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COMPARISON OF BAYESIAN-UTILITARIAN AND MAXIMIN PRINCIPLE APPROACHES

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Abstract. The Precautionary Principle implies the adoption of a set of rules aimed at avoiding possible future harm associated with suspected, but not ascertained, risk factors. Several philosophical, economical and societal questions are implied by precaution-based public health decision making. The purpose of the present paper is to specify the scope of the principle examining the notion of uncertainty involved, and the implication of different approaches to the decision-making process. The Bayesian-utilitarian approach and the approach based on the maximin principle will be considered, and the different meaning of prudence in the two settings will be discussed. In the Bayesian-utilitarian approach the small number of attributable cases will end up in a low average expected value, easily regarded as acceptable in a cost-benefit analysis. In a maximin approach, on the other hand, the issue will be to consider the high etiologic fraction of a rare disease in the highest category of exposure. In the light of the aforementioned cautions in interpretation, the core difference between the two approaches has to do with the choice between averaging knowledge or equitably distributing technological risks.

Key words:
Precautionary Principle, Bayesian approach, Maximin role, Electromagnetic fields

The Precautionary Principle implies adoption of a set of rules aimed at avoiding possible future harm associated with suspected, but not ascertained, risk factors [1]. According to this definition, when an adverse effect is ascertained, its avoidance is based on prevention, not on precaution. On the other hand, precaution cannot be invoked in order to avoid a technological development whose future adverse effect can merely be hypothesized in the absence of any evidence. The domain of precaution thus lies in between the domain of proper prevention and instances in which no action is warranted.

A recent World Health Organization (WHO) workshop extensively discussed a central issue in the implementation of the Precautionary Principle, namely to define what is meant by "prudent approach to risk" [2]. It was stated, among other things, that adoption of the Precautionary Principle implies some sort of immediate action followed by a second stage of undertakings, including scientific investigations and search for alternatives. Action inspired by precaution is characterized by uncertainty, and the policy framework should thus regularly be reviewed.

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Several philosophical, economic and societal questions are implied by precaution-based public health decision making. The purpose of this paper is to specify the scope of the principle by examining the notion of uncertainty involved, and the implication of different approaches to the decision-making process. The Bayesian-utilitarian approach and the approach based on the maximin principle will be considered, and the different meaning of prudence in the two settings will be discussed.

Uncertainty may have at least a two-fold meaning. An adverse health effect may be ascertained in qualitative terms, e.g., the carcinogenicity of an agent, in the absence of a quantitative risk assessment. These instances can be dealt with using the Bayesian notion of risk. Alternatively, the presence of the adverse effect may be suspected but not proven, which implies the actual notion of uncertainty. The precautionary principle can be applied in both cases.

According to the Bayesian-utilitarian approach, as elaborated by Harsanyi [3], which is largely used in public health, it is rational to choose the action with the most favorable outcome for all involved. In this frame the expected value is the weighted sum of all possible consequences of the action, and the weights are given by the probabilities associated with each consequence; probabilities are usually based on prior knowledge.

"Maximin", from "maximum minimorum", is a rule according to which, in decision making, our attention should be focused on the worst outcome possibly occurring in any course of action, which should be taken into account in the decision process [4]. Alternative options should be classified according to their worst possible result. The worst alternative consequences should be avoided, even if highly improbable.

Both approaches are concerned with social welfare, but the first considers it as the amelioration of the total or average well-being, while the second as the reduction of the gap between those who are better and worst off. As such the maximin strategy is considered more adequate to deal with the problem of distributive justice; inequalities are allowed inasmuch as they maximize long-term expectations of the worst-off part of society. In this framework, one society can be said to be better than another if the worst-off members of the former do better than the deprived members of the latter.

Before comparing these two approaches in the context of environmental health decision making, it should be stressed that conventional methods of risk management leading to "evidence-based" policies at the light of cost-benefit analyses have provided major contributions to public health [5].

Decision making based on the Bayesian-utilitarian approach may not be successfully applicable in all contexts characterized by scientific uncertainty and mostly whenever the issue of equity in exposure distribution is raised. Limited work, however, has been done in the environmental health sciences in order to clarify alternatives to such an approach [6].

An example may help to illustrate the different practical implications of Bayesian-utilitarian and maximin approaches in the frame of precautionary action. Since this example refers to possible long-term effects of extremely low frequency (ELF) magnetic fields, some preliminary points should be made.

Exposure to magnetic fields generated by electric power lines is associated with an increased risk of childhood leukemia. Nine case control studies on this association have been the object of a pooled analysis by Ahlbom et al. [7] who estimated an odds-ratio of 2.00 (95% confidence interval (CI) int. 1.27–3.13) for residential exposures to more than 0.4 μT. The same authors offer a dose-response function based on a constant increase of the odds ratio for a unit increase of exposure. The causal meaning of this association is currently being debated. According to the International Agency for Research on Cancer (IARC) [8], there is limited evidence of the carcinogenicity of ELF electromagnetic fields in humans, leading to their allocation to the category of possible carcinogens (group 2B).

Conflicting opinions exist in the scientific community about the appropriateness of applying precautionary policies to electromagnetic fields in general, and ELF electromagnetic fields in particular. Foster et al. [9], with reference to radio-frequency electromagnetic fields, criticize the use of mandatory exposure limits for precautionary reasons, while favoring supplementing international limits with precautionary policies aimed at improving public acceptance of new emitters. Kheifets et al. [10] suggest that the Precautionary Principle should merely provide a general framework for electromagnetic field exposure regulation, while cost-benefit analysis should provide guidance for decision making in specific contexts. Jamieson and Wartenberg [11], finally, emphasize the need to overcome a difficulty often raised by governmental bodies: resistance to regulate on the basis of avoiding false positives that may heighten public anxiety. This argument could be rejected through education of citizens to risk assessment and dissemination of information. In the aforementioned WHO workshop, the applicability of the Precautionary Principle to ELF electromagnetic fields was discussed but no general agreement was reached.

The purpose of the present example is not to advocate in favor or against the adoption of a precautionary approach for exposure to ELF electromagnetic fields, but to discuss health impact estimates under the Bayesian utilitarian or maximin approach.

Martuzzi [12] applied the relative risks estimated by Ahlbom et al. [7] to a categorization of exposure levels in the Italian population initially developed by Anversa et al. [13] and subsequently modified by Polichetti [14]. This model only takes into account the high tension transmission lines. The annual estimated number of attributable cases corresponding to exposure at more than 0.2 μT is 2.31 (95% CI 0.42–6.82). If this figure is compared to the average annual number of childhood leukemia (about 430 cases) [15], it represents a small fraction. If the same figure is referred to the total number of children living in buildings with the highest exposure levels (about 10 000–15 000 children experience more than 1 μT), it turns out to be of the same order of magnitude of the number of expected cases.

The model, as it has been stated, considers a possible, not an ascertained, long term health effect and is affected by low precision.

Even if it is assumed that the association may be causal, in the Bayesian-utilitarian approach the small number of attributable cases will end up in a low average expected value, easily regarded as acceptable in a cost-benefit analysis.

In a maximin approach, on the other hand, the issue will be to consider the high etiologic fraction of a rare disease in the highest category of exposure. The suggested solution will be to concentrate efforts in order to mitigate exposure among this particular subgroup of population.

As it was stated earlier, the purpose of the present contribution was not to embrace a particular approach, but rather to illustrate some value-laden aspects that frequently underlie risk management and decision making. At the same time, while considering these options, it may be appropriate to pay attention to some distinctions.

Individual and societal decision levels are inherently different, and any comparison between the Bayesian-utilitarian and the maximin approach should explicitely be referred to one of these two levels. Analogously, the difference between self-inflicted and involuntarily imposed risks should not be overlooked.

In light of the aforementioned cautions in interpretation, the core difference between the two approaches has to do with the choice between averaging knowledge or equitably distributing technological risks [16]. While fairness of outcome has to be evaluated case by case, there is a widespread awareness of the growing importance of fairness in the decision making process itself. The latter implies, among other things, competence, and independence of involved stakeholders, coupled with transparency of the whole process. The procedure itself can thus be said to have moral relevance.

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