

Lessons from the California EMF Program (1994-2002)

Raymond Richard Neutra MD
DrPH

Status Quo vs Calif. Approach

- Status Quo
 - Hazard Assessment: certain/not, appeal to authority instead of reasons
 - Risk Management: only if certain, no other reasons, yes/no management.
- Calif Approach
 - First explore cheap and expensive alternatives and ask how certain you need to be to select them, considering ethical and practical reasons
 - Provide Hazard Assessment on scale of certainty with reasons for degree of certainty.

Required Certainty Principle

- The degree of certainty *required* for precautionary action ought to get smaller if the potential hazard is:
 - Severe
 - Wide-spread
 - Irreversible
 - Unfair
 - Cheap to correct

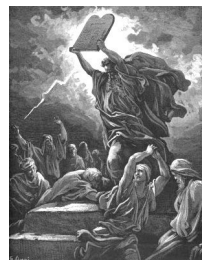
A Basic Policy Question

- *“All other things being equal how certain must we be of how much ill-health before we would opt for cheap or expensive protective alternatives?”*

Answer depends on Ethical World View

- Duty ethics (Deontological, Kantian)
- Result ethics (Utilitarian)

We ought to do that which best conforms to Moral Duties



- Deontological ethics
- Moses: Honor your mother and father even when it is not cost-beneficial to do so.
 - Kant: Don't lie no matter what!

Do that which increases happiness for the most people



- Utilitarian, Results-based Ethics
- Jeremy Bentham
- Cost Benefit Analysis
- Problem: Swamps minority interests

Different Precautionary Styles



- What protection for powerline neighbors?
- Utilitarian: Decision tree: buy up electric blankets
- E.J. spare no cost to remove exposure
- Libertarian: Post signs

Examples of Utilitarians, Kantians

- Utilitarians
 - Business interests
 - Engineers
 - Regulators
 - Scientists
- Kantians
 - At risk citizens who don't pay for mitigation
 - Right wing ideologues about war
 - Left wing ideologues about environment

Simplified Excel Model

OVERALL ANALYSIS:

CAUTION: The sliders are set in the middle of the scale. These values may not be reasonable. For reference, the analysis base case values are in column B.

Total Equivalent Cost per Mile for 35 Years - 115 kV Line

Alternatives	No Change	Re-Phasing	Underground
Distribution Line Retrofit			
EMF Health	\$680,501	\$124,205	\$12,953
Cost	\$574,016	\$577,436	\$3,773,049
Property Values	\$0	\$0	-\$1,685,333
Outages	\$119,657	\$119,657	\$111,541
Total	\$1,374,174	\$821,298	\$2,212,210

USER SELECTIONS

Economic Assumptions	Base	User	Min	Range	Max
% of TPC Financed	80%	80.0%	0%	0% - 100%	100%
Interest Rate	10%	10.0%	0%	0% - 20%	20%
Discount Rate	3%	3.0%	0%	0% - 10%	10%
Probability of Hazard	7	0.1	0	0 - 100	1
Risk Ratio	7	2	1	1 - 500	5
Mitigation Effectiveness					
Opt Phasing	\$1.8%	81.8%	0%	0% - 100%	100%
Undergrounding	98.1%	98.1%	0%	0% - 100%	100%
Total Project Cost Multiplier					
Opt Phasing (1+\$1.75K)	1	1	0	0 - 3	3
Undergrounding (1+\$1.650K)	1	1	0	0 - 3	3
Property Values (1+\$1.655K)	1	1	0	0 - 3	3
Values					
One Life-Year Lost	\$100K	\$100,000	\$0	\$0 - \$500K	\$500K
One Non-Fatal Cancer	\$300K	\$300,000	\$0	\$0 - \$500K	\$500K
One Alzheimer's Case	\$200K	\$200,000	\$0	\$0 - \$500K	\$500K
One Person/Challenge Hour	\$10	\$10	\$0	\$0 - \$20	\$20
One Contingency	\$10K	\$10,000	\$0	\$0 - \$100K	\$100K

Total Project Cost Multiplier Bar Chart:

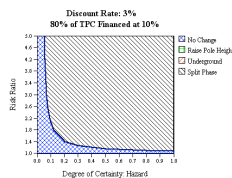
- Outages: ~\$1,000,000
- Property Values: ~\$0
- Cost: ~\$3,773,049
- EMF Health: ~\$12,953

Alternatives Bar Chart:

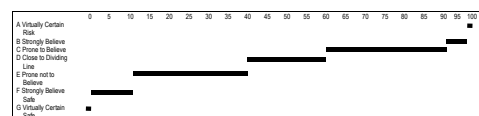
- No Change: ~\$1,374,174
- Re-Phasing: ~\$821,298
- Underground: ~\$2,212,210

Even Economists Don't Require Absolute Certainty for Precaution

- Ask how certain must be of how much disease before adopting cheap or expensive avoidance



Transparency: Used Degree of Warranted Certainty, not "Yes/No"



Why “Strength of Certification”

- “Likelihood of Causality” or “Probability that it is Causal” evokes Platonic Quality “out there”.
- “Degree of Certainty” evokes a subjective state that might be unwarranted.
- “Strength of Certification” clarifies that it is a warranted official action done by some real persons (like the inspectors who inspected your beef steak and certified it as Grade A)

Strength of Certification Terms

- *Very Strongly Certify* the X causes an increased risk of Y
- *Strongly Certify*.....
- *Moderately Certify*.....
- *Close to dividing line of certifying or de-certifying*
- *Moderately deny* X as a cause of Y
- Strongly deny
- Very strongly deny.

Why Avoid Dichotomous Certifications?

- If the quality of beef steaks are certified from F to A you want your restaurant to tell you the exact grade and not “this steak is not Grade F”
- Some people will only act on “very strongly certified as causal” while others will act on “moderately certified as causal”

How California Risk Assessment Process Differed From IARC’s

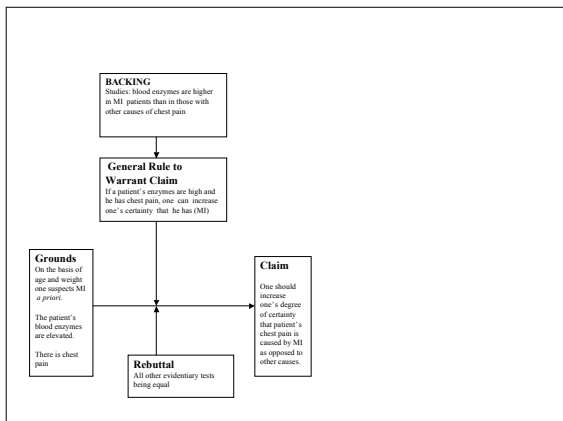
- A risk evaluation guideline was prepared, submitted to public comment, revised and approved by an external advisory committee
 - A) Warranted certainty categories
 - B) Agreed upon inference rules to warrant degree of cert.
- Risk Assessment done by government scientists submitted to public comment and approved (with reservations) by external advisory committee
- All meetings open to public

PROBLEM WITH IARC CLASSIFICATION

- How “probable” is Class 1 B “probable carcinogen”?
- What does Class 2 B “possible carcinogen” mean? “Not impossible”? “Just short of more likely than not?” Coffee and Fiberglass are both in 2B.
- Committee diversity suppressed
- Hinges on adjectives about likelihood of bias and confounding in Epidemiology

Transparent Justification of Claimed Degree of Certainty of Hazard

- Traditional risk assessments are heavy on documenting factual grounds but justify conclusions through appeals to authority: “The IARC committee concluded X after viewing all these studies”
- California risk evaluation guidelines tried to specify the inferential rule to:
 - Warrant admitting a study into evidence
 - warrant degree of certainty.
 - Warrant degree of action given degree of cert.



Steps where rules of inference need to be made explicit

- (1) Entering facts into the evidence "worthy of consideration"
- (2) Moving to warranted degree of certainty from "features of evidence:"
 - volume, methodological quality, pattern of results, consistency of results, multiplicity of streams of evidence, coherence of evidence
- (3) Moving from degree of certainty to degree of mitigation

Bayes' Theorem, the Universal Rule to Warrant Degree of Certainty

- Prior Odds * Relative Likelihood of Evidence = Posterior Odds

Example of Bayesian Thinking

- Prior Odds of Man-of-War winning the Derby are high because he has won all prior races.
- Just before the Derby race I see him limping. Limping is relatively less likely among winners than among losers. Relative Likelihood is a number less than 1.00.
- Multiplying Prior Odds by a number less than 1.0 gives a Posterior Odds that he will win that is lower than the Prior Odds

Display Arguments of Defense, Prosecutor and Judge

CHANCE		
AGAINST CAUSALITY	FOR CAUSALITY	COMMENT AND SUMMARY
(A1) Results are due to chance and multiple comparisons	(F1) Meta-analyses show that overall the association is statistically significant, is unlikely to be due to chance.	(C1) The test of statistical significance on the pooled or meta-analyzed data show that chance is a very unlikely explanation (p<0.02, one sided).

Consistent Evidentiary Tests & Etiological Balancing

SUMMARY TABLE FOR DISEASE			
Evidentiary Tests	Likelihood of this evidentiary test result under:		
	Null hypothesis	Causal hypothesis	Effect on Certainty
chance is not a likely explanation	Very unlikely	Very likely	Increases Certainty
Confounding shown etc	Possible	unlikely	Decreases Certainty

Sources of Uncertainty

- Biophysicists had miniscule prior odds
- (Inadequate) animal studies gave null results
- No demonstrated biophysical mechanism
- No demonstrated carcinogenic mechanism
- Inconsistent animal toxicology
- Only persistent epidemiology results a little above resolving power of studies.

Certification Cannot Flow Automatically from Evidence

- Judges need juries to sift evidence in order to declare guilt.
- Doctors need professional judgement to claim diagnoses on the basis of clinical evidence.
- Risk Assessors cannot mechanically derive strength of certification on the basis of evidence volume, quality and result- pattern

Display Disagreements on Prior and Posterior Certainties

POPULATION	SCIENTIST	MARK CLASS	CERTAINTY PHRASE	RI	DEGREE OF CERTAINTY FOR POLICY ANALYSIS THAT AN AGENT (EMF) INCREASES DISEASE RISK TO SOME DEGREE
infants that could develop leukemia	1	N/A	Prone not to believe	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2		Strongly believe not	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3		Strongly believe not	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
adults	1	1	Prone to believe	29	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	28	Close to dividing line	21	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	28	Close to dividing line	4	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

HAZARD IDENTIFICATIONS (1)

To one degree or another all three of the DHS scientists are inclined to believe that EMFs can cause some amount of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage.

- They strongly believe that EMFs do not increase the risk of birth defects, or low birth weight.
- They strongly believe that EMFs are not universal carcinogens, since there are a number of cancer types that are not associated with EMF exposure.

HAZARD IDENTIFICATIONS (2)

- To one degree or another they are inclined to believe that EMFs do not cause an increased risk of heart disease, Alzheimer's Disease, Depression, or symptoms attributed by some to a sensitivity to EMFs.
- All three scientists had judgments that were close to the dividing line between believing and not believing that EMFs cause some degree of increased risk of suicide.
- For adult leukemia two of the scientists are close to the dividing line between believing or not believing and one was prone to believe that EMFs cause some degree of increased risk,

Summarizing Arguments for Stakeholders

- Summary subjected to focus group
- "The three DHS scientists thought there were reasons why animal and test tube experiments might have failed to pick up a mechanism or a health problem; hence, the absence of much support from such animal and test tube studies did not reduce their willingness to certify causality much or lead them to strongly distrust epidemiological evidence from statistical studies in human populations. They therefore had more faith in the quality of the epidemiological studies in human populations and hence gave more credence to them."

Last Chapter

- 1st Unanimous vote: Reopen Hearings
- PUC ignores issue for 2 years
- Angry power line controversy reopens PUC hearings
- Utilities capture PUC process
- Program products ignored
- Stay with 1993 no and low cost avoidance in new Transmission Lines

Was it Worth It?

- Time will tell
- Flexible computer policy modules and reports still on web to help policy if science heats up again
- Exposure Assessment in Schools, Cars, and Homes on Web
- A tool for predicting workplace exposures
- CPUC probably authorized program to buy time, they did buy time.

Further Reading

- See www.ehpb.org/emf for program products and on-line decision models
- Neutra RR in Wiedemann&Schutz eds Role of Evidence in Risk Characterization, Wiley VCH, 2008
- Von Winterfeldt, Eppel, Adams, Neutra et al. Managing Potential Risks..., Risk Analysis 2004;6(24) 1487-1502
- Neutra RR in Baker and Nieuwenhuijsen eds Environmental Epidemiology, Oxford 2008