figure was 71,000 in men and 103,000 in women, in 2005 it was 189,000 in men and 272,000 in women and nearly 752,000 in both gender is predicted in 2015 (Konecny et al. 2008). It means 6,037 cancers per 100,000 men and 8,033 per 100,000 women as the expected ethic and economic burden of the Czech population. About 30% of them are confronted with cancer during their lifetime and 25% die for it. The incidence of some cancer diagnoses is moving to younger age groups (Geryk et al. 2008). Very similar (= dangerous) situation are in diabetes and other lifestyle diseases. These little fortunate results are connected with the late detection especially of cancers and worse prognosis of their therapy in view of other subsequent neoplasms (Geryk et al. 2010).

The phenomenon places stress on the health care system. A higher number of cases needs greater expenditure on health care – 300 million Euros were accounted for by all cancers in 2005, according to Czech cancer sites. The state budget, however, is not increasing as quickly as the number of cancers, diabetes or other diseases. The situation is like a time-bomb, and there is only one possible answer. We have to support people to change their lifestyle and to use prevention. Early recognition of cancer increases probability that therapy will be successful and cheaper. We must inform the general public about the problem and the possibilities (Stampach et al. 2010, 1).

MOST IMPORTANT INTERNATIONAL HEALTH DATA PROVIDERS

For good decision relevant data and information is necessary. Nowadays, there are many databases of international health data. This part describes databases of the most important health data providers – WHO, OECD, IARC and Eurostat. Information summary of various sources (link, available spatial and temporal extent) is in Table 1.

Table 1: Basic information about accessible international health data sources.

Name	Link	Region, Number of Countries [1)]	Level of Regions	Years [2)]
WHO	**http://www.who.int**	World		
WHO Statistical Information System	http://www.who.int/whosis/en/	194	state	1990-2008
WHO Global Infobase Online	http://www.who.int/infobase	194	state	various
WHO/Europe	**http://www.euro.who.int**	Europe + Central Asia		
European health for all database	http://www.euro.who.int/hfadb	53	state	1970-2008
European detailed mortality database	http://data.euro.who.int/dmdb	36	state	1990-2008
European hospital morbidity database	http://www.euro.who.int/InformationSources/Data/20061120_1	26	state	1999-2008
European mortality database	http://www.euro.who.int/InformationSources/Data/20011017_1	53	state, NUTS 2 (12 states)	1980-2008

IARC	**http://www.iarc.fr/**	World		
Cancer Incidence in Five Continents	http://www-dep.iarc.fr	31	state (more values for some states)	1953-1997
Globocan 2002	http://www-dep.iarc.fr	173	state	2002
OECD	**http://www.oecd.org/**	World		
OECD Health Data	http://www.oecd.org/health/healthdata	30	state	1960-2008
Health Statistics	http://stats.oecd.org/	30 (20 for Health Accounts)	state	2000-2007
Eurostat	**http://epp.eurostat.ec.europa.eu/**	Europe		
Health section	http://epp.eurostat.ec.europa.eu/portal/page/portal/health/introduction	33	state	1997-2008
Regions and cities section	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/main_tables	25	NUTS 2	1994-2008

Notes: 1) Number of countries is an approximate value. It varies according to attributes. 2) The first and the last year in the database. The time series of most of states and attributes are much shorter.

World Health Organization – http://www.who.int

WHO and its regional offices collect and provide great amount of data. Only the most important of them are described here.

WHO Statistical Information System – http://www.who.int/whosis/en/

There are health data about 193 member states of WHO. It contains demographical indicators, public health resources etc. There is possibility to compare situation in different countries.

WHO Global Infobase Online – http://www.who.int/infobase

Tables and other information about alcohol, overweight, diabetes etc. are provided here.

World Health Organization – Regional Office for Europe – http://www.euro.who.int

European office of WHO (WHO/Europe) manages the greatest amount of data from all regional offices of WHO. Data are supplied by institutions that manage health statistics in each country.

European health for all database – http://www.euro.who.int/hfadb

It is the main WHO/Europe database. There is a broad range of data – demography, mortality, health care resources etc.

European detailed mortality database – http://data.euro.who.int/dmdb

This database allows comparing causes of death in 5-years age groups.

European hospital morbidity database – http://www.euro.who.int/InformationSources/Data/20061120_1

Hospital care statistics (number of patients, length of hospitalization etc.) are contained.

European mortality database – http://www.euro.who.int/InformationSources/Data/20011017_1

This database provides data about causes of death. In contrast to European detailed mortality database, data for regions smaller than state is also provided (strictly speaking NUTS 2). The problem is that data for NUTS 2 regions is provided only for 12 states including Russia and Uzbekistan, many European countries are, however, missing – e.g. Germany.

International Agency for Research on Cancer – http://www.iarc.fr/

Many databases belong to IARC. Two of them (cancer epidemiology databases) are described here.

Cancer Incidence in Five Continents – http://www-dep.iarc.fr

Annually updated database contains data about cancer incidence (new cases occurring in members of a population in a specified time period). Incidence is provided as a cases numbers, crude rate per 100,000 inhabitants and age standardized incidence rate standardized on World Standard Population (ASR-W). A complication for using these data is that numbers are not collected for states but for cancer registries. It means that Spain, Britain etc. has more values in databases because there is not only one registry in this country.

Globocan 2002 – http://www-dep.iarc.fr

The Globocan 2002 database contains the global estimation of cancer incidence, mortality and 5 year prevalence by 25 sites in 173 countries in 2002. Each value represents one state. There is not only incidence but also cancer mortality and prevalence (number of persons in a defined population who have been diagnosed with that type of cancer, and who are still alive at a given point in time). It should be emphasized that values are only estimation for year 2002! All states of world are in databases including countries where data is rarely collected. E.g. number for Afghanistan is the mean from neighbouring states numbers.

Organisation for Economic Co-operation and Development – http://www.oecd.org/

OECD collects a great number of data including health statistics.

OECD Health Data – http://www.oecd.org/health/healthdata/

Dataset of more than 1200 attributes is accessible after paying fee. A few of basic indicators (number of doctors, risk factors, health care expenditures etc.) can be downloaded for free in Excel file.

Health Statistics – http://stats.oecd.org/

The first part of this database contains the same health data as the free Excel file which was mentioned above. The second part of database consists of System of Health Accounts statistics. User can find expenditures, provider and funding of health care. This type of data is hard to find in other sources. Unfortunately these very interesting statistics are provided only for 20 states and only for period 2003-2006. Definitions are unavailable in some cases.

Eurostat – http://epp.eurostat.ec.europa.eu/

Statistical office of European Union manages wide spectrum of data including health statistics. Types of collected data are defined in Regulation No. 1338/2008 of the European Parliament and of the Council on Community statistics on public health and health and safety at work (EU 2008). Health data are concentrated in two sections:

Health – http://epp.eurostat.ec.europa.eu/portal/page/portal/health/introduction

This section consists of two parts. In part Public Health is statistics about expected length of life, causes of death, number of patients and doctors etc. Part Health and safety at work contains information about accidents at work.

Regions and cities – http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/main_tables

This section contains various data for regions smaller than state (for NUTS 2). Health statistics is represented by numbers of doctors, dentists and hospital beds. Values are provided for states of EU and some other countries. Unfortunately not all data are filled for all countries – e.g. number of doctors is not known for NUTS 2 of Germany.

Possibilities and problems of data comparison

There are many international health data providers and many of their datasets are accessible on Internet. We did not find discrepancies in compared datasets; however, it is dangerous to combine data from different sources. Values are frequently computed not for real but for theoretical "standard" population. Different databases are using different standard population – e.g. OECD and IARC uses World Standard Population, WHO/Europe and Eurostat uses European Standard Population. Some values are only estimates (Globocan). It means that it is very important to read the attribute definition. Definitions are not accessible easily in some cases (OECD).

Definitions of collected attributes are changing in time; it means that statistical time series are not homogenous (OECD datasets). Definition of attribute can be also different in different countries that send them into international databases. Some states do not provide all attributes – e.g. some attributes for Germany are missing in Eurostat datasets. Data of regions smaller than state is important for complex spatial analysis but there is a lack of these values. Only WHO/Europe and Eurostat provide them but only for a few countries.

Economical sustainability of public health system is a hot political theme nearly in all developed countries. Economical funding of the essential health care is similarly hot issue in the rest of countries. In both cases analyses of health system and its economical data are necessary. But only a small amount of economical data about health system is accessible. Only source of international data about health account system is OECD and there are values only for 20 states.

HEALTH MAPS AND THEIR RULES

Cartographic visualization is a possible method for presentation of health statistics. A good map is more interesting and visually pleasing to the user than a table with numbers. Cartography can be also used for monitoring and analyzing a situation – in space as well as in time. The oldest known medical map is probably Arietta's map of plague in Bari from 1694 (Koch 2005, 19). The most famous is the map of the London cholera epidemic in 1854 published by John Snow in 1885. Since that time, numerous medical and health status maps and atlases have been published. At the present time more and more medical information is published over the internet (Stampach et al. 2009, 869).

Maps visualizing health data must fulfil the same rules as each statistical map. It is necessary to care about quality description of data and method of data collection etc. Except these general rules there are also some specificities of health map cartography.

Personal data protection

Personal data protection is an important issue in case of health data. Data about patients and health are very sensitive. Current practices in spatial analysis of health data as well as methods to protect confidentiality (e.g. aggregation) were described by Bell et al. (2006, 10). Patient privacy is one of reasons, why there is a lack of data for regions smaller than state in international databases.

Cognitive studies recommendations

Health maps are not only used by professional cartographers. They are used by medical specialists and also by the general public. Too complex or confusing map can cause users, especially non-cartographers, to misinterpret its data. Health maps and statistics are used for important decisions, e.g. disease predictions, and prevention planning. A bad interpretation can therefore have far-reaching consequences (Stampach et al. 2010, 2).

In the last decades many cognitive studies have dealt with the best way to visualize statistical data in medical maps and make them easily readable. A complex set of experiments is described by Pickle (2003). General recommendations from the mentioned studies for making statistical maps for non-cartographers can be summarized as follows:

- Non-cartographers prefer well-known classic choropleth (classed, area shaded) maps.
- Colours should be chosen consistently with colour conventions. The well-composed double-ended colour scale was better than the grey scale, although, the grey scale was only slightly inferior. Brewer offers recommended colour schemes for printed and digital maps in her ColorBrewer web tool (Brewer 2010).
- It is important to identify unreliable rates and values in health statistical map. Non-identification or blanking them out is not a good way. Identification can be done e.g. by diagonal hatching.

Using of administrative units in maps

Most of statistical maps including health maps use administrative regions. The reason is that most of health statistics are collected and managed for this type of units. However, diseases do not respect political boundaries; they are not limitation for spreading of diseases. Administrative borders can cause a bad interpretation of health situation.

It can be solved by using very small administrative units e.g. municipalities. Higher number of them in map should ensure that the phenomenon pattern in territory will be preserved. However using of small units with small population can cause that computed or predicted values of these units will be unreliable. Another solution – data smoothing – suggest

Bell et al. (2006, 12). This method disadvantage is that smoothing will treat all rates as equally reliable, possibly smoothing away important and reliable "hot spots" of high rates, e.g. higher HIV mortality rates in cities.

HEALTH MAPS PROVIDERS

International health map providers are similar to health data providers. There are differences in quality of accessible maps and in a way of maps publishing. Following part is not a complete list of organizations offering health maps. There are only examples representing these differences.

World Health Organization – http://www.who.int

The main source of maps is a web page http://www.who.int/globalatlas. There are two types of maps – static and interactive maps.

Maps and Resources

This is a name of great archive of classic maps prepared for print that covers various themes, regions and time. They can be downloaded as PNG and JPEG format. Their graphical quality is mostly very good. An example is on Figure 1.

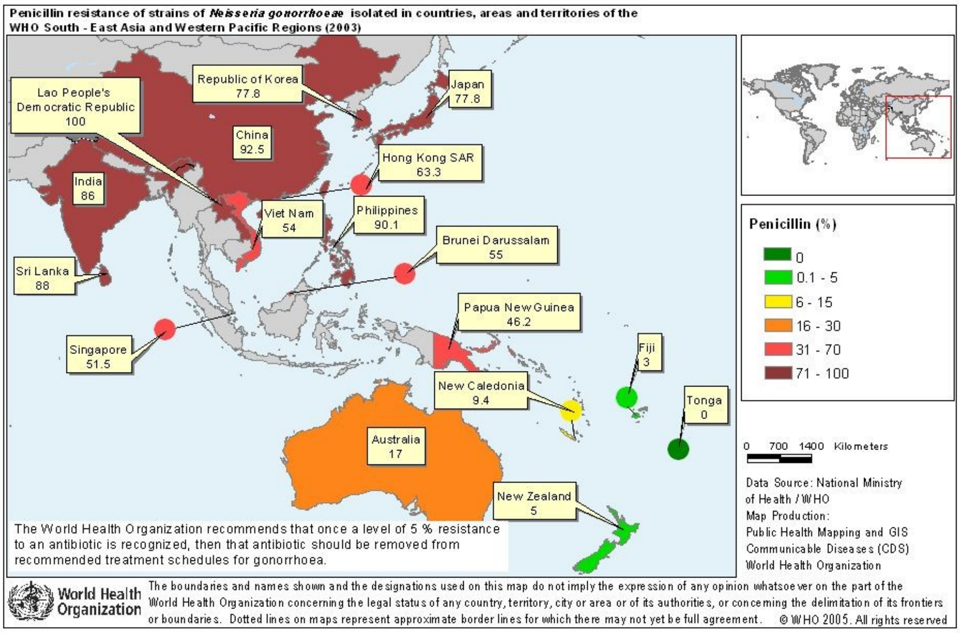

Figure 1: Map of penicillin resistance of etiological agents in 2003. Source: WHO, Maps and Resources.

Interactive Mapping

This application is an inversion of previous archive. User chooses theme, time and region and produces his own map. There is a possibility to combine more than one attribute in the map. Accessible attributes can be divided to categories: contagious diseases, non-contagious diseases, health system employers and indicators of health status and health care.

World Health Organization – Regional Office for Europe – http://www.euro.who.int

Two of above mentioned databases (European health for all database and European mortality database) can visualize their data in map. User has only small possibilities to change produced map. He can specify classification type and change interval borders. Example of map is on Figure 2. The map is not very satisfactory for cartographers. The legend is deformed and blanking out of states outside the Europe can be confusing – Israel looks like an island.

International Agency for Research on Cancer – http://www.iarc.fr

Data from Globocan 2002 database can be visualized in map. User has no possibility to change the map. Cartographic problems were not found.

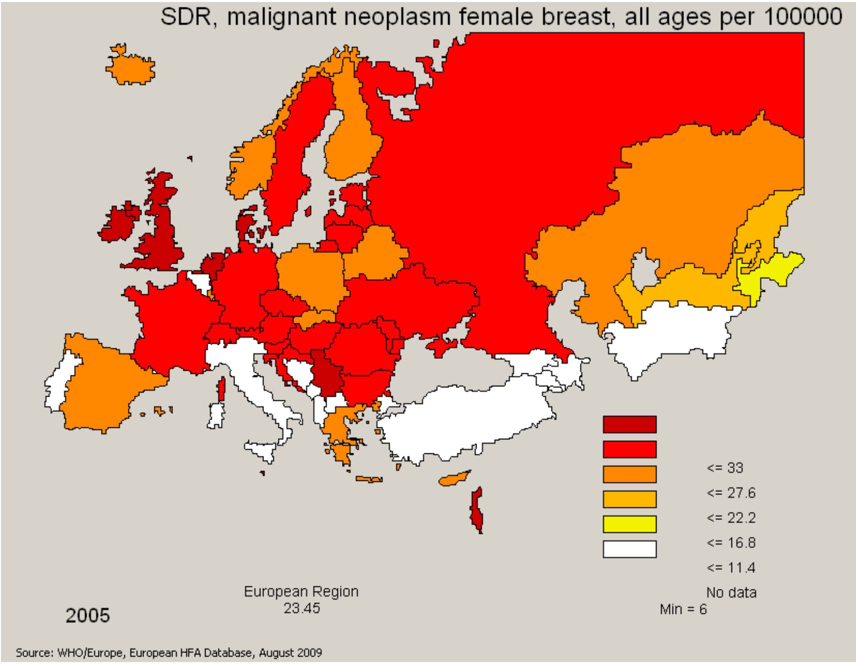

Figure 2: Breast neoplasms mortality in 2005. Source: WHO/Europe, European mortality database. Visualized in Mozilla Firefox 3.6

Eurostat – http://epp.eurostat.ec.europa.eu/

Eurostat allows visualization of its data in an interactive map. In contrast with WHO/Europe and IARC maps, Eurostat application offers wide possibilities to change map appearance. It is only map application from the group described in this paper that allows alternation to choropleth map. Figure 3 shows using of graduated symbols. Values can be shown in map; user can change number and borders of intervals. A statistical distribution of values is also very useful.

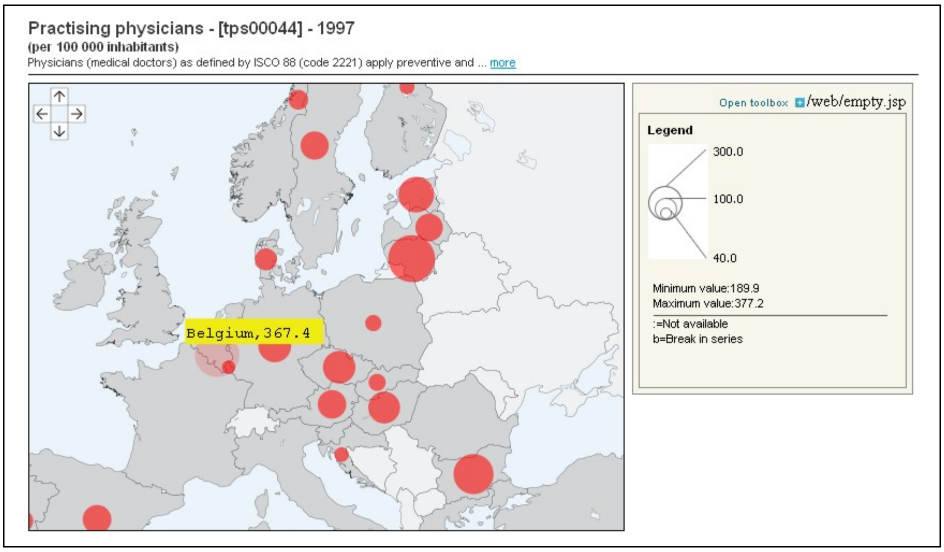

Figure 3: Practising physicians per 100,000 inhabitants in 1997. Source: Eurostat.

Comparison of offered health maps

Facts described above show that there are differences in health data visualization between data providers. There are not many institutions that offer classic static maps (WHO). Most of maps are produced by cartographic web tools. Some of these tools do not allow any changes in produced map (IARC), some of them allow limited changes (WHO/Europe). On the other hand tools of WHO and Eurostat are highly interactive – user can influence many parts of map.

The most frequent type of cartographic visualization is a choropleth map. Only Eurostat offers also other possible type –

graduated symbols. It is worth to say that from cartographic view choropleth map is not good for all types of attributes. Visualization of raw values e.g. "number of doctors" in choropleth map can cause the bad interpretation of situation! Quality of offered maps differs source to source but mostly there are no important problems. However, there is one exception – maps of WHO/Europe are not suitable to be printed and used for data presentation (Figure 2).

GLOBAL HEALTH INFORMATION INFRASTRUCTURE

The advent of Geoinformation infrastructures (GII)

The development of Geoinformation infrastructures has started in Europe in the late 80's, due to the emergence in the market of geospatial technology as ready to use computer software packages. Since the mid 90's, the GIS industry started to offer software tools that could be remotely accessed, without the need for the user to have his or her own GIS. This was the door that opened the possibility for citizens to explore geographical information and National GII were challenged with the need to supply geoinformation useful to citizens (Frank et al., 2000).

The first political step was done by President Clinton's Executive Order of 11 April 1994 setting up the National Spatial Data Infrastructure. One of the actions under the order is to require all future federal geographic information collection, storage and reporting to adhere to the standards of the Federal Geographic Data Committee (FGDC), and co-ordination structures are being set up to this end. European policy framework for rules, standards, procedures, guidelines, and incentives for geographical information was first drafted within the proposal of GI2000 document (EU 1998). The concept of GII has further developed on several hierarchies from national to global level.

National Committee on Vital and Health Statistics (part of United States Department of Health and Human Services) (2001) proposed a term "National Health Information Infrastructure" (NHII) that includes not just technologies but, also values, practices, relationships, laws, standards, systems, and applications that support all facets of individual health, health care, and public health. The heart of the vision for the NHII is sharing information and knowledge appropriately so it is available to people when they need it to make the best possible health decisions. The key NHII stakeholders and health information users are consumers, healthcare providers (both individuals and organizations), and public health professionals at local, State, and national levels. While the first two non-anonymous and legally limited data levels are likely out of the focus of GII, the public health professionals' levels are in correspondence with geoinformation sources and have a spatial dimension where the spatially referenced (georeferenced) health data can be combined with other geospatial sources and publicly used for both profit and non-profit purposes. This concept of potential link between health and geographic infrastructure is only implicit.

Thompson et al. (2008) proposed explicit Health Spatial Data Infrastructure (SDI) across Australia as a solution for the harmonisation of data integration and reporting. The vision for the Health SDI is to provide a highly accessible framework for linking users (community) with health service providers. The Health SDI comprises the people, policies and technologies to enable the use of spatially referenced data through health agencies, hospitals, local government, the private sector, non-profit organisations, academia and ultimately the community. The Health SDI architecture is to deploy interoperable services that assist users to produce and publish, find and access, and eventually, analyse, use and understand health geographic information over the internet.

INSPIRE directive and health data infrastructure – the European perspective

INSPIRE directive (EU 2007a) lays down general rules to establish an infrastructure for spatial information in Europe. This infrastructure should be specifically used for the purposes of Community environmental policies and policies or activities which may have an impact on the environment. INSPIRE is based on the distributed infrastructures established and operated by the Member States and currently is the only explicit geoinformation relevant EU wide directive, which can serve as a template for other human activities areas (security, agriculture, transportation). INSPIRE covers in total 34 Spatial Data Themes laid down in 3 Annexes.

EU has also established the Second programme of Community action in the field of health (2008-2013) (EU 2007b) where one of the objectives is also to generate and disseminate health knowledge, hence there exit a need for more policy integration and development of information and decision management support systems at various level of government (Health Information and Knowledge Systems) (Smits 2009).

The health relevant issues are explicitly mentioned within INSPIRE Annex III.5 Human Health and Safety namely two main groups of data:

- Geographical distribution of dominance of pathologies (allergies, cancers, respiratory diseases, etc.).

- Information indicating the effect on health (biomarkers, decline of fertility, epidemics) or well-being of humans (fatigue, stress, etc.) linked directly (air pollution, chemicals, depletion of the ozone layer, noise, etc.) or indirectly (food, genetically modified organisms, etc.) to the quality of the environment.

No spatial (state, regions, NUTS) or temporal (last year, month, decade) extent has been yet specified for this part of Annex III. Preliminary identification of links and overlaps with other Annex I-III themes includes among others – Administrative units, Statistical units, Utility and government services, Environmental monitoring facilities, Atmospheric conditions, Meteorological geographical features.

Other relevant documents must be taken into account especially Decision No 1350/2007/EC of the European Parliament and of the Council of 23 October 2007 establishing a second programme of Community action in the field of health (2008-13) (EU 2007b). Among actions to collect, analyse and disseminate health information and knowledge there are following activities mentioned:

- Develop further a sustainable health monitoring system with mechanisms for collection of comparable data and information, with appropriate indicators; ensure appropriate coordination of and follow-up to Community initiatives regarding registries on cancer, based, inter alia, on the data collected when implementing the Council Recommendation of 2 December 2003 on cancer screening; collect data on health status and policies; develop, with the Community Statistical Programme, the statistical element of this system.
- Develop mechanisms for analysis and dissemination, including Community health reports, the Health Portal and conferences; provide information to citizens, stakeholders and policy makers, develop consultation mechanisms and participatory processes; establish regular reports on health status in the European Union based on all data and indicators and including a qualitative and quantitative analysis.
- Provide analysis and technical assistance in support of the development or implementation of policies or legislation related to the scope of the Programme.

The Health portal proposal is in close relation with INSPIRE principles and it is likely that both activities will be harmonised in future.

Skouloudis and Rickerby (2009) further extended the health-spatial paradigm with temporal views and introduced the term temporal data infrastructure (TDI). This approach is important for health hazards caused by environment where the long term studies must be accomplished in order to verify the health effects and development trends. Selected relevant projects on both European and global level are described and analysed in Kilpeläinen et al. (2008). The authors described ECHI projects trying to establish a European wide system of health information standards (e.g. health indicators) that enable national health information providers to adopt these standards for public health monitoring and reporting. The keyword of this activity is “comparability of data and information”.

The global dimension

The global dimension of GII is officially presented by the Global Spatial Data Infrastructure Association (GSDI). Defining its objectives the GSDI (2009) officially stated among the goals to: “...foster spatial data infrastructure developments in support of important worldwide needs such as improving local to national economic competitiveness, addressing local to global environmental quality and change, increasing efficiency, effectiveness, and equity in all levels of government, and advancing the health, safety and social wellbeing of humankind in all nations” (GSDI 2009). Even though the term “health” and associated health data are only one many on the GSDI list, they are officially mentioned within this strategic document. The incorporation of standard based, regional level health monitoring data into the thematic geoinformation infrastructure is thus one of the missions to be accomplished within the next decade.

CONCLUSION

A number of information sources of data and maps with health thematic is increasing as well as a number of attributes provided by each source. The problem is an incomparability of different sources; distinct definitions and method of standardization do not allow combining data from different providers. There is a lack of data for smaller administrative (enumeration) units than state and a lack of data about economical indicators in health systems.

Health data can be used for current situation analysis and for planning of health system for future. But to make data useful, they must be presented for medical specialists as well as for general public. A good way to present data about health status and health care is a map. International data providers offer their data also in maps; however, their quality and possibilities of user to modify the map are very different source to source.

Spatial data infrastructures are gradually developing in many countries and regions of the world – USA, Australia, Europe. Interoperability of spatial information with health data is changing from only implicit level (NHII – USA) to explicit enumeration of health relevant issues (INSPIRE EU directive). Health data is also one of themes of GSDI Association which propagates spatial data infrastructures on a global dimension.

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