ASQRAD: A COMPUTER CODE FOR THE QUANTIFICATION OF RADIATION DETRIMENT

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Recent years have seen several new analyses of the risk associated with radiation exposure based on updated epidemiological data. This paper presents information on a personal computer code under development that will provide decision-makers and researchers with a tool to aid evaluation of these data. The key elements of the code are described in terms of its objectives, and in terms of its content. As one of the principal aims of the code is its friendliness, there is an emphasis on library and graphics facilities, as well as simplicity of use.

INTRODUCTION

During the last few years, two international organisations, UNSCEAR[1] and ICRP[2] have undertaken extensive re-evaluations of information on the risks associated with radiation exposure. As a consequence, national bodies have sought to determine how this reflects on their own situation[eg 3,4]. These national studies tend to employ different sets of assumptions, and it follows that the quantitative data on risks often do not readily lend themselves to simple comparative exercises. Given that the flow of new data is unlikely to cease, and given also the range of measures of radiation detriment now being proposed to interpret risk, there is now a distinct need for a system that is capable of rationalising and encompassing all the relevant models, population distributions, and other data sets that are important in the quantification of radiation-induced stochastic effects.

This paper describes PC-based software, ASQRAD (Assessment System for the Quantification of RAdiological Detriment), that is being developed with this aim in mind. It is the centrepoint of a joint research project between CEPN and NRPB, and largely funded under the CEC scientific programme, with the support of the Radiation Protection Committee of EdF (France).

OBJECTIVES

It is envisaged that ASQRAD (see Figure 1) will be applied in the development of policies where the radiation risk incurred or averted is an important factor in

decision-making. Obviously, it will also be of use for ongoing research on radiation detriment; it should find application in risk communication and training; and perhaps also in compensation issues. To this end, there are several features, not always associated with scientific software, that are deemed essential.

(i) completeness: ASQRAD will accommodate all the principal health effects models, in particular those that interpret A-bomb survivor and medical exposure data, and a comprehensive range of national population parameters;
(ii) a capacity for simple up-dating and adaptation: the user will be able to input other demographic statistics, and moreover the code is being constructed in such a way as to ensure that revised models can be readily installed;
(iii) simplicity of use: the system will be menu driven and contain default pathways for common applications; and will be supported by help and library facilities;
(iv) sensitivity analysis will be fully integrated; and
(v) display and graphic facilities: a range of these will be available

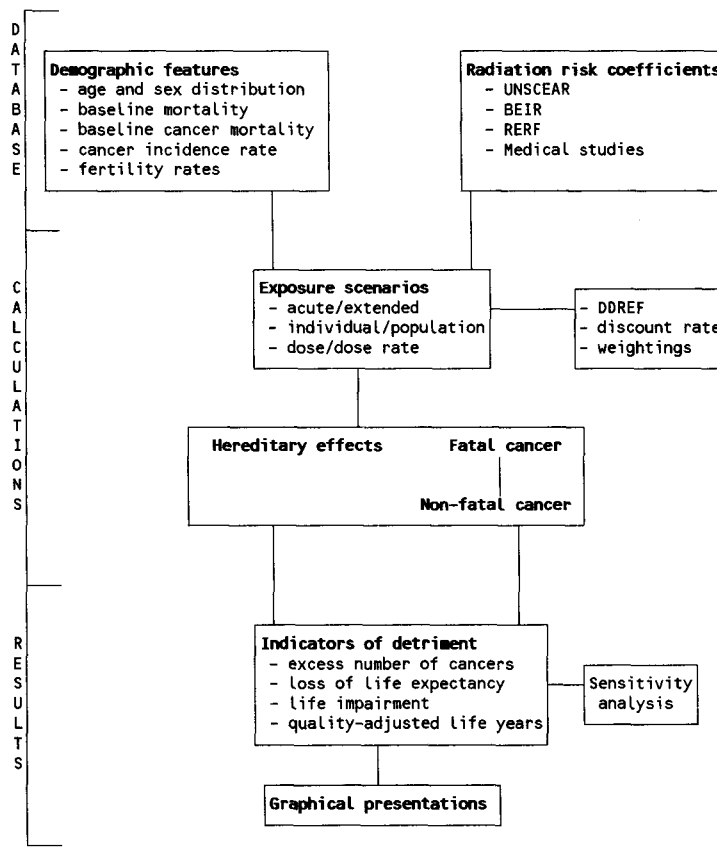

Figure 1. Outline of ASQRAD

HEALTH EFFECTS MODELLING

Risk and detriment estimates are obtained by combining 'fitted coefficients' with demographic details for a given exposure scenario. These health effects models have been developed either for specific organ sites or for groupings of sites, for example 'digestive'. There are two broad types of risk projection model applied. The additive (absolute) is where the results are independent of the baseline cancer rate in the population under consideration, and the multiplicative (relative) is where the results are a function of these baseline rates. Typically, these are becoming more complex as analysts seek to model the data more accurately, and thus often they are neither strictly additive nor multiplicative[5]. The code will, however, provide the user with a choice of all the relevant risk coefficients for each cancer type.

The demographic details required are a breakdown of the populations by age and sex cohorts in terms of numbers, death rates, and the cancer death rates for each site. In addition, two other sets of population statistics are used: the lethality fractions for each cancer type are needed for calculating the probability of non-fatal cancers; and the fertility rates by age and sex (the probability of an individual of given age and sex having a child during the forthcoming year) are used to calculate the probability of hereditary effects in progeny.

With all these data available, it will be possible to perform extensive sensitivity analyses. The library functions will provide background information on the data, and guidance on the legitimacy and consistency of these combinations.

OUTPUT

Measures of detriment will be calculated according to the following scenarios:

(i) individual whole-body exposure: acute or extended (at variable annual dose), to an individual of given age or sex, or assuming an average for both sexes;
(ii) population whole-body exposure: a single low dose and dose-rate exposure to a population (either default or user input) of mixed age and sex;
(iii) non-uniform exposure: assuming doses to a single organ or a combination of organs; and
(iv) committed exposure: as (iii) but assuming an intake of activity

For each of these situations, probability of cancer and hereditary effects, and associated loss of life expectancy (years of life lost, or YOLL) can be calculated directly using a chosen or default DDREF. Moreover, additional measures of detriment are proposed to take into account the severity of these effects in terms of morbidity and lost quality of life. Thus, two other expressions are introduced: years of life impaired (YOLI), and the quality-adjusted life year (QALY).

In addition, it will be possible to sum risk over different periods, for example probability of fatal cancer prior to age 75, and to make direct comparisons of radiation-attributable death rates against background death and cancer rates. The excess risk will also be assessed in terms of the excess lifetime risk (this subtracts the number of cancer deaths that would have been expected in due course in the population from the total

of radiation-induced cancer deaths) as used by BEIR V[4], or the lifetime risk of exposure-induced death, as used by UNSCEAR[1], and in most other analyses.

It is worth adding more detail here on the QALY measure. This was originally developed in the field of health economics for the assessment of health care options that take into account the quality of life during and after treatment as well as survival rate and life expectancy. There is therefore a close parallel with the aspects of detriment that are now being incorporated into radiological protection quantities. As such, if the quality of life associated with different non-fatal, radiation-induced effects can be assessed using health indices[6], then the QALY may provide for a more accurate measure of detriment than has hitherto been available. However, in keeping with the ICRP formulation of effective dose[2], there will also be the option in ASQRAD to weight fatal effects according to YOLL, and to add a weighted non-fatal fraction based on 'curability'.

Extensive graphical presentations of the results will be provided as output in addition to the raw data. The library facility will provide information on any other measures of detriment that may be of interest in addition to those calculated, and also information on the variability and uncertainty of the data.

CONCLUSIONS

This paper has briefly presented a computer code, ASQRAD, for the calculation of the risk associated with exposure to low doses of radiation. The key features of the code are its comprehensiveness, and its simplicity of use. The aim is to produce a tool that is relevant to those decision-makers charged with decisions that require quantified assessments of radiation detriment.

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