

Transparent Democratic Foresight Strategies in the California EMF Program

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SYNOPSIS

A California Department of Health Services program dealt with possible health effects from Electric and Magnetic Fields (EMF) from power lines. With the advice of stakeholders, and well before any risk determinations were made, transparent policy analyses about the power grid and schools asked the question, "How confident must one be of how big an effect before one would adopt cheap or expensive EMF avoidance measures?" A risk evaluation was carried out with features that promoted transparency. It was formatted to provide a policy-neutral "degree of certainty of causality" to adherents of utilitarian, environmental justice, and libertarian policy frameworks. Though the program had many features advocated by adherents of the precautionary principle, it might be better characterized as following "Transparent Democratic Foresight Strategies," since no single principle justifies the strategies used in this participatory program, and it examined the pros and cons of options but made no recommendations, precautionary or otherwise.

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In November 1993, after a several year process of stakeholder involvement and regulatory hearings, the California Public Utilities Commission (CPUC) asked the California Department of Health Services (CDHS) to oversee a program, whose approach has substantial relevance to discussions of precautionary strategies. While no risk management recommendations were made, precautionary or otherwise, to increase transparency and exercise foresight, the California Electric and Magnetic Fields (EMF) Program did explore the pros and cons of EMF-avoidance policy options, according to a range of criteria, well before any risk determinations were made. It was democratic in that a Stakeholders Advisory Committee (SAC) suggested both the policy options to be explored and the criteria to judge them. The risk evaluation was more transparent than usual in that it was governed by publicly discussed guidelines aimed at making the evaluation of precautionary strategies possible. The Program's web site, <http://www.dhs.ca.gov/ehib/emf>, contains all the Program's products.

CREATION AND GOAL OF THE CALIFORNIA EMF PROGRAM

California Public Utilities Commission Decision 93-11-013 created the California EMF Program to do research and provide education and technical assistance on the possible health effects of exposure to electric and magnetic fields from power lines and other uses of electricity. Funded by money provided by the state's investor-owned utilities and overseen by stakeholders, the \$7 million program continues to be based in the California Department of Health Services. Its goal is to foster a rational and fair approach to dealing with the potential hazards, if any, of exposure to EMF. The Program is scheduled to end on June 30, 2003.

PROGRAM STRUCTURE AND OVERSIGHT

The Program had both stakeholder and outside scientific oversight. The CPUC decision that created the California EMF Program states that the involvement of stakeholders and the public is very important to the development of effective EMF policies to assure that what is done is relevant and unbiased. This decision required CDHS to determine what form of stakeholder and public involvement best met its needs. CDHS decided that the most appropriate role for the SAC would be to advise the Program on the development of the research projects and on budgetary matters, and to monitor its progress to ensure that the scientific and

technical staff members could exercise their responsibility and authority to carry out an effective program on behalf of the CPUC. The core members of the SAC include representatives from established public interest groups (e.g., the state Parent Teacher Association, and so on), unions, utilities, and citizens concerned about health effects. The California EMF Program assembled the SAC in 1994 and they have met several times a year since then.

At the request of the SAC, the California EMF Program created an external Science Advisory Panel (SAP) to provide scientific opinions and guidance on the Program's Risk Evaluation Guidelines and the Risk Evaluation itself. An additional function of the SAP is to comment on whether the policy analysis documents incorporate the uncertainties about potential biological effects of EMFs in a scientifically sound and unbiased manner. The members of the SAP had to be free of conflict of interest and not to have taken sides in the EMF debate.

The goal of the Program's extramural research was to help answer the following three questions that decision makers face as they deal with the EMF issue:

- Is there a health problem? (risk research)
- Where is the problem? (exposure assessment and analysis)
- What are the policy options and their pros and cons? (policy analysis)

In order to answer these questions, the Program included policy analyses with regard to possible EMF avoidance along the power grid and in schools; exposure assessment studies in schools, electric cars, and in workplaces; and the epidemiology of EMFs and miscarriage.

As a result of SAC discussions, the Program staff members were asked to pursue a "program synthesis" that included two elements:

- An evaluation of the evidence of risk based on results of this program as well as other research;
- A policy integration document to help decision makers use the results of the policy analyses.

Formatting the risk evaluation for use in policy analysis (precautionary or otherwise)

One of the unique characteristics of the California EMF Program was that its risk evaluation was formatted to be transparent and to be used in policy analyses. The Program funded two policy projects, one to evaluate avoidance options on the power grid, and one to evaluate avoidance options in schools. Both projects

addressed the question: “How certain does one have to be of how big an effect before one would pursue cheap or expensive EMF avoidance measures?”

These projects in turn required the California EMF Program scientists to consider the various streams of experimental and epidemiological evidence to derive a “degree of certainty,” which was: (a) an input variable in the cost benefit decision trees used, respectively, in the school and the power grid policy analyses; and (b) discussions of how various degrees of certainty would be viewed by stakeholders who didn’t adhere to cost-benefit/utilitarian framework—most good for the most people at least cost, but instead adhered to a social justice framework—protect the most vulnerable regardless of cost, or a libertarian framework—protect my autonomy above all else.¹ As a general rule the cost-benefit utilitarian would require a degree of certainty of a health benefit from mitigation that would make cheap or expensive avoidance options cost beneficial for society at large (tolerating the disadvantage of stakeholders who were few in number). The social or environmental justice stakeholder would advocate expensive avoidance to protect the most vulnerable and/or the previously disadvantaged, unless there was virtual certainty of safety and, therefore, no benefit from mitigation. The libertarian stakeholder, regardless of the certainty of hazard, would protect autonomy, the right to know, and voluntary individual actions. Thus the same degree of certainty could lead these different types of stakeholders to very different courses of action.¹

The main thrust of the rest of this article describes the means used by the program to achieve transparency, a balanced concern for false positives and false negatives, and a policy-relevant formatting of conclusions in the EMF risk evaluation.

How experts combine streams of evidence to make judgments about causality has been of great practical interest. Musen et al. emphasize two general approaches.² One is to infer statistically (see Holman et al. 2002)³ or interview experts about the rules they usually employ. This approach assumes that the rules of thumb that experts use are optimal. As Holman points out, however, this may not always be the case. The other approach is to use statistical information to indicate what weights ought to be used for different pieces of evidence. An example of this was de Dombal’s early work using a probabilistic approach to diagnosing acute abdominal pain on the basis of the prior probability of patients with certain diagnoses showing up in emergency rooms, and the relative likelihood conveyed by elements of medical history, physical signs

and laboratory test results in the several possible diagnoses.⁴ According to Musen et al. neither approach has so far been reduced to computer applications that render the combining of streams of evidence as an uncontroversial, cut-and-dried activity. It should be expected then, that the analogous task of risk evaluation will still rely on professional judgment and will not be free of controversy. For this reason the California EMF stakeholders urged Program staff members to opt for transparency rather than computational elegance in the risk evaluation guidelines. Even though we didn’t actually use the variety of statistics commonly called “Bayesian,” the format of the verbal discourse we used *was* influenced by the insights of Thomas Bayes, an 18th-century mathematician.⁵ His insights suggest that one starts with some initial degree of certainty that any given agent is capable of being harmful, based on knowledge about agents in general. Then one accumulates evidence on this specific agent. The pattern of the accumulated evidence is examined to determine if it would be relatively more likely under the hypothesis that the agent caused disease than under the hypothesis that the agent is harmless. If this relative likelihood is big, one updates one’s degree of certainty (that the agent is harmful) to be greater than it was initially. We describe below just how we embodied these basic ideas in the format of verbal discourse that we used. This format could be called a “Bayes-Influenced” format.

To begin with, Program staff members received training to avoid the classic pitfalls of probability elicitation and then elicited their own expert judgment about their initial (prior) degree of certainty that magnetic fields could cause some degree of excess risk of disease. This degree of certainty related to the following specific question: “How certain are you that EMFs at or above the ninety-fifth percentile of residential exposure (2 milliGauss) conveys epidemiologically detectable relative risks ($RR > 1.2$), when compared to the first percentile (and below) of residential exposure?”⁶ This prior degree of certainty was based on general principles and not based on the research done specifically on EMFs during the last 30 years. For purposes of transparency, it was important to be explicit about prior certainties, because a large range of prior degrees of certainty among different kinds of scientists explained one source of the EMF controversy. For example, some physicists argue on the basis of physical theory applied to simplified biological models of the cell, that any biological (much less pathological) effect from residential EMFs was impossible, and thus had a vanishingly small initial credibility.⁷ This meant

that these physicists would require extraordinarily strong, specific evidence to increase their posterior (updated) degree of certainty above their initial impression, and this tended to make them discount any incriminating evidence as defective in some way. Previous risk assessments had not explicitly revealed the reviewers' prior degree of certainty or its importance for their ultimate conclusions.

After a carefully structured discussion of the evidence, the staff reviewers elicited their own expert

judgment on the posterior degree of certainty about a causal relationship. In the discussion, they considered how much more (or less) likely the pattern of evidence would be if the hypothesis was true that everyday EMFs conveyed risks of regulatory concern as compared to the likelihood of that evidence if EMFs were safe. This consideration was guided by a series of pre-agreed upon questions, or evidentiary tests, with graded (a lot less likely, somewhat less likely, about as likely, and so on) answers (see Table 1). As Hutchison and

Table 1. Evidentiary tests relevant to causality

<i>Alternative explanations</i>
Chance: How likely is it that a meta-analytic or pooled association from these studies is due to chance alone?
Bias: How convinced are we that EMFs, rather than a study flaw that can be <i>specified and demonstrated</i> , caused this evidentiary pattern? If no specified bias explains it, how convinced are we that EMFs caused these associations rather than <i>unspecified</i> flaws?
Confounding: How convinced are we that these disease associations are due to EMFs rather than to a <i>specified and demonstrated</i> risk factor associated with EMF exposure? If not due to a specified risk factor, how convinced are we that they are due to EMFs rather than to <i>unspecified</i> confounders?
Combined effect: How convinced are we that these disease associations are due to EMFs rather than to a combined effect of chance and specified or <i>unspecified</i> sources of bias and confounders? (Attributes similar to those often used by epidemiologists to evaluate the credibility of a hypothesis).
Strength of association: How likely is it that the meta-analytic association is strong enough to be causal rather than due to minor study flaws or confounders?
Consistency: Do most of the studies suggest some added risk from EMFs? How likely is it that the proportion of studies with risk ratios above or below a RR of 1.0 arose from chance alone?
Homogeneity: If a large proportion of the studies have risk ratios that are either above or below a RR of 1.0, is their magnitude similar (homogeneous) or is the size of the observed effect quite variable (heterogeneous)?
Dose response: How clear is it that disease risk increases steadily with dose? What would be expected under causality? Under chance, bias, or confounding?
Coherence/visibility: How coherent is the story told by the pattern of associations within studies? If a surrogate measure shows an association, does a better measurement strengthen that association? Is the association stronger in groups where it is predicted? What would be expected under causality? Under chance, bias, or confounding? How convinced are we that the magnitude of epidemiological results is consistent with temporal or geographic trends?
Experimental evidence: How convincing are the experimental pathology studies supporting the epidemiological evidence? What would be expected under causality, bias, chance, or confounding?
Plausibility: How convincing is the mechanistic research on plausible biological mechanisms leading from exposure to this disease? What would be expected under causality, chance, bias, or confounding? How influential are other experimental studies (both <i>in vivo</i> and <i>in vitro</i>) reporting effects other than the endpoint under consideration?
Analogy: How good an analogy can we find with similar agents that have been shown to lead to similar diseases? What would be expected under causality, chance, bias, or confounding?
Temporality: How convinced are we that EMF exposure precedes onset of disease and that disease status did not lead to a change in exposure?
Specificity and other disease associations: How predominantly are EMFs associated with one disease or subtypes of several diseases? What would we expect under causality, chance, bias, or confounding? How much is our confidence in EMF causality for disease X influenced by our confidence that EMFs cause disease Y?

Table 2. Example of pro, con, and summary argument

<i>Chance</i>		<i>Comment and summary</i>
<i>Against causality</i>	<i>For causality</i>	
Not all the associations are above 1.00 or statistically significant.	The narrow confidence limits in the meta-analytic summaries and the low likelihood of this pattern of evidence by chance leans away from chance as an explanation.	A non-chance explanation must be sought.

Lane have pointed out, consistently asking how likely the observation is under both the causal and non-causal hypothesis (etiological balancing), and answering in a graded, rather than a “yes/no” format, leads to a more balanced assessment, which is concerned with both false positives and false negatives.⁸

The discussion included pro, con and summary arguments. Table 2 is an example of how the pro and con format was applied to the question of whether to require that all studies reach conventional statistical significance or whether to pay attention to the direction of results, even if not all studies were “statistically significant.”

The streams of evidence, which are relevant for judgments on EMF health effects, are biophysical evidence about the physical induction mechanism, biological evidence about mechanisms linking physiological to pathophysiological changes, experimental evidence on animal pathology, and epidemiological evidence. The “Bayes-Influenced” perspective, used by the California EMF Program reviewers, recognizes that a reassuring pattern of evidence from a stream of evidence that often falsely exonerates agents does not allay one’s suspicion as much as a reassuring pattern of evidence from a stream of evidence that is not prone to falsely exonerate agents. Thus, the fact that a mechanism for EMF effects has not been found by research techniques, which have also not found mechanisms for agents whose pathological effects are well accepted, means the exonerating evidence does not lower our confidence as much as it would if most harmful agents were mechanistically understood soon after their harmfulness was suspected. Appendix II of the Program’s Risk Evaluation Guidelines (available from: URL: <http://www.dhs.ca.gov/ehib/emf/research4.htm#REG>) demonstrates why the likelihood ratio conveyed by exonerating evidence from a test with poor sensitivity is close to 1.0, and thus is not capable of moving us away from our prior odds that an agent is hazardous. Paying attention, in a transparent way, to the inherent proclivity of streams of evidence to falsely

exonerate or falsely incriminate agents is important for a balanced risk evaluation. Though this structured discussion helped organize the reviewers’ judgments, it did not involve a mathematical combination of weights, as would be the case in a quantitative Bayes’ evaluation.

How the “Bayes-Influenced” risk evaluation compares to other approaches

Table 3 compares the “Bayes-Influenced” evaluation to the traditional and quantitative Bayes approaches to risk evaluation with regards to a number of characteristics. Both the “Bayes-Influenced” and the quantitative Bayes evaluations provide a posterior degree of certainty, which, if in the range from 10% to 90%, will often stimulate policy discussions. The statements often used in the traditional risk assessment to describe this range of certainty—“there is no proven hazard” or “there is no consistent evidence”—will not stimulate such discussions and this traditional format for presenting conclusions may be preferred by those who have an interest in not changing the status quo. Thus, both the “Bayes-Influenced” and quantitative Bayes methods pose risk communication “problems” for those who believe that society should not begin policy discussions until most scientists are absolutely certain (e.g., more than 90% certain) that a hazard exists. The traditional hazard identifications would pose the same problem if they routinely used more nuanced categories of hazard, which distinguished between 11% certain and 89% certain. As it is now framed, the traditional format for expressing conclusions poses a risk communication problem for those who believe that policy discussions *should* begin before most scientists are extremely certain that a hazard exists.

Some of the commentators on the EMF Program’s draft Risk Evaluation seemed to believe that the “Bayes-Influenced” approach would inevitably lead to a higher degree of confidence than the traditional risk evaluation approach. We see no reason why that should be true. We have no doubt that critics could use the

Table 3. Comparing styles of risk assessment: traditional, Bayes-Influenced and quantitative Bayes

<i>Characteristic</i>	<i>Usual method</i>	<i>Bayes-Influenced</i>	<i>Quantitative Bayes</i>
Evaluates all streams of evidence	Sometimes	Yes	Focuses on epidemiology, other streams influence prior
Elicits prior probability	No	Yes	Prior dose response curve
Compares likelihood of each element of the evidence under the hazard and non-hazard hypotheses	No	Qualitatively	Quantitatively with many of the parameters subjectively elicited
Pro, con and summary arguments to make rationale transparent	No, most risk assessments are skimpy in justifying hazard categories assigned	Yes	Not unless a supplementary document were to accompany the model
Combines relative likelihoods mathematically to derive posterior	No	No	Yes, but in some versions non-epidemiological evidence is folded into the prior subjectively
Elicits an expert posterior probability after considering all elements of the evidence	No	Yes	No
Displays judgments of various judges separately	Usually strives for semblance of consensus	Yes	Technically possible for different experts to elicit their own parameters
Frames median degrees of confidence as "not a proven hazard"	Usually	No, reveals posterior probability	No, reveals posterior probability

"Bayes-Influenced" format to make their points. A physicist, who believes that he has a theory to prove that no residential EMF effect is possible, would use very low priors. A toxicologist, who believes that exonerating animal tests prove that EMFs are safe, would make a case that the animal study results pull down his/her degree of certainty of a hazard to a level below the initial degree of certainty. In a contentious area such as EMFs, we doubt very much that any of the three styles of risk evaluation discussed in Table 3 would force a consensus among subject-matter experts who weigh and interpret the several streams of evidence differently. Even in the quantitative Bayes model, experts will use different priors and will elicit different subjective relative likelihood parameters for the items, such as bias and confounding, for which there is no direct evidence. But the reasons for these different judgments will be transparent in the "Bayes-Influenced" style of risk evaluation, because of the use of pro and con arguments about what the pattern of evidence means, because the principles by which those arguments were guided were made explicit, and because the a priori degree of certainty has been made explicit. The traditional risk assessment is usually heavy

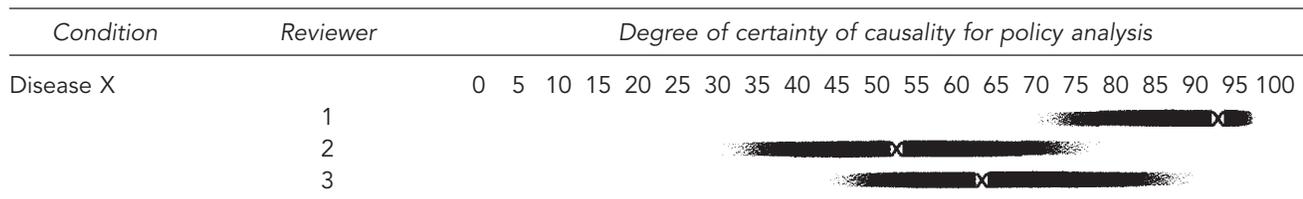
on the description of the evidence and light on the reasoning behind the conclusions. The only quantitative Bayes risk evaluation for public health, of which we are aware, is highly quantitative, quantifies only the epidemiological part of the argument, and is accessible only to the few people who are adept in "Bayesian" statistics.⁹ But a quantitative Bayesian risk evaluation could, with some translational work in the future, be made transparent as well. We believe that this transparency is desirable in controversial areas.

What phrases should we use to express our degree of certainty?

The Risk Evaluation Guidelines specified that the three CDHS reviewers would present their hazard evaluation for a series of endpoints in three forms:

- A degree of certainty number for use in the policy models;
- A pre-agreed upon English phrase to describe this degree of certainty;
- The International Agency for Research in Cancer (IARC) hazard classification (so as to compare the CDHS evaluation with the recent Na-

Figure 1. A format for displaying degrees of certainty of several reviewers



The EMF Programs policy analysis required the three reviewers to express their professional judgments that the added personal risks suggested by the epidemiological studies were “real.” They did this as a numerical “degree of certainty” on a scale of 0 to 100. They each created a graph, similar to the example given above, that depicts their best judgment as an “x” and the margin of uncertainty with a shaded bar.

tional Institute of Environmental Health Sciences (NIEHS), and IARC evaluations).

We presented our prior degrees of certainty and our updated degrees of certainty about EMF causality in a graphical form similar to Figure 1 (we do not present the actual EMF judgments because at this writing the final risk evaluation has not been cleared for release). The scale, which ranges from 0 to 100, is represented as an arbitrary scale, and not as a percent or as a probability, to avoid the confusions described later in this article. For both the prior and the updated degrees of certainty, each reviewer’s best judgment was presented as an “x” with a shaded bar around it to indicate the uncertainty. We believed that seeing the range of opinions, and the uncertainty bars, would allow decision makers to plug in a range of values into the policy models to see if they influenced the options chosen. Having access to the degree of certainty is also of use to adherents to ethical frameworks other than “the most good for the most people at the least cost.”

The English phrases were surprisingly difficult to settle on. We started with one set in the Guidelines, found difficulties in using them during the writing of the draft of the Risk Evaluation itself, and went through several iterations with the SAP, to finally settle on the phrases and graphical representation in Figure 2.

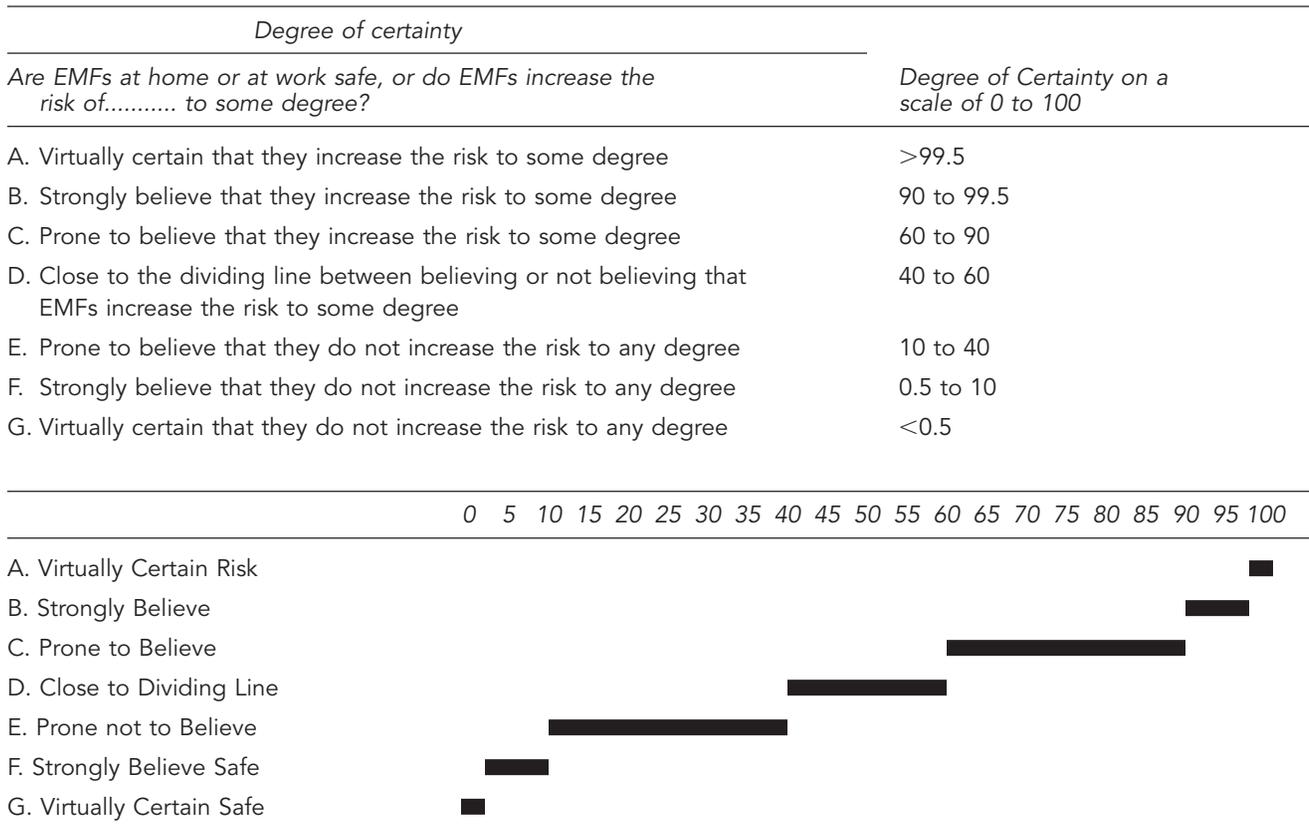
As mentioned before, the decision models prepared for the Program required the staff members to provide a degree of certainty that the epidemiological risk—conveyed by exposure at or above 2 milliGauss relative to the risk conveyed by very low exposures—represented a causal, as opposed to a chance, biased, or confounded association. This certainty number was converted to a fraction and used as a kind of weight to develop an “expected effect” in the policy analyses models. A 10/100 confidence in a relative risk of 50 would be the same as a 100/100 confidence in a relative risk of 5.0 (since $0.1 \times 50 = 1.0 \times 5$). The cer-

tainty number needed to be distinguished from the epidemiologically estimated probability that an exposed person would develop the disease. For example, we could be 99/100 sure that a 2 milliGauss exposure would double the annual risk of male breast cancer from 1/100,000 to 2/100,000 per year, but that does not mean that 99 of 100 exposed men will develop breast cancer. The degree of confidence also needed to be distinguished from the probability used in tort law that a particular person, living next to a transmission line, with a disease, such as male breast cancer, got his cancer as a result of that transmission line. As language was extremely important in this particular area, we tied the degree of confidence to an understandable range of exposure, “at home or at work.” Then, to signal to the reader that we had not yet specified *how much* added risk was involved, we couched our certainty as the belief that EMF “increase the risk to some degree.” As mentioned above, the certainty scale in Figure 1 is a number between 0 and 100, which is purposely not presented as a probability or a percent, so as to avoid confusing it with (a) the probability of developing the disease; or (b) the probability that existing disease in a particular person was caused by EMFs. The categorical boundaries purposely avoided the cut point at 50% used in tort law to deal with the probability that a particular person was harmed by a hazardous agent.

Should one display the winner-take-all majority position of review committees or reveal the judgments of the individual members of the committee?

The three California risk evaluators displayed their individual numeric degrees of certainty, the standard English phrase that best described it, and the IARC category they thought most appropriate. The IARC hazard identification categories are:

Figure 2 . Phrases and graph to describe degrees of certainty of causality



1. Carcinogenic to humans;
2.
 - a. Probably Carcinogenic to Humans (sufficient epidemiological evidence or limited animal plus limited epidemiology);
 - b. Possibly Carcinogenic to Humans (limited epidemiological evidence);
3. Evidence Inadequate to Classify (inadequate animal and epidemiological evidence);
4. Not Carcinogenic to Humans.

The IARC categories were not designed to denote particular ranges of certainty, so stating the IARC category does not provide a format that is useful for quantitative decision analysis or ethical analysis. Deciding whether an agent falls into the 2a (probable) or the broad 2b (possible) category hinges on the interpretation of the adjective *limited*, which in turn depends on the interpretation of the adverb *reasonably*, as applied to the question whether bias, confounding, and chance could be reasonably excluded as explanations of epidemiological associations or animal effects.

Though each of the three CDHS reviewers revealed their own determinations, only one of us, VDP, was invited to participate in the IARC review of EMFs in June 2001. We discovered that the IARC process involved an additional filter. The panel, as a whole, votes on the animal data, and the majority opinion—as to whether it is sufficient, limited, or inadequate—is noted. The group then votes on the epidemiological evidence in the same way. The majority opinion on the two streams then strongly influences the final classification. Thus, even though VDP thought the animal evidence was limited and the epidemiological evidence was sufficient, he was constrained to vote for a “Possible 2b” for childhood leukemia, since the majority of the committee thought the animal evidence was insufficient and the epidemiology limited. This use and display of a majority vote and the decision *not* to reveal the committee’s vote count, seems predicated on the assumption that the scientific community ought to serve as a kind of gatekeeper for society, protecting it from false positives and from the confusion engendered by scientific disagreement. The California EMF

Program placed this burden back on policy makers by revealing each reviewer's IARC classification, the more nuanced "degree of certainty," and the pre-agreed upon English language descriptive phrases. We also contrasted the California IARC classifications with determinations made earlier by IARC and NIEHS. The California EMF Program did this with the belief that uncertainty should be made explicit, and that it is the public decision maker's burden to decide what to do in light of this kind of uncertainty.

TO WHAT EXTENT DOES THE CALIFORNIA EMF PROGRAM EXEMPLIFY THE PRECAUTIONARY PRINCIPLE?

The Wingspread formulation of the precautionary principle is:

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of a full range of alternatives, including no action.¹⁰

Although the project staff members of the California EMF Program were not familiar with the precautionary principle literature when the project began, some, but not all, features of the Program seem to coincide with strategies recommended in the Wingspread statement:

1. *Foresight—Don't Wait for Certainty to Explore Policy Options:* Before full confidence in an EMF hazard was established, alternative courses of action were explored through policy analysis projects, which included computerized decision models that stakeholders could use and challenge.
2. *Foresight:* The policy projects posed the question, "how confident does one have to be of how big an effect before one should pursue cheap or expensive EMF avoidance procedures?"
3. *Democratic Involvement of Stakeholders:* Stakeholders were involved in the direction of the Program and in the details of the policy projects. Stakeholders were provided funding to obtain their own experts.
4. *Transparent Formatting of Scientific Conclusions to Accommodate Various Policy Frameworks:* Careful thought was given in the Risk Evaluation Guidelines on how scientific judgments could be for-

matted so that stakeholders could use them. We developed an understanding, not mentioned in the Wingspread statement, that stakeholders often operate with different ethical frameworks. We wanted to be sure that adherents of environmental justice, libertarian, and utilitarian policy frameworks would find the information in our risk evaluation to be usable. In particular, we looked for evidence about inequitable exposures and vulnerabilities to respond to environmental justice concerns. We expressed our judgments in a nuanced graded fashion, so as not to preclude the evaluation of precautionary risk management prior to absolute certainty about EMF hazards.

5. *Summarizing Science Transparently and Valuing Both False Positives and Negatives:* Careful thought was given in the Risk Evaluation Guidelines as to whether we should use inferential steps that were equally concerned with false positives and false negatives. The inferential procedure was to be as transparent as possible. The risk evaluation itself uses Bayes Theorem as a heuristic for guiding the explanation of why a degree of confidence of causality was chosen. It involves an explicit presentation of the a priori credibility of the EMF hypothesis, and a pro and con discussion of the likelihood of the observed pattern of evidence under the hypothesis that EMFs caused disease, as compared to the hypothesis that there is no EMF effect and only bias, confounding, and chance, to explain the observed evidence.
6. *Transparent Policy Discussions:* The Stakeholders were involved in the initial framing of the policy analyses and the computerized decision models were made available so stakeholders could run them with varying assumptions about costs and risks.
7. *Burden of Proof:* The Program was funded by the utilities (and ultimately the ratepayers), but overseen by a Stakeholder Advisory Committee.

The Program has features that some precautionary principle advocates would probably dislike:

1. The project makes no risk management recommendations precautionary or otherwise. It explored the pros and cons of low and high cost avoidance strategies on the power grid and in schools in ways that adherents to the several policy frameworks would find useful, but leaves the choice of options to a political process at a later stage.

2. Unlike the Wingspread statement, the project recognizes the existence of utilitarian, environmental justice, and libertarian adherents in the body politic and that individuals may shift frameworks depending on whether they themselves derive benefit or pay the costs of an option. The policy analysis, therefore, addresses all concerns, including those of cost.
3. Cost-benefit and cost-effectiveness sensitivity analyses *are* carried out for the benefit of the utilitarians in society, but the written analysis and the computer models are also prepared so as to illustrate the impact on different stakeholders and the importance of economic assumptions. Indeed, the models allow stakeholders to change assumptions, such as discount rate, value of a human life, cost of mitigation, confidence in hazard, size of hazard, and so on, to see how they influence the assessment of the various mitigation options considered. Some proponents of the precautionary principle have grave reservations about cost-benefit analysis.¹¹
4. The project does carry out risk assessments based on epidemiological studies and provides best professional judgments as to:
 - a. The degree of certainty that EMFs increase risk of certain diseases, to some extent;
 - b. The population burden of morbidity and mortality that might be avoided by certain mitigations (of interest to utilitarians);
 - c. The added lifetime risk to highly exposed individuals (of interest to adherents to the social justice policy framework);
 - d. The probability of escaping the EMF relevant diseases, even if highly exposed for a lifetime (of interest to individuals making their own choices).

Some advocates of the precautionary principle prefer no use of risk assessment at all.¹¹ Since the EMF issue rests primarily on epidemiological evidence (the right species and the relevant dose of the relevant mixture of exposures), approximate estimates of risk were deemed relevant by our stakeholders and they asked for the risk evaluation, which we ultimately provided.

PRINCIPLE OR STRATEGIES?

We think it is more accurate to state that, as California EMF Program scientists, we followed *transparent democratic foresight strategies*, rather than state that we were

guided by the *transparent democratic foresight principle*. Invoking a principle invites critics to demand that one state what that single principle is, and one cannot do that, because, in fact, a number of different basic ethical principles underlie the strategies the Program chose to use.

The promise of a “fair and rational” approach to the EMF controversy reveals that we were guided by ethical principles aimed at benefiting stakeholders (beneficence), not harming them (non-maleficence) and facilitating their autonomy to make their own informed decisions, and making clear, in the risk evaluation and policy analysis, any potential injustice in the distribution of risks and costs. These are basic *duty-ethics* principles.¹² However, recognizing that stakeholders have diverse interests and that any public policy will affect them differently, the policy projects sponsored by the Program rationally evaluated the likely impacts of policies on different stakeholders. So this was a *results-ethics* commitment to exercise *foresight*. When policies affect stakeholders in different ways, participation is deemed important so the Program had, as a policy, the commitment to *democratic* processes. But for democracy to work, the participants need to be well informed, and this logically leads to the commitment to be *transparent*. Thus the Program had, as a matter of policy, the commitment to be transparent in the discussion of policy and in the “Bayes-Influenced” style of risk evaluation. Hence, we could call these actions “Transparent Democratic Foresight Strategies.” Since the products of the Program did not include risk management recommendations, precautionary or otherwise, the activities of the Program could not be called precautionary in the usual sense of the word, although the policy of the Program was to go to great lengths to make sure that cheap and expensive precautionary options were considered and evaluated. The risk management steps by the CPUC and the California Department of Education have not yet begun. Only then, when that process is complete, will one be able to evaluate whether the strategies used in the California EMF Program were helpful in facilitating a fair and rational course of action.

Though the authors led the program described above, the views expressed in this article are those of the authors and do not necessarily reflect opinions of the California Department of Health Services.

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