STOCHASTIC AND NON-STOCHASTIC EFFECTS . A CONCEPTUAL ANALYSIS .

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Stochastic and non-stochastic effects are defined on the basis of descriptive laws relating dose to the appearance of effects .

Stochastic effects appear randomly in exposed populations and the severity of effects does not depend on dose exposure . The incidence of effects increases with dose .

On the other hand , non-stochastic effects are necessary and all individuals are affected provided the dose exposure reaches a certain threshold . The severity of effects depends on dose . The higher the dose the more intense the effect . Carcinogenesis, increased mutation rate , chromosomal aberrations and congenital anormalities represent stochastic effects . Aplastic anaemia , myelofibrosis , skin lesions, processes involving the destruction and secondary fibrosis of speci- -fic tissues or organs represent non-stochastic effects .

The theory suggests that the effects of ionising radiation can be classified in two separate and mutually exclusive classes , stochas- -tic and non-stochastic effects . In addition it suggests that there are two types of events and two types of dose-effect relationship which correspond prima facie to two different processes . These two distinct processes are described by different natural laws as shown by the presence or absence of a threshold , necessary vs probable ef- -fects, quantitative vs quantal outcome . The terminology underlines a fundamental conceptual difference between these two processes . In the first case the law which describes them supposes a natural neces- -sity and in the second case a probability law . The theory suggests that stochastic and non-stochastic effects represent a partition of the class of effects into two mutually exclusive subclasses .

1. <u>On the necessity of effects</u> . *Are there such things as neces- -sary effects ?*

Philosophy of science shows there are no necessary empirical re- -lations in nature . If <u>a</u> and <u>b</u> are two events (e.g. <u>a</u>,exposure to radiation or to a toxic agent and <u>b</u>,its effect)either <u>a</u> differs from <u>b</u> , in which case <u>a</u> can happen in the absence of <u>b</u> , or the two e- -vents are a single and unique event in which case <u>b</u> necessarily fol- -lows <u>a</u> . In other words if two events are bound by a law of necessi- -ty the two events are identical .

Let us suppose that event <u>a</u> , swallowing a lethal dose of potas- -sium cyanide , occurs at time t_1 , and that event <u>b</u> be the death of the person . As long as there is a time interval (t_2-t_1) between the two events , it is possible that the second event will not occur because of the possibility of intercurrent events or interventions (the subject may vomit or else the repletion of his G I tract may slow down absorption..) . One can object that this example is mis- -leading . Event <u>a</u> should be defined as the swallowing of cyanide and its passage through the wall of the G I tract into the blood . But this will not do either , since the subject might be receiving some sort of antidote . The only way to establish a necessary connection between a and b would be to include "cerebral death" in the definition of a ; a would be a lethal dose of cyanide which causes death so that the dose-effect relationship becomes necessary . However a is now no more distinct from b and the necessity which binds outcome to exposure is definitional and no more empirical or contingent . This discussion illustrates a well-known principle of logic : necessity is of semantic nature . Natural laws describe regularities of nature and never express necessary connections but only contingent ones .

2. On the complementarity of stochastic and non-stochastic effects . *Are non-stochastic effects the residue left after substracting stochastic effects from the class of effects ?*

If the terminology is correct , the answer is yes . But is it correct ?

Actually stochastic and non-stochastic effects are not two different empirical or biological processes but rather two ways of looking at reality which means they mainly differ in the conceptual approach .

In the case of stochastic effects the exposed population (rats, cells, persons ..) is defined by its exposure and the observed outcomes are analysed according to dose . A *dose-response* or *dose-per cent curve* is obtained which is a qualitative relation between dose and percentage of response . In the case of non-stochastic effects the exposed population instead of being defined by exposure is defined by outcome and one obtains a *dose-effect relationship* . The outcome in the second case is quantitative while in the first case , percent of response is quantal or qualitative . Radiodermatitis can be described as a quantitative effect of ionising radiation and in this case it represents a non-stochastic effect . If on the other hand one considers the dose-response of a population of skin cells it is possible to describe the radiodermatitis as a stochastic effect with the recruitment of an increasing number of cells with increasing radiation dose .

High thresholds are needed to produce so-called non-stochastic effects since a certain percent of response is needed to obtain a phenomenological , i.e. clinical , skin erythema, a cataract or a tissue fibrosis .

Conclusion

1. It is argued that stochastic and non-stochastic effects are not complementary i. e. that they do not represent a partition of the class of radiation effects .

2. Stochastic and non-stochastic effects represent different ways of describing outcomes and the "non-stochastic" or necessary character of some effects is of semantic nature .

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