Guard, Anticipation and Prediction: A New Approach to Health Risk Prediction

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Abstract: The protection of the public's health is one of the most important aims of European countries. The objective of this project is to develop a model for an ICT system and a roadmap for research in the area of Guard (detection), Anticipation and Prediction of potential large scale threats to public health. In order to represent the "state of the art" in this area, we conducted a survey to describe information systems and predictive models existing in European Countries and Israel. The survey addressed five categories of risks: biological (pandemics and bioterror), natural, industrial, nuclear and terrorist. Since these risks are all of a different nature, the systems differ in the management of their surveillance, data flow and modelling methods. For these reasons we developed a questionnaire for each of the five relevant categories to each of the project partners countries. Data collected was analyzed and a total of 19 systems were reported. Systems for surveillance and early detection of communicable and infectious diseases were found in all of the GAP partner countries. Different systems use different types of data and transmission modes. Some of them were highly computerized and others rely more heavily on personal communication. Some of systems revealed a number of predictive models that have been tested at varying levels and in various situations. This survey provides the basis for the next step in the project which is the development of a model for an ICT system that will be able to predict potential threats before the event occurs or turns into crises.

Keywords: Pandemics, Natural and Man Made Disaster, Industrial Risk, Terrorism, Disaster prediction, Preparedness

1. Introduction

The protection of the public's health is one of the most important aims of European Countries and broadly worldwide. There are many possible threats to the public, these can be biological (pandemics and bioterrorism), natural, industrial, nuclear and terrorist risks. Since these risks (that include nuclear, radiological, biological and chemical risks, threat of bio-terrorism, climatic risks, natural catastrophes, infectious illness, etc.) are all of a disparate nature, different systems for the management of their surveillance, information (data) flow and modelling methods are needed. However, they share the need for systematic surveillance and predictive tools in order to facilitate the dissemination of information and prevention of health crises. Prompt response and mitigation of damage requires that threats be detected as early and specifically as possible, especially before an event may occur or turn into crises. The detection problem is a challenging one for a variety of reasons including the complexity of collecting data about affected individuals who may be widely dispersed by the time that symptoms develop.

For communicable diseases an early warning system that enables an early detection of public health threats has been recently developed. This system could lead to an earlier, more rapid response. However, many authorities have questioned the nation's ability to effectively detect and respond to such a health threat. A first step towards improved detection and response is the evaluation of the ability of existing information systems to

detect and enhance response to a major public health threat. It is critical that we also understand how existing surveillance systems, including emergency departments and public health surveillance systems, could be enhanced for earlier recognition of a health threat.

The Guard, Anticipation and Prediction (GAP) project deals with a new approach to the major health risks. Its objective is the realisation of a roadmap for Information and Communication Technology (ICT) research in the area of detection and anticipation of possible large-scale public health threatening events. The focus of the project is on information systems and on predictive and anticipative models.

The research aims at evaluating the needs for a generic predictive solution able to produce the necessary alarms for all kinds of weak signals related to the major health risks (nuclear, radiological, biological, chemical, bio-terrorism, climatic, natural catastrophes, infectious illness, etc.). The GAP project does not focus on management of crises, but it aims at complementing the efforts done by DG SANCO's Health Emergency Operations Facility (HEOF), which uses a set of tools to facilitate the dissemination of information concerning health crises.

GAP is a Support Action funded by European Commission- Information Society and Media Directorate-General within the 7th Framework Programme and the Specific Programme "Cooperation". The project is driven by a consortium composed of high-level representatives of HealthCare Ministries of EU countries (Spain, France, Denmark, Italy) and Associated States (Israel), and is coordinated by Departament de Salut, Secretaria d'Estratègia i Coordinació, Generalitat de Catalunya in Spain.

2. Objectives

This study will detail GAP's perimeter, describing the relevant existing information systems related to health risks monitoring. The main objective of the GAP project is to use collected data from participating countries in order to present predictive systems and models that may form the basis for the development of a true (generic) predictive model.

3. Methodology

In order to present a synthesis of the existing major health risks surveillance systems in the participant Member States, Israel and at the European level we developed a questionnaire containing specific information regarding monitoring and alert system.

The questionnaire used to analyze existing systems was a matrix that focuses primarily on information flow.

The methodology for collecting the relevant information was determined collaboratively by all of the GAP Partners. In order to investigate the existing information systems, each participating country was required to:

- Identify relevant risks that are characteristic of its territory and primary organisations in charge of monitoring systems;
- Complete matrices that describe the information flow for each information system investigated.

In the initial stage, the Partners were defined relevant risks in their countries and the term crises.

4. Results

During the first three months of the project, each partner identified the most relevant systems in its country in order to complete a matrix on each system with the relevant information.

4.1   Definition of Relevant Risks

A risk results from an apprehension of a threat (gravity of its impact combined with the probability of its occurrence). Nowadays, the gravity of the threats and their capacity for rapid spread and dissemination necessitates the identification of an event as a risk when the consequences may be high even though there is only a small, even minimal probability of its occurrence.

The risks that are the focus of interest in the GAP project are of many types. The large scale risks are characterised in particular by the fact that their causes as well as their effects can come from outside of the borders of Europe as well as from within and have consequences for a given national territory in as well as beyond the European national borders.

Five large risk categories have been identified (Table 1).

Table 1: Definition of the Main Risk Categories Identified in the Gap Project

Risk categories	Description
Biological risks	Communicable diseases such as pandemics and bioterrorism
Natural risks	Natural disasters as flood, earthquake and so on.
Industrial risks	The use of toxic products, food industry, medical industry, etc; but also risks concerning consequences of human activities on the environment (water or air contamination, etc.)
Nuclear risks	Given its specificity this risk is separated from the industrial one. For instance, it concerns the explosion or the contamination risks
Terrorist risks	All type of man-initiated attacks such as voluntary introduction of chemical agents in Europe.

In the GAP project, the predictive model will prioritize large scale risks which threaten the well being of the population or damage the infrastructure.

4.2   Definition of Crisis

A crisis has being defined as a situation in which the available operational capacities are inadequate for managing it. It is often the consequence of an incorrect evaluation of the risk, which results in a lack or inadequacy in the pre-planned rescue chain. Crisis management is the organization of the process for dealing with the crisis, based on a preliminary planning of the roles of every link in the rescue chain. The preliminary planning is based on the study and the evaluation of the risks and the evaluation of their impact.

In Figure 1 all the steps that have to be implemented in crisis definition and management are presented.
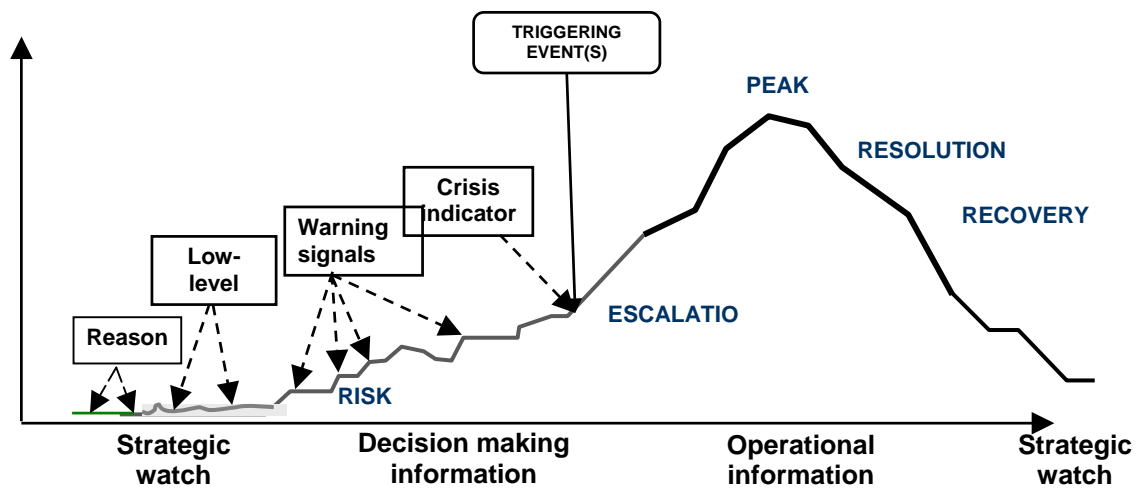
Figure 1: Representation of crisis definition and it's management

Prevention strategies

Action and mitigation strategies

4.3 Survey Results

A total number of examined systems in the 5 GAP partners countries and at the European and international level were 36. Systems for surveillance and early detection of communicable and infectious diseases were found in all of the Gap partner countries as well as in other European countries and at the European level.

4.3.1 Biological Risks Including Pandemics and Bioterrorism

The source of the information in all of the systems is health care professionals i.e. doctors, hospital personnel, community clinics, lab personnel, pharmacists. In some of the systems, the full population data is transmitted, while in others, only representative data is transmitted. In most of the systems the information is transferred to regional and national health authorities responsible for emergency response. In most of the systems, the information is transmitted continuously or on a daily basis. In a minority of the systems, the information is transmitted on a weekly basis or once an event has been detected and emergency monitoring has been enacted. Most of the systems are fully or partially computerized. All the 19 systems identified are surveillance and early detection systems. None are designed to predict events that have not yet occurred. However, some of the systems, once a case has been identified, can predict the nature of the outbreak and its dissemination. The majority of the systems are dedicated reporting systems. Some of the newer systems (particularly the European wide systems) proactively search for relevant data using text and data mining techniques.

In addition to the above operative systems, there are numerous systems in various stages of research and development that are designed to predict the dissemination of a disease, once it is detected in its early stages. These models are based on mathematical epidemiology, data mining or reality mining.

4.3.2 Natural Risks

The consequences of natural disasters can have significant impacts on public health (for example, floods can trigger epidemics, heat waves may increase mortality in certain populations, etc.). Four operational systems were identified by the GAP partners countries. Systems for surveillance and early detection of natural disasters were not found in all of the GAP partner countries or at the European level. The following generalizations can be made in order to describe the results. The source of the information in the existing systems is

infrastructure organizations such as weather centres, water companies etc. Only one of the systems receives information from the medical system. In most of the systems the information is transferred to regional and national authorities responsible for emergency response. In some of the systems, the information is transmitted continuously or on a daily basis. In others, the information is transmitted only once an event has been detected or an administrative directive has been issued. Most of the systems are fully or partially computerized. Most of the systems are not designed to predict events that have not yet occurred. The Italian system for early detection of floods and monitoring of volcanic activity is unique. It provides meteorological and hydrological forecasts by analysing observed data and using an estimation model.

4.3.3   Industrial Risks

Systems for ongoing surveillance and early detection of industrial disasters were not found in any of the GAP partner countries or at the European level. However, we found emergency systems in all of the GAP countries that are activated upon occurrence of an industrial accident. The source of the information in most of the systems is emergency first responders. In most of the systems the information is transferred to regional and national authorities responsible for emergency response. In most of the systems, the information is transmitted once an event has been detected and emergency response has been enacted. Most of the systems are not computerized. None of the systems are designed to predict events that have not yet occurred. The systems are basically crisis management systems.

4.3.4   Nuclear Risks

From the GAP partners countries only two systems were identified. A System for surveillance and early detection of nuclear risks was found only in France. This system is part of a global telemetry network of radiological measurement that provides continuous and real-time environmental monitoring using autonomous devices measuring radioactivity in the environment in which they are located. It is comprised of two networks that monitor the air and two networks that monitor water. Data acquired by these 4 networks are automatically sent to centralized computerized infrastructures dedicated to storage, exchange and consultation data and the pilot networks in radiological emergency phases. Even this system does not extend to prediction.

4.3.5   Terrorism

Most of the GAP countries did not identify systems for surveillance, anticipation or prediction of terror events. However 4 operational systems were found. We hypothesize that there are additional systems in the various countries that anticipate and even predict terrorist activities, however these are part of the counterterrorist intelligence agencies and are classified as confidential.

5.   Conclusions

Results of our study highlights some strengths and some limitations in health threats surveillance systems within the participating countries. All the systems identified, emergency and routine, are organized on a geographical level. Some systems are local, others are regional or national. Different systems use different type of data and transmission modes. Some of them are highly computerized and sophisticated and others rely more heavily on telephone and interpersonal communication.

Considering the sustainability, some of the systems operate on an ongoing basis and some of them are only activated at the time of an anticipated threat. Some of systems revealed a number of predictive models that have been tested at varying levels and in various situations. We identified two types of models that are presently being used:

- Models that predict the duration, magnitude, and different patterns of dissemination of risks. This type of model relates to risks such as bioterrorism, natural risks, the dissemination of toxicological agents, food contamination, and pandemic risks. These models focus on minimizing the damage once the risk is identified. They serve as early stage of crisis management.
- Models that predict a possible outbreak based on existing databases and known "background patterns" of the examined risk. These models are used when there is a periodic (continuous or repeated) data flow that enables comparison of new data to existing data with known patterns. These types of models are used for modelling risks such as infectious diseases and food contamination but can also be adapted for other systems, depending on surveillance technologies. For example, in Italy, natural risks (floods, storms, volcanic activity) are continuously monitored and are predicted using this kind of a mathematical model.

Moreover, most existing surveillance systems do not supply enough/high quality data for prediction and most existing modelling systems focus on anticipation, not prediction. Early detection of new (unknown) risks at early stages is limited. Text-mining systems put in place by the EU represent a new monitoring tool. However this tool uses only WEB based information and not medical and emergency system information. The existing systems are not interactive, "learning" systems and therefore they are limited and cannot respond to changing threats and dynamic environment. The level of prediction remains relatively the same and does not improve over time.

The survey and analysis of existing systems provide the basis for the next step in the project which is the development of a model for an ICT based system that will be able to identify and predict potential threats before the event occurs, as well as a roadmap for the development of such a system.

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For further information please visit www.gaptheproject.eu

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