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ALEATORY UNCERTAINTIES

Aleatory uncertainties can be understood as those arising from factors internal to the system. They are inherent, unpredictable and stochastic in nature. The other type of uncertainty is epistemic that arises from limitation of knowledge. The details of epistemic uncertainties are also given.

VARIATION DUE TO HOST FACTORS

Most prominent contributor to aleatory uncertainty in the context of medicine is biological variation among the subjects. This could be both in terms of factors such as age, gender, heredity, and parity that can not be manipulated, and in terms of anthropometric, physiological, and biochemical parameters that can be manipulated to a degree. Different signs-symptoms can emerge in different patients because of these variations.

Other factors at individual level are socio-economic such as income, education and occupation. They can work through life-style, personal hygiene, and nutrition on one hand, and knowledge-attitude-practice regarding health on the other. Cultural and behavioural factors also cause a lot of variation. Psychological factors such as personality traits and tension-anxiety-stress can cause independent variation or can operate through addictions such as smoking and drug abuse, altered sexual and other behaviour, as also through self-esteem and confidence level that could be dominant factors for some health conditions. All these can affect the susceptibility or vulnerability, and the response to a stimulus such as a drug can vary. We have presented these variations in a simplistic format but they all work in a web affecting each other in an intricate manner.

OTHER NATURAL VARIATION AND ENVIRONMENTAL FACTORS

Natural variation among observers, instruments, and laboratories is also aleatory. This includes inadvertent measurement errors. Human reliability is not uniform as each person performs differently on different occasions—perhaps interacting with the nature of the occasion. Thus there is inter-observer variability and there is intra-observer variability. Only the chance component of these is aleatory. Biases, preferences, and inadequacies are epistemic about which we discuss separately.

The last level of aleatory factors is environment. This comprises factors such as water supply, pollution levels, infection load, weather conditions, population and vehicular density, and communication facilities. In addition, accessibility and affordability of health care services,

their timeliness, and quality can make a substantial difference. Family and societal support also are prominent contributors.

Obviously all the above-mentioned factors can not be simultaneously observed in any practical set up. At the same time, interaction can not be studied without observing them simultaneously. Unobserved factors can cause substantial uncertainty. Even among observed factors, unobserved values also generate certain amount of uncertainty. Whereas these two aspects are basically epistemic, they can have chance component that could be aleatory.

SAMPLING FLUCTUATION

A product of one or more of the above factors is the sampling fluctuation. However, the term applies to the estimates of the characteristics of the target population and not to the individual values. One group of subjects tends to give results different from the other groups despite being chosen from the same target population. Medicine is an empirical science that invariably depends on the evidence provided by samples. Uncertainty remains a prominent component of the decision in this set up.

Another aleatory uncertainty arises from applying group results to individual cases. Even if the study is perfectly executed on a representative group, the results are in terms of probabilities. These results hold in the long run in certain percentage of cases but can desperately fail in some individual cases.

MANAGEMENT OF ALEATORY UNCERTAINTIES

One important feature of aleatory uncertainties is that they are empirical and can be evaluated by probability. Second aspect of aleatory uncertainty in medical research is its control. This is achieved by developing a design that can provide evidence largely free of variation encumbrances. Various designs are presented separately.