Why cannot we conclude to the harmful effect of electric and magnetic fields or their safety on the basis of a single study?

Prepared by Belgian BioElectroMagnetics Group (BBEMG)

To determine whether exposure to fields is harmful to health, researchers use different study methods:

- Epidemiological studies
- Controlled clinical studies in humans
- *in vivo* studies (on animals)
- *in vitro* studies (on cells and tissues)

Each method plays its part; each method has its advantages and disadvantages (Table 1).

Epidemiological studies should normally be the most interesting considering human health because they take into account individuals in their environment.

➔ But establishing a relationship between an environmental factor and an illness is a delicate process because a factor can cause disorder in one person and not in another. Moreover, it is difficult to isolate a particular factor in the multitude of factors that constitute our living environment (chemical, physical factors...) and our individual characteristics (genetic and socio-economic factors...).

Therefore, epidemiological studies need to study a large number of people. Based on data, researchers get an overview of the relationship between the studied factor and a disease. Despite its interest in human health, it is important to note that epidemiology gives **correlations, rarely causal relationships**. If an association is found between a factor and a disease, it does not mean that the factor caused the disease because to be causal, several criteria must be verified.

➔ Other study methods are needed to improve the understanding of the pathophysiological mechanisms and to improve the credibility of epidemiological studies.

Well-conducted in vitro studies can reveal mechanisms of action at the cellular or molecular level that can explain pathophysiological effects. But the results of in vitro studies do not necessarily mean that an effect will be observed in vivo.

It should also be remembered that if the in vitro methods have a **high sensitivity** (few or no false negatives, i.e. negative results that do not reflect reality: they are false because they should not be negative), they have a **low specificity** (many false positives, i.e. positive results that should not be). It means that a negative result is probably really negative, but a positive result must be confirmed by other in vitro or in vivo studies.

Results obtained by one method must be confirmed by other study methods.

It is clear that no method is neither perfect nor infallible. Each of them requires a very rigorous working protocol. Despite their efforts, researchers can hardly take into account all parameters. Take the example of epidemiological studies: it is needed to not only consider a sufficient number of individuals, which is not always possible in the study of « rare » diseases, but also to identify confounders, to adapt the working protocol…

In laboratory studies, it is needed to properly control parameters to which cells or animals are submitted and to work with specific animal or cell models, in accordance with the purpose of the study. Further information are available in in vitro studies and in vivo studies.

➔ According to the difficulty of having perfect experimental conditions and the fact that all parameters cannot be controlled, results of one single study are rather meaningless.

Results of a single study are not sufficient to validate a theory.
It is compulsory to replicate the study and to compare with results of other laboratories.

In summary…

Results of a single study cannot allow drawing conclusions. It is only accurate to formulate hypotheses, which will need to be confirmed by the replication of this study or by other studies.

Scientific validation of results requires a thorough evaluation of all well-conducted studies for which results are available. Often heard statements that assert that fields are dangerous based on the results of a study are therefore incorrect.

For their part, researchers must do all they can to publish well-controlled studies. It is on this basis that it will be possible to answer the question: Are electric and magnetic fields harmful?

Table 1 - Advantage and disadvantage of each method

Epidemiological studies

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• Focused on people • Real-life exposure • Studies on acute and chronic exposures • Conclusions in termes of mortality and morbidity • Studies on potentially hypersensitive people	• Causal relationship? • Taking into account all confounding factors? • Accurate assessment of the actual exposure of subjects? • Very expensive and time-consuming studies (in particular cohort studies)

Controlled clinical studies in humans

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• Understanding of pathophysiological mechanisms of action • Identification of possible protection measures • Explanation of the observed data of mortality and morbidity	• Ethical limits • Studies of effects related to acute exposures • Limited number of subjets • Very expensive studies and specific infrastructure

Studies on animals (in vivo)

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• Many animals can be studied • Relatively inexpensive studies • Use of more invasive procedures • Studies on chronic exposures • Use of specifi model (eg: genetically modified…)	Extrapolation of results to humans? • Animal ≠ Human • Specific experimental conditions

Studies on cells and tissues (in vitro)

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• Understanding what is going on at the cellular level • Swiftness • Negative result in vitro = Negative result in vivo • Relatively inexpensive studies • Use of specific cell lines	• Cells treated outside their normal environnement • Difficulty to properly simulate in vivo exposure