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## SEARCH: a system for evaluation and archiving of radiation accidents based on case histories

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**Abstract** Overexposure of humans to ionizing radiation has occurred worldwide in the past and will surely occur again in the future. In order to allow an effective radiation accident management, it is consequently necessary to be prepared for such emergency situations and to improve means and ways to help people suffering from radiation-induced health impairments. Such approaches should rely on knowledge and experience gained from previous radiation incidents. A prerequisite for any scientific evaluation and comparison of information related to radiation accidents is to collect data in a standardized way. Therefore, the SEARCH database (System for Evaluation and Archiving of Radiation accidents based on Case Histories) has been developed in our department and implemented as an Oracle 8.0 database containing to date more than 800 case histories. The use of this registry is so far limited to active contributors and requires each contributor to sign a cooperation agreement. More information is available under <http://www.faw.uni-ulm.de/radmed/>.

### Introduction

About 407 major radiation accidents involving more than 133,000 persons were reported between 1944 and 1999 (personal communication 1999, R. Toohey, REAC/TS Radiation Accident Registry) [1]. Some of these accidents are generally well known, e.g. the one at Chernobyl in 1986 where more than 200 persons were severely injured and even many more affected [2]. The Chernobyl accident also caused some devastating environmental consequences in the surroundings as well as

adjoining states. Furthermore, some minor and more localized accidents took place, such as in San Salvador (El Salvador, 1989), Soreq (Israel, 1990) or Nesvizh (Belarus, 1991) (see [3]).

These examples as well as the latest critical accident in Tokai Mura (Japan, 1999) [4] indicate that accidents potentially resulting in health and environmental effects continue to happen and that from the medical point of view, one country might not be able to handle such an emergency situation alone, either because of inadequate resources, lack of sufficient national expertise (due to the relatively rare occurrence of such incidents) or because of neighboring countries being involved.

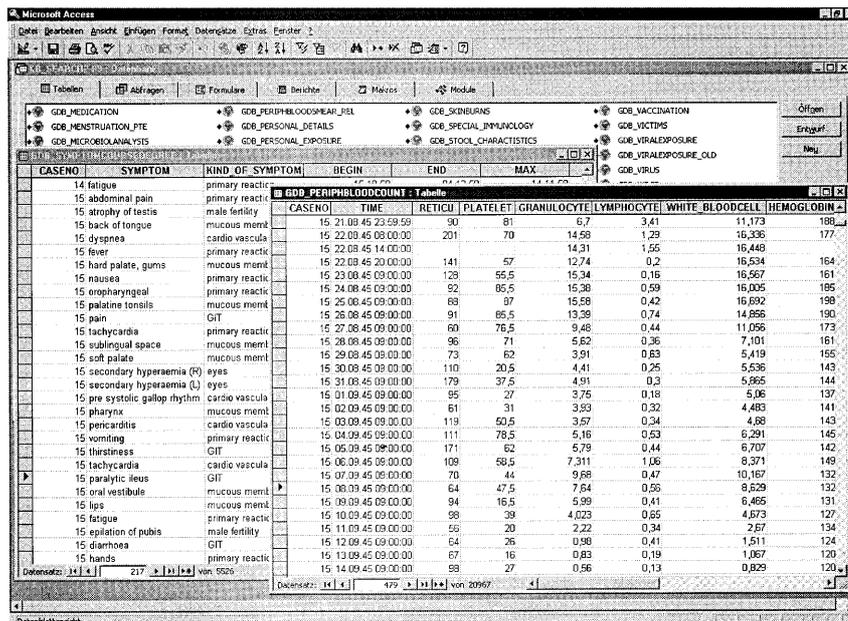
Apart from basic research world wide, the registration, evaluation and analysis of information of previous radiation accidents and subsequently observed health effects should form the basis for improving the medical management of patients who have been exposed to ionizing radiation. Although some local databases relating to special research projects (e.g., Hiroshima – Nagasaki Life Span Study) [5, 6], or subjects of interest (e.g. cancer mortality) [7, 8, 9], or databases mainly dealing with accident information [10, 11] are maintained in different parts of the world, no systematic collection of case histories, comprising accidents as well as medical data following radiation overexposure has been done on an international basis in the past. Being aware of this shortcoming, the Radiation Medicine Research Group (also serving as a WHO-Collaborating Center for Radiation Accident Management at the University of Ulm) developed a powerful data acquisition, storage and retrieval system called SEARCH (System for Evaluation and Archiving of Radiation accidents based on Case Histories).

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### Materials and methods

In 1990, the Moscow Ulm Radiation Accident Database (MURAD) was developed and started collecting data on case histories from the acute phase (first 100 days) after

**Fig. 1** Screen shot of the MS Access interface to view the SEARCH data in tabular form. A section of two tables is displayed, one gives information on the clinical signs and symptoms, the other on peripheral blood counts, each as a function of time



**Table 1** Information categories and selected topics to be collected in the questionnaires as a basis for SEARCH

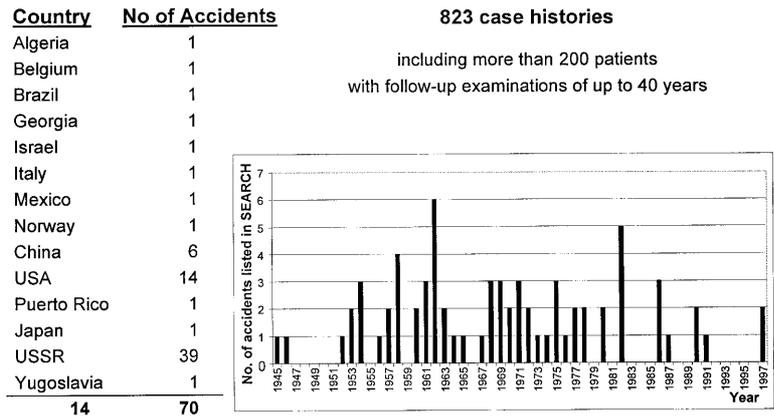
Information on...	Topics (selection)
Accident and personal exposure conditions	General description of the accident, source of irradiation, individual shielding, duration of exposure, dose estimates, occupational activity at the time of exposure
Investigator	Reporting physician, primary and definite care institution
General data of the patient	Individual patient data such as age, sex, date of birth, address
Clinical data after exposure	Assessment of subjective and objective clinical symptoms of different organ systems as a function of time, hematological and other laboratory data, survival status
Past medical history	Clinical status before accident, living conditions, occupation prior to accident, habits, family history
Treatment	Drug and non-drug therapy, blood products, hematopoietic stem cell transplantation including donor information
Diagnoses	Diagnostic interventions and repeated special investigations, diagnosis in ICD9/10, information on necropsy
Annexes	Reference tables, conversion tables for laboratory tests, severity scores (e.g. INES = international nuclear event scale, Karnofsky performance scale, location code for skin lesions), normal values, SI units

an incident. This was done in cooperation with some colleagues from the Institute of Biophysics, Clinical Hospital No. 6, in Moscow [12]. Since 1992, an additional database has been established for the acquisition of case histories in the follow-up phase after acute radiation exposure, together with the Institute of Clinical Radiology at the Ukraine Academy of Medical Science in Kiev. In order to also collect case histories after chronic radiation exposure, a third database was developed from 1994 onwards in cooperation with the Urals Research Center of Radiation Medicine in Chelyabinsk. Due to the fact that the above-mentioned databases were developed with basically the same conceptual and logical structure, it was possible in 1998 to merge them together into one database which is now called SEARCH [13].

For each of the above-mentioned exposure patterns (i.e., acute and chronic exposure and their follow-up), questionnaires<sup>1</sup> were developed ensuring that data be documented in a standardized way and format [14, 15]. Apart from elementary information, the questionnaires differ slightly in structure and content in order to gather data unique to the specific exposure pattern. Since data are collected from different countries, English is used as a standard language for all information. Table 1 gives an overview of the principal characteristics to be collected in the questionnaires. This information will then be transferred via user interfaces to the database structure

<sup>1</sup> The "Questionnaire for the clinical, laboratory and functional follow-up of persons chronically exposed to radiation" has not been published, but is available upon request

**Fig. 2** Contents of SEARCH as of January 2000



which allows the clinical data to be retrieved in a corresponding table (Fig. 1).

In SEARCH, any information concerning the accident as such is stored in 11 tables with about 50 columns, whereas clinical data are kept in 117 tables comprising about 1500 columns. These two types of information are linked together by one table which as-signs each patient to a unique identification number (CASENO) and to the corresponding accident.

From the technical point of view, SEARCH is realized in a typical client-server architecture. The underlying database is a relational Oracle 8.0 database with a size of about 480 MB at present [16]. The connection between the database and the client is performed via Internet or Intranet [17]. On the client side, the interfaces or programs for entering data, usually written in MS-Access, use open database connectivity drivers (ODBC) and the SQL-Net package to interact with the central database [18]. Furthermore, similar to an ordinary patient record, graphical applications mainly developed in JAVA for viewing and retrieving the database contents were developed [19, 20].

Due to the sensitive nature of the individual patient data stored in SEARCH, access to the database is limited to authorized clients and personnel only.

## Results

Currently, SEARCH contains 823 case histories. Data were collected from 70 accidents that occurred between the years 1945 and 1999 in 14 different countries (Fig. 2). For 200 persons out of all the case histories, follow-up examinations over a time period of up to 40 years are documented. The intervals for the follow-up examinations depend on the clinical course of the patients as well as on the doctors' judgment. On average an annual re-admittance to hospital was performed in our follow-up cases.

The data sets now available in SEARCH were either collected within cooperation projects with the institutes responsible for the care of the irradiated persons or gained from the public scientific literature. However, so far only about 17% of the major accidents reported

world wide are entered (70 out of 407 accidents) as our effort was mainly restricted to accidents with total or large volume partial body exposure exceeding level 3 of the International Nuclear Event Scale (INES). In an ongoing data acquisition process, to date information is available on about 80% of the significantly exposed victims of the 70 accidents covered in SEARCH. Furthermore, only a small study cohort of 80 persons out of the 940 officially reported residents involved in the Techa River accidents were included who developed clinical signs and symptoms compatible with a known chronic radiation exposure [21].

Using the information available in SEARCH it is possible to evaluate and compare intra- and inter-individual effects of ionizing radiation on different levels of biological organization in the human organism [22]. This can be done by scrutinizing radiation-related symptoms which serve as indicators of effect and therefore are relevant for predicting the patients outcome and the development of secondary late effects as a function of time.

## Discussion

Many national and international institutions as well as scientists and researchers world wide are compiling radiation accident-related information. Depending on the scope and purpose of these institutions or working groups different aspects of the accident information are considered for collection. These local or national databases are important and match for example immediate requirements for establishing a national registry for the documentation of radiation accidents, or a local reference source of overexposed persons.

But as soon as specific information is required, which is suitable for an international comparison of the clinical course of persons irradiated, a standardized system for archiving and retrieving of such data is needed. SEARCH proposes an approach that provides a knowledge base which allows a wide range of scientific hypotheses to be elaborated.

However, it has to be stated clearly that the development of such a system caused and still causes problems that have to be overcome. Some of these problems stem from the fact that SEARCH is an international and interdisciplinary project, with difficulties arising from communication, language and terminology aggravated by the spatial separation of data entry and analysis. Furthermore, rapid methodological developments result in changes of reference values, a widened spectrum of diagnostic interventions or new options in therapeutic management. The introduction of new and automated laboratory methods in the clinical routine over the last decades, for example, can lead to difficulties in the comparison of data over periods of time. Therefore, specific information on the method used and the corresponding normal values are required in order to allow correct interpretation of these data. Such difficulties have to be overcome by constant adjustment to basic standards as well as regular quality control of data entries in SEARCH.

Although only officially known radiation accidents are dealt with in SEARCH, the question of an international access to and use of SEARCH is not yet clarified with respect to property rights, data protection issues etc. At the moment the use of SEARCH is limited to active contributors and regulated in a preliminary cooperation agreement covering these issues. The legal basis and options for a wider scientific cooperation have to be discussed in detail on an institutional level together with proprietors and contributors.

## Conclusions

As SEARCH facilitates a systematic data acquisition and archiving, it provides a unique opportunity for the evaluation and analysis of effects of ionizing radiation on humans including an enhanced ability to compare medical data of "new cases" with those of "older cases".

SEARCH is a valuable knowledge base that can be tapped for various clinical and scientific questions and it is a crucial component of an informed decision-making process in the field of radiation accident management. However, SEARCH is not meant to replace other local databases or individual data acquisition efforts.

It is hoped that in the future more national as well as international colleagues will participate in SEARCH and support this database by providing additional data in order to maintain it as a dynamic instrument. More detailed information on the research and development activities based on SEARCH as well as the preliminary cooperation agreement can be found on the Internet under <http://www.faw.uni-ulm.de/radmed/>.

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