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Survey on methodologies in the risk assessment of chemical exposures in emergency response situations in Europe

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HIGHLIGHTS

- There is variation in risk assessment practice of acute chemical releases in Europe.
- Training especially on the application of acute exposure reference values is needed.
- Release of toxic and irritating/corrosive chemicals are perceived as a serious risk.
- Globalisation and high productivity demands are potential future risk drivers.

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ABSTRACT

A scientifically sound assessment of the risk to human health resulting from acute chemical releases is the cornerstone for chemical incident prevention, preparedness and response. Although the general methodology to identify acute toxicity of chemicals has not substantially changed in the last decades, there is ongoing debate on the current approaches for human health risk assessment in scenarios involving acute chemical releases.

A survey was conducted to identify: (1) the most important present and potential future chemical incident scenarios and anticipated changes in chemical incidents or their management; (2) information, tools and guidance used in different countries to assess health risks from acute chemical releases; and (3) needs for new information, tools, guidance and expertise to enable the valid and rapid health risk assessment of acute chemical exposures.

According to the results, there is an obvious variability in risk assessment practices within Europe. The multiplicity of acute exposure reference values appears to result in variable practices. There is a need for training especially on the practical application of acute exposure reference values. Although acutely toxic and irritating/corrosive chemicals will remain serious risks also in future the development of plausible scenarios for potential emerging risks is also needed. This includes risks from new mixtures and chemicals (e.g. nanoparticles).

Abbreviations: ACUTEX, ACUTe EXposure (an EU project in 2002–2005); AEGL, acute exposure guideline level; AERV, acute exposure reference value; AETL, acute exposure threshold levels; CLP, regulation on classification, labelling and packing of substances and mixtures; ERPG, emergency response planning guideline; IDLH, immediately dangerous to life and health limit; QSAR, quantitative structure-activity relationship; REACH, regulation on registration, evaluation, authorisation and restriction of chemicals; SCAPA, subcommittee on consequence assessment and protective actions; STEL, short term occupational exposure limit value for 15 min; TEEL, temporary emergency exposure limit.

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1. Introduction

Public health management of acute chemical incidents is based on the knowledge of health risks arising from short term, high level exposure, which enables the assessment of public health consequences and the needs for evacuation and other protective measures. This is a special situation that is not covered in most other existing risk assessment schemes such as Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) [1] or, for example, the approval of new pesticides or biocides for access to the market. These schemes are focused on the risks of chemicals from their normal use and handling and do not take into account short term high level exposures due to, for example, accidents or incorrect use. Therefore the related methodologies are mostly focused on subacute to chronic exposure and are aimed to identify the levels at which no harm is likely to result from exposure.

The methodology to identify acute toxicity of chemicals has not substantially changed in the last decades. However, there is ongoing debate regarding the current approaches for human health risk assessment in scenarios involving acute chemical releases. One question concerns identification of the most relevant substances that should be considered in acute chemical incident scenarios. Secondly, there is an issue concerning the types of health effects that should be included in such an assessment. As individual assessments performed by different authorities or organisations may result in different conclusions (that can all be scientifically justified) there may be a need for further co-operation and harmonisation of approaches for risk assessment of acute chemical releases and for deriving chemical specific guidance values applicable for acute chemical release scenarios. A harmonized and consistent response is especially important in case of transboundary incidents to mitigate consequences.

In addition to the concern over accidental chemical releases, there is growing awareness about potential deliberate exposure stemming from the release of a dangerous substance through an intentional act of violence, terrorism or sabotage. In addition to classical chemical weapons, commonly used industrial chemicals have been suggested as possible threats in scenarios involving deliberate releases of chemicals [2,3]. As another new area of concern, potential acute health effects due to chemical releases associated with new technologies, for example, nanotechnology and current or future trends engendered by nature or society, such as climate change and globalisation, are issues that also should be considered.

Acutely toxic or corrosive chemicals, such as hydrogen cyanide, chlorine or hydrogen sulphide, are usually well recognised in acute exposure risk assessment schemes. However, concerns have been raised about other toxic effects, for example, carcinogenic or reprotoxic effects of chemicals after single, incidental exposure (e.g. "one-shot carcinogenicity" [4]). Carcinogenic and reprotoxic effects are typically studied in repeated dose toxicity studies and there is, at present, no clear methodology for the extrapolation from those studies to single, peak exposures lasting only days or even hours. However, since the risk cannot to be excluded, there should be a method to assess, for instance, the cancer risk caused by a single, peak exposure to a carcinogenic substance [4,5].

Acute exposure reference values (AERVs) are used to express the likelihood of adverse health effects following the exposure to a particular substance. During chemical incidents these values are applied to models, e.g. atmospheric dispersion models, to predict consequences in a certain area or to estimate evacuation distances to enable rapid decision making in such emergency situations.

Reference values applied for food, consumer products or to the workplace define exposure levels at which no harm is likely to result from exposure i.e. are protective values. In contrast, AERVs, define predictive exposure levels for different degrees of health impairment, on a continuum from exposure levels without an expected health effect to those with an anticipated degree of harm or where lethal effects are to be expected. There are at present several AERVs in use in Europe [6]. The two most frequently used values are *Acute Exposure Guideline Levels* (*AEGL*) [7–9] developed by the U.S. National Advisory Committee for the Development of Acute Exposure Guideline Levels for Hazardous Substances (AEGL Committee), which is managed by U.S. Environmental Protection Agency (U.S. EPA), and *Emergency Response Planning Guidelines* (*ERPG*) [10] developed by the American Industrial Hygiene Association (AIHA). Other values include *Temporary Emergency Exposure Limit* (*TEEL*) [11–13] values developed by Subcommittee on Consequence Assessment and Protective Actions (SCAPA) and *Immediately Dangerous to Life and Health limit* (*IDLH*) [14] values defined by the U.S. National Institute of Occupational Safety and Health (NIOSH). In addition, there are national values available in some European countries, for example in the Netherlands (*Intervention Values for Dangerous Substances*) [15] and France (*SEI and SEL*; *Threshold of Lethal Effects and Threshold of Irreversible Effects*) [16].

In recent years, there have been some efforts to promote greater co-operation and harmonisation within Europe. EU-funded ACUTEX project (2002–2005) aimed to develop an European methodology for producing Acute Exposure Threshold Levels (AETL) [6]. The project took advantage of best practices established in existing methodologies, and incorporated new techniques to address particular needs of European end-users. This project was beneficial in moving Europe closer towards adopting some common principles for developing exposure levels, but full co-operation and harmonisation of procedures for the development of AERVs is still an unmet need in Europe.

For these reasons, a study was launched to explore the current practices, needs and developments of the risk assessment of acute chemical releases in EU. The specific aims of the study were to identify:

1) the most important present and potential future chemical incident scenarios and anticipated changes in chemical incidents or their management;
2) information, tools and guidance used in different countries to assess health risks from acute chemical releases; and
3) needs for new information, tools, guidance and expertise to enable the valid and rapid health risk assessment of acute chemical exposures.

This study was conducted as a part of the EU FP7 funded project iNTeg-Risk (Early Recognition, Monitoring and Integrated Management of Emerging, New Technology related, Risks).

2. Methods

2.1. Questionnaire design

A web-based questionnaire was chosen as being the most efficient method to conduct the study. The draft questionnaire was developed by the Finnish Institute of Occupational Health in collaboration with eight other institutes from seven different European countries. The survey consisted of 37 questions that included both open and multiple choice questions, many with scaled answers. The same scales were used on each question as far as possible, and an 'I don't know' option was included in most questions. Respondents also had the opportunity to add additional comments for each question.