APPENDIX B

ON THE PROBABILITY OF NUCLEAR WAR

World War I was the "war to make the world safe for democracy" and "the war to end all wars." If these objectives had been met either by WW I or by WW II, there would have been no Korean or Indo-China wars, and there would have been no need for civil defense; and this thesis would have had to be on some other subject.

> For all sad words of tongue or pen,
> The saddest are these: "It might have been!"
> --John Greenleaf Whittier, Maude Muller

But World War I and World War II did not end wars, and today's prospects for a completely peaceful world do not seem much brighter than they did then.

There are now (and probably will continue to be) wars involving huge numbers of people that History will not classify as one of the World War series. Perhaps at this stage of history, almost by definition, any war that does not include a massive nuclear strike on the homeland of a major world power will not meet the criterion for designation as a World War. It is conceivable even that the nuclear threshold could be crossed through employment of tactical nuclear weapons on the battlefield without escalation to the category of a World War. (Many analysts, however, doubt that escalation could be stopped once either side resorted to nuclear armaments of any type.)

In any case, the probability of nuclear war involving the United States, though perhaps very low, is finite and (unfortunately) seems likely to remain so for years to come. The basic causes for the wars that have occurred more or less continuously throughout history--religious fanaticism (and Communism might be considered under this heading) - aggressiveness - the territorial instinct - misunderstanding - fear - exploitation - liberation--still exist. Indo-China, the Arab-Israelis conflict, Nigeria-Biafra, the Chinese-Russian dispute, and Honduras-Nicaragua, are ready reminders of this fact.

It is not particularly reassuring that no one of these wars has reached the nuclear threshold. In most cases, nuclear armament was not available to the combatants. Would Biafra have resorted to "nukes" if it had the option before its final capitulation to Nigeria? Although wholly academic, this is not a question one can answer with a strong, "NO." Will Israel "milk" her reactors for enough plutonium to make a "bomb" if annihilation seems the only alternative? What change in circumstances would have led the U.S. to employ nuclear weapons in Korea or Vietnam?[1] There would have been those who advocated use of nuclear weapons, or at least the threat thereof, in

[1]General Curtis E. LeMay, former Air Force Chief of Staff, as Vice Presidential running mate on George Wallace's Independent Party ticket in a nationally televised campaign appearance on October 2, 1968, said he "would use anything we could dream up, including nuclear weapons, if it was necessary to win the Vietnam war." [Ref. 20.]

Vietnam, and it is widely accepted that President Eisenhower's threat of nuclear escalation helped bring about the end of the Korean War.[1]

Just what the numerical probability of nuclear war is now, or will be at any given time, is impossible to know (unless of course, we get into such a war). Arthur Schlesinger reports that during the Cuban crisis of 1962, President Kennedy said, "Of course, if you simply consider mathematical chances, the odds are even on an H-bomb war within 10 years." [Ref. 61, p 802.] Schlesinger suggested that the President probably added to himself, "or within ten days."

Many defense analysts would argue that no matter how close we came to nuclear war over Cuba, the danger of war has reduced appreciably since. If true, this reduction at least is partly due to the fact that "Cuba" was a very painful experience for both sides. This can be seen in the agonizing reflected in Khrushchev's personal letter to President Kennedy of October 26, 1962 [Ref. 40, pp 86-90], as well as in Robert Kennedy's account of what was going on in Washington. [Ref. 40.] One tangible result was establishment of the "hot line" between Washington and Moscow, aimed both physically and symbolically to help avoid such a confrontation in the future.

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[1] In his book, Mandate for Change, President Eisenhower said, "One possibility was to let the Communist authorities understand that, in the absence of satisfactory progress, we plan to move decisively without inhibition in our use of weapons and would no longer be responsible for confining hostilities to the Korean Peninsula. We would not be limited by any world-wide 'gentlemen's agreement." In India and in the Formosa Straits area, and at the truce negotiations at Panmunjon, we dropped the word, discreetly, of our intention. We felt quite sure it would reach Soviet and Chinese Communist ears." [Ref. 18, p 181.]

The Niskanen Hypothesis

In a paper written in 1966 [Ref. 52], Dr. William H. Niskanen of the Institute for Defense Analyses suggested some quantitative estimates of the probability of nuclear war (to be abbreviated as P_{nw}). He suggested that P_{nw} could be expressed in the form:

$$P_{nw} = (b + cM^{-d})$$

where:

b = the probability of a strategic attack during a 10-year period, with an indefinitely large U. S. missile force;

$(b + cM^{-d})$ = the probability of a strategic attack during a 10-year period, with a nominal U. S. missile force;

c = a parameter relating to the general strategic environment (his state of preparedness, for example, and our weapon yield);

M = the number of standard survivable U. S. missiles that could penetrate a Soviet missile defense;

and d = a missile effectiveness parameter.

Niskanen argued that the value of b, though small, is not zero--zero being inconsistent with an imperfect understanding of what constitutes deterrence; also, a non-zero value allows for some possibility of accidents and for the chance that someone in authority might get an overwhelming temptation to initiate a nuclear strike--the "mad-leader" scenario. Niskanen selected a value of 0.02 for his base case. The parameter, c, was given a base-case value of 0.4. The parameter, d, is derived primarily from the population distribution (or some other value index) in the Soviet Union. A value of 0.5 was used in the base case, which is to say that potential damage is closely related to the square root of attack level.

To illustrate, assume the U.S. has 1,000 missiles that meet the requirements, then:

$$P_{nw} = (0.02 + 0.4 \quad x \; 1000^{-0.5})$$

$$= 0.03 \text{ (rounded to a single significant figure)},$$

i.e., the chances are 3 in 100 that the U.S. will be, or will have been, involved in a strategic nuclear war during the coming decade. (If M were 2,000, P_{nw} would still be 0.03 as rounded to one significant figure.)

The Richardson Data

Dr. Lewis F. Richardson, in his book Statistics of Deadly Quarrels [Ref. 59], presents a listing of over 300 wars during the period 1820 to 1949, with perceptive statements as to causes and conditions, and the approximate number of dead in each. He applied statistical methods to his body of data and produced important and plausible conclusions, among which were the following:

1. Wars seem to have been distributed in time by chance in respect to both beginning and end. There is no evidence that they have been becoming either more or less frequent, though there seems to have been a tendency, at least since 1820, for large wars to become more and small wars less frequent.

2. The increase in world population from 1820 to 1949 seems not to have been accompanied by a proportionate increase in the frequency of, and losses of life from, war, as would have been the expectation if belligerency had been constant. Thus, "there is a suggestion, but not conclusive proof," that mankind has become less warlike since AD 1820.

3. States have varied from one another in the frequency of their participation in wars during this period, but each has varied so much during its history that none can be properly characterized as inherently belligerent or inherently pacific. The problem of war does not arise from the diabolism of one or a few states.

4. Allies in one war may become enemies in the next, but alliances seem to have had some influence in preventing war between former allies. That influence, however, declines with the passage of time since the war alliance.

5. Similarity of religion seems not to have made for peace, except in the case of Confucianism, but differences of religion have apparently caused war, especially the differences of Christianity and Islam. The statistics suggest, but do not prove, that "Christianity incited war between its adherents."

6. The larger the number of belligerents in a war, the more neutrals have tended to be drawn in. Wars with many participants have tended to be longer and less frequent.

7. A trend for war to become indivisible, that is, for every war to become universal, has not been proved. Most wars have been localized. Neutrals have tended to become belligerents only if two or more world powers have been fighting each other. [Ref. 59.]

The data for the outbreak of wars of magnitudes 3.5 to 4.5 ($10^{3.5}$ to $10^{4.5}$ people killed) over the 110 calendar years from 1820 to 1929 were compared by Richardson with the Poisson distribution of improbable events. The following resulted:

x = war outbreaks in a single year	0	1	2	3	> 4	Total
f(x) = number of such years	65	35	6	4	0	110.0
$Ne^{-\lambda}\lambda^{x}/x\,!$	64.3	34.5	9.3	1.7	0.2	110.0

where:

N is the total number of years and λ is the mean number of war outbreaks per year, 59/110.

Richardson pointed out that there is a considerable resemblance between historical facts and the Poisson Law, and he went on to examine available data in an attempt to gain some idea of the probability of war as a function of number of people killed. A plot of Richardson's data extrapolated to include the range of casualties that might have resulted if a war the size of a plausible nuclear war had occurred during this period, appears as Figure B-1. (The extrapolated range is in the area falling below the dashed line.)

By extrapolating Richardson's data, implicitly it is assumed that nuclear armament of the amount possessed by the nuclear countries during the last ten years had been available to possible combatants during the period of the plot (1820 to 1945) and that, therefore, there could have been wars during that period producing the numbers of fatalities that would be expected in a nuclear war.

The range of fatalities to be expected in a nuclear war, the exact values of which were selected for mathematical simplicity, is from about 32 million to about 320 million ($10^{7.5}$ to $10^{8.5}$). These numbers are not inconsistent with the results of numerous hypothetical attack analyses. This range,

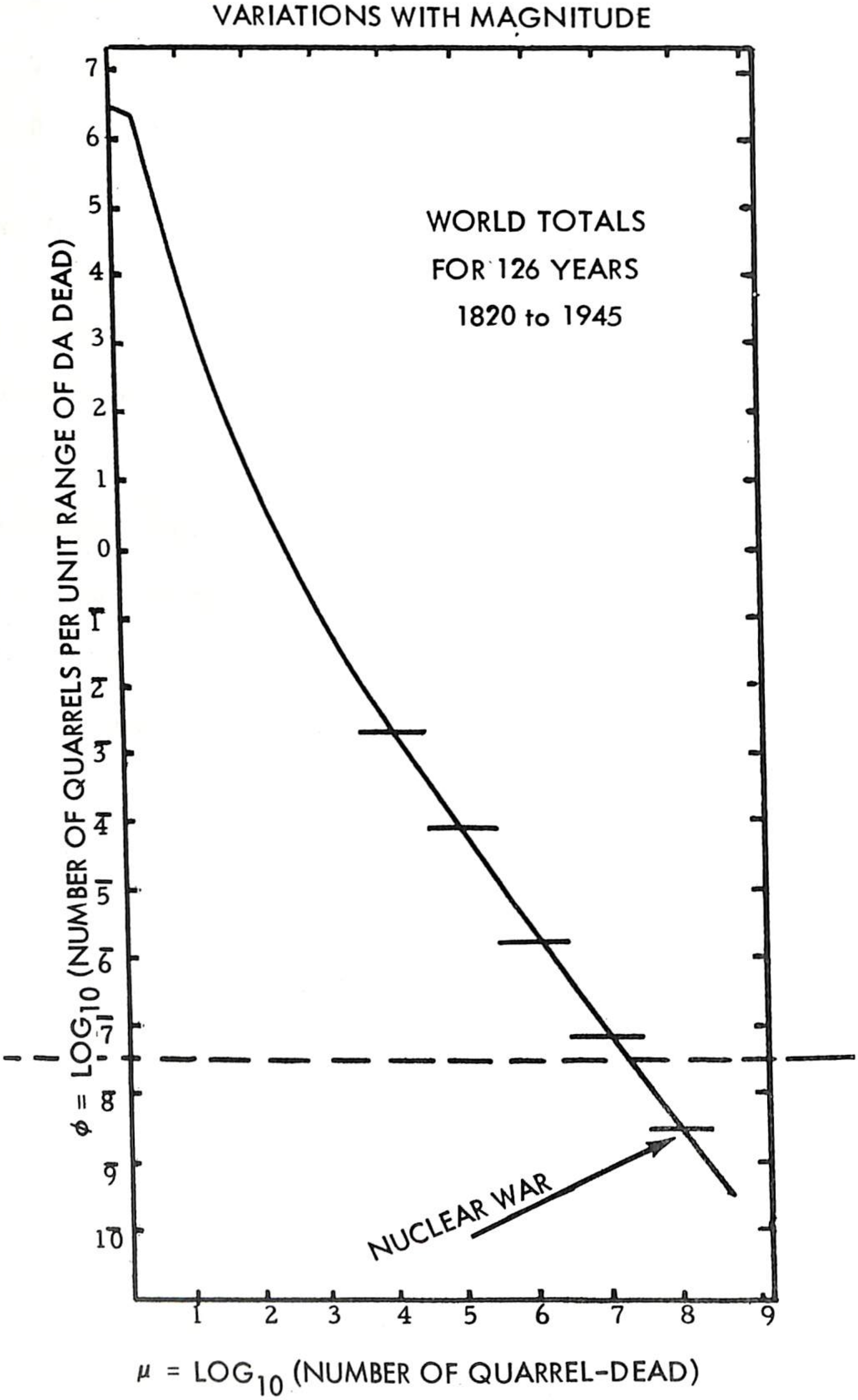

Figure B-1. The Whole Range of Fatal Quarrels (extrapolated to include nuclear war).

7.5 to 8.5, on the abscissa of Figure B-1 marked by the arrow, corresponds with the ordinate value of 8.5.

Therefore:

$$8.5 = LOG_{10} \text{ (number of nuclear wars per unit range of dead).}$$

(The range of dead is 320×10^6 less 32×10^6, or about 3×10^8.)

Therefore:

$$8.5 = LOG_{10} \text{ (number of wars times } 3 \times 10^8\text{)},$$

or

$$\text{Number of wars} = 1/3 \times 10^{0.5} \cong 1.$$

According to this reasoning and this model, the average number of nuclear wars per year would have been 1/126, or about 0.01, and if the future is like the past, the probability of nuclear wars per year is now about one in one hundred.

It is not suggested that the above analysis is in any sense rigid, or even that it should be taken seriously. Rather the analysis is included to illustrate kinds of data that are available, and how inadequate they are as a basis for predicting the future. It may be highly coincidental that the Richardson model gives a number that differs from Niskanen's number by only a factor of about 3 and is in the general range that many people inherently feel is appropriate (see page 93).

In any case, as the editors (Quincy Wright and C. C. Lienau) of Dr. Richardson's book (the book was published posthumously) stated in the introduction to it:

> The proof of the pudding is in the eating. The value of a system of classification and measurement depends upon the results obtained from it. Perhaps Richardson's very emancipation from the professional distortions of the social scientists, lawyers, and historians has enabled him to throw new light on the problem of war. No one should condemn his method without studying its application, the conclusions drawn from its application, and its potentialities for further development. [Ref. 59, p viii.]

There seems to be little hope for developing a satisfactory analytical basis for determining the probability of nuclear war. Even if some analyst could convince himself that his method had validity, he most likely would have trouble convincing others.

The primary reasons for being interested in the probability of war are twofold. First, being aware that the probability is not insignificant might motivate action to reduce it; and second, an estimate of war probability facilitates the comparison of the threat of death or damage by war with the threat of death or damage from other causes and should provide guidance as to where actions are needed to bring threats into balance, if such is found not to be the case.

<u>The Stannard Analysis</u>

Dr. Burke Stannard of the Defense Research Board of the Canadian Department of National Defence, in an article, "How You Risk Your Life--A

Study of Comparative Risks," [Ref. 66, p 30] compared the magnitude of a number of common and not-so-common hazards. Included was an estimate of the probability of death from fallout radiation in the event of nuclear war. (Note that this is a conditional probability, i.e., the probability of death from fallout radiation if the event, a nuclear attack, occurs.)

Dr. Stannard's chart, which is reproduced on the following page, provides a good perspective of the relative levels of various life-threatening hazards.

The University of Pittsburgh Public Survey

The Department of Sociology of the University of Pittsburgh for many years has been engaged in research to find out how the public evaluates and feels about civil defense issues. This research has depended heavily on national public opinion surveys. The following table contrasts the results of a 1964 and 1968 sample. It is taken from the report, American's Perceptions of the International and Civil Defense Environments: 1968. [Ref. 46, p 10.]

LIKELIHOOD OF WORLD WAR III

	1964	1968
Very likely and Fairly likely	39%	44%
Fairly unlikely and Very unlikely	57%	44%
Don't know	4%	12%

CHECK LIST OF COMMON RISKS

	Deaths per billion persons with one hour risk exposure
Being vaccinated or inoculated	1.3
Exposure to radiation in a two hour high altitude flight during solar flare	2.5
Living in area where snakes are present	3.8
Radiation exposure of world population in major nuclear war (areas away from conflict)	5.0
Railroad or bus travel (USA)	30.0
(Britain)	50.0
Child asleep in crib	140.0
Being struck by lightning	200.0
Coal mining (Br.)	400.0
Amateur boxing (Br.)	450.0
Climbing stairs	550.0
Coal mining (USA)	910.0
Hunting	950.0
Automobile travel	1200.0
Air travel	1450.0
Cigarette smoking	2600.0
Mountain climbing (USA)	2700.0
Boating (small boats)	3000.0
Motor scooter riding (Br.)	3000.0
Swimming	3650.0
Motor cycle riding (Canada)	4420.0
(USA)	6280.0
(Br.)	6600.0
Armed forces in Viet Nam	7935.0
Canoeing	10000.0
Motor cycle racing (Br.)	35000.0
Mountain climbing (Alpine)	40000.0
Professional boxing	70000.0
Being born	80000.0

It may be seen that the perceived level of tension in the international arena increased between 1964 and 1968, by which time nearly half the respondents thought World War III was not unlikely.

The University of Pittsburgh surveys consistently have shown that the general public is not opposed to civil defense (as many people who are themselves opposed to civil defense have claimed). There is a "clear pattern of support for civil defense--nearly nine in ten respondents in 1966 were favorably disposed to civil defense . . . (findings) suggest a high level of commitment and support for the goals of public protection as well as for certain means which the Office of Civil Defense has set forth as necessary." [Ref. 46, p 1.]

The Greene Poll

Jack C. Greene, Director of the Postattack Research Division of the Office of Civil Defense (and author of this thesis) during the early part of 1970 conducted a poll primarily among officials of the Office of Civil Defense (but also including a few scientists who have been involved in strategic analyses) in an attempt to find out how likely they considered the event for which they were planning--nuclear war. The question asked was, "What do you think is the probability of a nuclear war between the United States and the Soviet Union in the next decade, that is, before 1980?" If the answer was not quantifiable, for example, "Not very." or "Inevitable." as sometimes it was, the respondent was pressed to provide a numerical answer. Figure B-2 shows the results.

The sample was small (totaling only 34 people), and the data based on it are not claimed to have high statistical significance. It was interesting to note that there was some correlation between status of the respondent in the organizational hierarchy of civil defense and the magnitude of the perceived threat. The higher the responsibility level of the respondent, generally, the greater he perceived the threat to be. One might attribute this to the assumption that the higher the official, the better his information sources or the more realistic his analysis of the problem. On the other hand, one might ascribe it simply to functioning of Festinger's cognitive dissonance theory [Ref. 22], i.e., the higher the position, the more important the role and, consequently, the higher the perception of the threat.

About 35% of Greene's respondents thought the probability of nuclear war involving the United States is greater than one in ten during the next decade; about 62%, equal to or greater than 1 in 10; about 75%, greater than 1 in 100; and 79%, greater than 1 in 1000 (a level below which it was considered that the threat was negligible).

This basically heuristic exercise can be carried one step further by comparing the perceived nuclear hazard with other more familiar hazards. For illustration, assume this is being done for the 62% group of respondents who thought war probability was equal to or greater than 0.1 in the next decade.

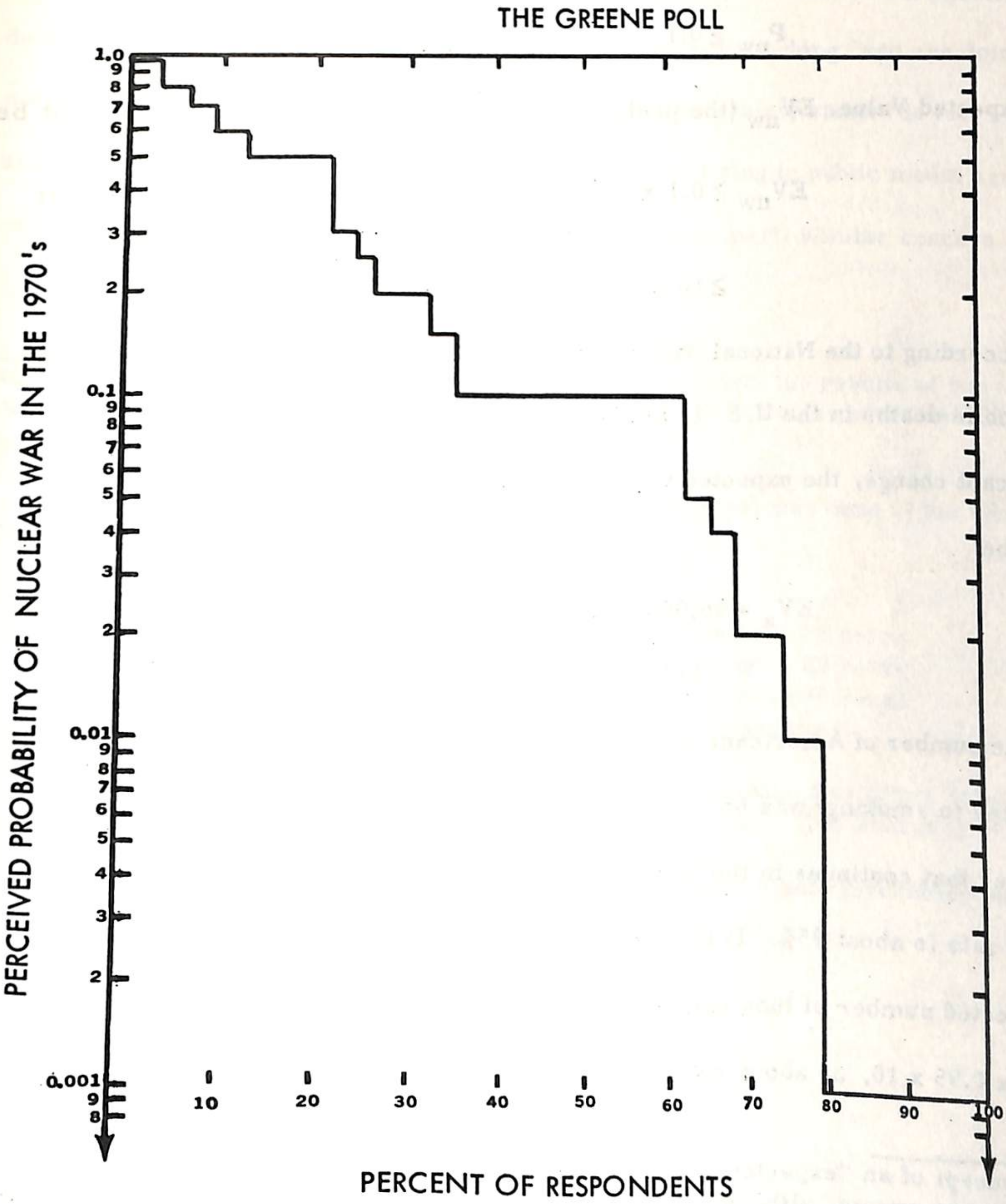

Figure B-2. Estimates of Civil Defense Officials on Nuclear War Probability.

Let P_{nw} again be the symbol, then:

$$P_{nw} \geq 0.1$$

and Expected Value, EV_{nw} (the probability times the consequences), might be

$$EV_{nw} \geq 0.1 \times 10^8 \text{ (100 million is a typical number for the deaths in a hypothetical war.)}$$

$$\gtrsim 10 \text{ million dead in the '70's.}$$ [1]

According to the National Safety Council, the current fatality rate from automobile deaths in the U.S. is about 56,000 per year. Assuming no significant change, the expected value for automobile deaths in the '70's would be:

$$EV_a = 56{,}000 \text{ per year} \times 10 \text{ years}$$

$$\cong 1/2 \text{ million.}$$

The number of Americans diagnosed to have lung cancer (primarily attributed to smoking) was 65,000 in 1968, and 68,000 in 1969; the only type of cancer that continues in the U.S. to increase each year. Currently, the fatality rate is about 95%. If the 1969 rate were to continue through 1980, the expected number of lung cancer deaths in the next decade qould be 68,000 x 0.95 x 10, or about 650,000.[2]

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[1] The concept of an "expected value" for very low-probability/high-consequence events, although mathematically acceptable, is not philosophically acceptable to some people who prefer to think in terms of most probable value. For the case in question, according to the assumptions, the most probable value is zero--the only other possible value being 10^8 dead. The expected value, 10 million, could not occur during a single decade.

[2] Data are from the National Cancer Society obtained by the author (by telephone from the Washington, D.C. office) July 1970.

The general public and its leaders are concerned about the automobile death rate, and about the consequences of cigarette smoking, and are doing something about them. Federally imposed higher-safety standards for automobiles, and restrictions on cigarette advertising in public media are examples. The nuclear war threat would seem to merit similar concern.

NOTE: Subsequent to the first printing of this report, the results of two Delphic inquiries into the probability of nuclear war have become available to me.

The first (which I should have known about earlier) was done at the RAND Corporation in the early '60's. The statistics are:

100 participants

● lower quartile	4% probability over 25 years
● median quartile	20% probability over 25 years
● upper quartile	30% probability over 25 years
● concensus	1% probability per year

The second Delphi was conducted in 1970-71 in connection with a Joint Chiefs of Staff Post Nuclear Attack Study (PONAST II). The statistics are:

30 people (military - government officials - non-government scientists)

- 46% $>$ 10% in next 20 years
- 80% $\geq$ 10% in next 20 years
- median ~1/2% per year
- mean ~ 1% per year.