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RESEARCH TRIANGLE INSTITUTE
Durham, North Carolina

FINAL REPORT VOLUME I

Emergency Health Problems Study

OCD Project 2411A
by
W. T. Herzog
31 July 1963

Prepared for
Office of Civil Defense
United States Department of Defense
under
Office of Civil Defense Contract OCD-OS-62-250

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ABSTRACT

The peacetime health status of the population (based on the U. S. Public
Health Service National Health Survey) and the range of complications due to
shelter living were evaluated. Rough estimates suggest that medical care and
public health measures could add a number of survivors equal to 1 - 2 percent
of the total preattack population during a single two-week period under ideal
conditions. Postattack medical care of casualties would not seriously compete
with measures directed toward health maintenance of the general population, except
for consumable medical supplies. Because casualty care and health maintenance
of non-casualties are capable of adding comparable numbers of survivors during
the shelter period (a maximum of 2 percent of the preattack population for either
type of emphasis), it is concluded that both approaches should be emphasized.

The available data on chronic, non-communicable diseases is sufficient to
allow more quantitative stockpile planning of medical items for these conditions
in shelters. Further research will be necessary before this is true for communi-
cable diseases, because of the complexity of disease spread during shelter con-
finement. A method for optimizing the allocation of drugs for support of non-
communicable chronic and acute conditions to shelters in a stockpiling program
is suggested and illustrated by an example.

GLOSSARY

amebiases -   "amebic dysentery" symptoms include chronic diarrhea and abdominal pain; only occasionally causes death; spread by fecal contamination; incubation period commonly 3 to 4 weeks.

arthropod -   animals of the phylum Arthropoda; including insects; arachnids; and crustaceans.

bacillary dysentery -   an acute bacterial infection; symptoms include fever, cramps and diarrhea; deaths are most frequent among infants and elderly persons and would be rarely fatal to a healthy child or adult; incubation period is usually less than four days.

communicable disease -   diseases caused by specific agents which may be transmitted directly or indirectly between persons.

enteric diseases -   diseases affecting the gastro-intestinal tract.

fatality -   the ratio of deaths from a specific disease to the total number of cases.

febrile -   relating to fever; feverish.

incidence -   the ratio of new cases of a particular disease to a given population unit over a specified period of time.

incubation period -   the time period between exposure to a disease and the onset of obvious symptoms.

infection -   entry and reproduction of disease agents within the body.

infectious disease -   a disease of man or animal resulting from infection by specific disease agents.

influenza -   an acute and highly communicable virus disease; symptoms include sore throat, non-productive cough, chills and back pains; deaths concentrate among elderly, women in late pregnancy, and infants; incubation period usually 24 to 72 hours.

meningococcal meningitis -	acute bacterial infection; symptoms include fever, intense headache, nausea, and vomiting. Fatality is less than 5 percent with modern treatment and 40 - 50 percent without treatment; incubation period 3 to 4 days; also called cerebro—spinal fever.
morbidity -	"sickness", a morbidity rate is usually expressed as the ratio of cases of a disease to the total population.
myocarditis -	inflammation of the muscular walls of the heart.
mortality -	"death", mortality rates are usually expressed for specific diseases as the ratio of deaths to the total population.
pathogen -	any disease agent; virus, bacteria, etc.
prevalence -	the ratio of all cases of a disease to a given population at a given point in time.
triage -	the practice of sorting persons needing medical care into categories according to the order in which they shall be treated. (Through the use of triage medical services can be used most effectively, because those cases for which treatment will be most beneficial can be treated first.)
typhoid fever -	a bacterial disease; symptoms include continued fever, rose spots on trunk and constipation; fatality of 10 percent or over without treatment and about 2 to 3 percent with treatment; incubation period is usually 1 to 3 weeks.

SUMMARY

Scope of Work

The research for this study was directed toward estimating the nature and extent of the health problem in the United States during the first two weeks following a general thermonuclear attack. The original Request for a Proposal from the Office of Civil Defense follows:

1. The contractor shall study and evaluate the overall nationwide health problem following a thermonuclear attack. The time period to be considered shall be from the time of attack through the emergency period (approximately 14 days).

2. The contractor shall study and evaluate, on the basis of progressively increasing shelter capability, whether redirection of present programs are necessary to place more emphasis on the general health of the non-injured population rather than on care and treatment of surviving casualties, and whether the great mass of people in fallout shelters throughout the nation will give rise to new medical problems.

3. The contractor shall study and evaluate the magnitude and nature of the health problem in order to place it in its proper perspective and to better define and plan the preattack and postattack measures that are necessary.

Conclusions

1. The surviving population can be roughly categorized into three groups: a) direct weapons effects casualties; b) radiation casualties; and c) non-casualties. The proportions of the population which are in each of the above three groups will be a direct function of the magnitude and pattern of the nuclear attack. Quantitative estimates of the survivors to be added by emphasizing the care of one particular group are therefore subject to our inability to predict the enemy's strategy at the time of attack. A number of general conclusions can

be made about the maximum probable payoff in terms of survival by providing medical care to the three categories of survivors.

If all medical resources survived and were used to provide casualty care, the maximum number of survivors added could be no greater than 2 percent of the total population. This is due primarily to the fact that medical resources could not treat sufficient numbers of casualties in time to prevent death among the more severely injured.

If all medical resources survived and were used to treat radiation casualties, the maximum number of survivors added would probably be much less than 1 percent of the total population. Due to the fact that there is no known medical technique for effective treatment of mass radiation casualties, the advantage of using medical personnel to treat radiation casualties is of doubtful value. Most of the treatment measures which are recommended by the medical profession are within the capabilities of paramedical personnel and skilled laymen.

If all medical resources survived and were used to maintain the health of the non-casualty population, the maximum number of survivors added during the shelter period would probably be less than 1 percent of the total population. The death rate due to disease and non-attack injury (excluding extremely adverse shelter environments) would probably not exceed 1 percent of the population, even if no medical care were provided. This is because of the

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relatively slow spread of epidemics in their early stages (the
incubation period often exceeds two weeks), the generally short
period of shelter confinement, and the peacetime health status
of the population

2.   Generally, there is very little conflict between casualty care
and health maintenance of the non-casualty population, except for
consumable medical resources. Even with consumable items the
possible areas of conflict are not clear. Medical personnel could
provide care to casualties in the immediate postattack period and
later divert their efforts toward health maintenance of the
general population. Public health personnel could concurrently
direct their efforts to controlling the spread of disease through
maintaining adequate sanitation and instituting epidemic control
procedures.

3.   Although epidemics of diseases which cause limited fatality will
occur in a few isolated shelters, the overall number of deaths due
to disease during the shelter period will probably be less than 1
percent of the total population. A nearly universal incidence of
respiratory diseases of varying degrees of severety can be expected.
The most severe respiratory diseases which can be expected to occur
in some shelters are meningitis and influenza. Enteric diseases
will affect the majority of occupants in shelters that have grossly
inadequate sanitation facilities, or in which widespread vomiting
occurs due to radiation sickness or other causes.

4. Barring the use of biological warfare agents, the combined impact of exotic diseases can be expected to be relatively insignificant during the shelter period. This is due to the small incidence of these diseases among the peacetime population and to the fact that the constraints on mobility will tend to confine the outbreaks that do occur to a limited number of shelters.

5. There is a wide range of uncertainty about the effects of sub-lethal doses of radiation on susceptibility to disease. It is obvious that some increase in the incidence and severity of diseases will be experienced among persons exposed to radiation doses ranging from 100 to 225 roentgens.

Recommendations

It is recommended that:

1. A comprehensive study be undertaken of the health problems of the postshelter period (about one year after attack) in order to estimate the need for medical resources during this time.

2. A sampling survey of NFSS shelters be conducted in order to determine the extent to which peacetime medical facilities (physicians' offices, pharmacies, etc.) are available within shelter buildings.

3. Research should be undertaken in order to determine the proportions of the ensheltered population that could be expected to contract those diseases having high case fatality rates when no medical treatment is provided. This research should include investigation

of the effect of nutritional deficiencies, confinement, and
radiation on the general level of susceptibility.

4. A statistical study should be undertaken to construct a mathematical
model describing the propagation of disease in shelters of various
size capacities.

INTRODUCTION

Scope of Research

This report summarizes the research completed by the Research Triangle
Institute (RTI) and the Department of Public Health Administration, School of
Public Health, University of North Carolina (UNC) on OCD Project 2411A,"Emergency
Health Problems Study." The primary objectives were to study and evaluate the
nature and magnitude of the overall nationwide health problem during the first
two weeks after a thermonuclear attack, and to determine whether redirection
of present programs is necessary in order to place more emphasis on the general
health of the non-injured population. The Office of Civil Defense description
of this project is quoted above in the SUMMARY.

Chapter One contains a brief description of the general parameters con-
sidered in the research, and an analysis of the problems and probable payoff of
providing medical care to casualties resulting from the primary and secondary
effects of thermonuclear explosions. Chapter Two describes the range of health
problems to be expected in a "typical" U. S. population upon entering a shelter,
calculates the expected occurrence of disease in shelters as a function of
shelter size, and discusses the influence of the shelter environment and radia-
tion exposure on the disease spectrum. Conclusions are drawn by estimating the
risk of fatalities due to disease during the shelter period and the payoff of
casualty care. These conclusions and the resulting recommendations to the Office
of Civil Defense are contained in the SUMMARY.

The"Shelter Medical Support System Study" (OCD Project No. 1341A) was
conducted concurrently involving RTI and a team of medical specialists from the
UNC School of Medicine. This study investigated the probable effectiveness of

of alternative strategies of providing medical care to the population during the period of shelter confinement (Reference 8).

Approach

In the course of the research it was necessary to explore four subject areas: (1) the "normal" peacetime health posture of the population; (2) the range of possible postattack environments, including the physical characteristics of the National Fallout Shelter Survey shelters and the survival items being stocked; (3) the interaction of the fallout shelter environment and the fallout radiation itself on the health status of the surviving population; and (4) the probable effectiveness of providing medical care to the different types of casualties which would be expected as a result of a thermonuclear detonation. Generally, the Research Triangle Institute, as prime contractor, investigated areas (2) and (4) while the University of North Carolina, as subcontractor, developed the essential input information on areas (1) and (3).

To provide a base from which to extrapolate to the postattack situation, data from the National Health Survey, gathered by the United States Public Health Service, were used to estimate the peacetime health status of the United States. In this continuing survey, household interviews are used to determine the health status of the respondents according to their own evaluation of their state of health. The National Health Survey data were considered the most appropriate for this study since the survey has been designed specifically to measure the extent of illness and disability of the civilian non-institutional population. Selective Service System records were inappropriate because they are concerned with a non-representative population group. Medical records (hospital admissions,

office calls, etc.) tend to reflect the demand for medical service rather than the actual health status of the population, The detailed findings of UNC are reported in Reference 1, and are summarized in Appendix A.

A scenario (Reference 2) was prepared for the use of UNC in order to define typical values for the several parameters which might be expected to influence the health status of the surviving population of a standard urban area during the first two weeks after attack, These parameters include: age, sex, and race characteristics of the population; NFSS fallout shelter characteristics -- PF, capacities, and survival items; and, a range of attack and postattack conditions.

Information on the interaction of the shelter environment and the health status of the confined population was developed through medical judgement concerning the epidemiology of the more important diseases and review of the available literature on disease spread in similar situations.

The analysis of casualty care, discussed in Chapter One, was based on review of information on battle casualties during World War II and previous wars, and review of the National Academy of Science - National Research Council, reports on natural disasters in the United States. A rough estimate of the payoff of casualty care was established by equating non-professional care tody with the level of care provided by military medical services during the Civil War, and by using data reported in the "Shelter Medical Support System Study."

Constraints

To reduce the scope of research to manageable size, the Office of Civil Defense excluded Bacteriological and Chemical Warfare and Psychoneurotic health problems. It is clear, however, that effective BW-CW would change the casualty picture substantially.

Psychological casualties (persons rendered ineffective due to psychological responses) are probably as difficult to predict as direct effects casualties, but their occurrence (or non-occurrence) has little impact on medical planning for their survival. Forecasts of the case load would permit better planning for their care and for minimizing their impact on other shelterees.

The numerous deficiencies in data (effects of radiation on health, particularly its interaction with disease and wounds, precise estimation of casualty type from direct effects, etc.) are unimportant in the context of the general uncertainties about the nature and magnitude of an attack. At least some of this information, however, will be important in the detailed design of medical plans. Where appropriate, such deficiencies in data are pointed out in the text. If improved medical plans are to be prepared, research is required to eliminate these deficiencies. It is our understanding that many of these problems are currently being investigated by the Office of Civil Defense, although the results are not yet available.

Chapter One

DIRECT WEAPONS EFFECTS CASUALTIES

Introduction

In order to understand the nature and extent of the health problem of the ensheltered population during the first two weeks after attack, it is first necessary to consider the immediate effects of the attack. These effects may be measured in terms of resources destroyed, damage to the nation as a whole, damage to the retaliatory force, or in other terms important to military planners. The primary emphasis of this research has been placed on the public health problems of the non-casualty population during the shelter period. In this chapter we will, however, discuss several parameters relating to care of the casualty population. This information will provide a basis for evaluating the relative payoffs of casualty and non-casualty care.

Parameters Considered

In attempting to estimate the nature and magnitude of the health problem after attack a number of parameters, as listed below, must be considered. From the standpoint of survival of the population as a whole, the most important parameters are those involved in the nature and magnitude of the attack itself (whether counter-force, counter-value, or combined) and the protective counter-measures taken. As a function of these two variables alone, the casualty rate among the population (direct effects and fallout) can be estimated to range from 5 percent to 80 percent (References 3 through 5).

 1. Nature and Magnitude of the Attack

  a. Warning Time

  b. Number of Weapons

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c. Targets Selected by the Enemy

d. Height of Burst

e. Fission Yield

f. Decay Rate of Fallout

g. Duration of Attack

h. Weather Conditions

i. Chemical and Biological Agents Used

2. Protective Measures

a. Civil Defense Organization and Operational Capabilities

b. Strategic and Tactical Evacuation

c. Fallout Shelter Availability and Characteristics

d. Blast and Fire Protection

e. Decontamination Activities

3. Health Status of Population at Time of Attack

a. Variation of Health Posture by Year, Season and Geography

b. Susceptibility of Population to Disease

c. Availability of Health Resources

Types of Casualties

To clarify the discussion of casualty care and protection of the health of the non-casualty population, it is important to recognize that several general types of casualties might be expected   These could include: prompt fatalities; blast and fire casualties; radiation casualties; BW-CW casualties; psychoneurotic casualties; casualties resulting from the adverse effects of the shelter environment; and combinations of these. While the emphasis of this research has been on defining the health problems of the non-casualty population, the medical problems of direct weapons effects casualties are also considered.

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Historical Military Medicine

Introduction

The question of whether program emphasis should be placed on casualty care or on non-casualty care requires interpretation in that there are few conceivable situations in which such an option exists. One would expect that in a public fallout shelter containing casualties and non-casualties, care would be rendered to casualties so long as any resources for care remained. An option does exist in planning when the overall budget for public health and medical care measures is limited. Such public health programs would include provisions for sanitation, water treatment, milk and food processing, rodent control and epidemiological measures for control of disease. The evidence from previous wars does give some indication of the relative importance of general public health measures, as well as casualty care.

Military Medicine

Historically, it was not until World War I that total deaths from battle injuries outnumbered total deaths from disease. In the Mexican War (1846-1848) deaths from disease outnumbered deaths from battle injuries by 6 to 1. In the Crimean War (1854-1856) this ratio was 9 to 1. In World War I there were 51,447 deaths due to disease and 50,510 deaths due to battle injury in the entire United States Army. In the Expeditionary Force, however, deaths due to disease numbered 16,951 while deaths due to battle injuries totaled 50,105. In World War II, 75.2 percent of the total deaths were due to battle injuries, 19.7 percent due to non-battle injury, and 5.1 percent due to disease (Reference 6). The factors contributing to the reduction of the proportion of deaths due to disease include general public health measures, preventive medicine, and effective medical care of the sick.

Another measure of the relative importance of disease and battle
injuries is the cost in manpower lost. During World War II it is found that
68.5 percent of man-days lost in the military services were due to disease,
17.2 percent due to battle casualties, and 14.3 percent due to non-battle in-
juries (Reference 6). Therefore, it is obvious that disease and non-battle
injury are still major problems, even though deaths have been greatly reduced.
If we had oriented the research toward temporary disability caused by disease,
rather than survival per se, the case for emphasizing health maintenance of the
general population instead of casualty care would have been strong.

Application to Treatment of Nuclear War Casualties

The mortality statistics from previous wars illustrate that greater
gains in terms of survival have been realized in preventing and treating disease
than in treating battle casualties. This observation anticipates the conclusion
which will be drawn below that, as a class, potential disease fatalities can be
much more effectively reduced than can potential direct weapons effects fatalities,
at least in the military battle environment. This conclusion, based on his-
torical evidence, can plausibly be extended to the post-nuclear war environment
as follows:

In World War II, of the total battle casualties among infantrymen,
22 percent were "killed in action" (died before reaching a medical facility),
3.4 percent "died of wounds" (died after being treated at a medical facility),
and 73.9 percent survived (Reference 7).

It is patently obvious that the medical support available to the
combat infantryman is greater than that available to the civilian population

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after nuclear attack by a weapon close enough to cause direct effects casualties. Accordingly, if nuclear weapons casualties (not immediately killed) were given "excellent" (World War II military equivalent) care, then about 4 percent would die and 96 percent would survive.*

This estimate of survival with "excellent" care must now be compared with some estimate of survival rate "without care" (or with very primitive care). Such an estimate can again be based upon military records. The highest recorded battle casualty records old enough to represent substantially more primitive care, yet recent enough to be fairly reliable are: French wounded in the Crimean War and Northern wounded in the Civil War; 22.1 percent and 14.1 percent fatalities respectively. Accordingly, the survivors added by "excellent" medical care among the casualties surviving long enough to be treated (i.e. those who are not quasi-immediate fatalities) can be estimated to be between 10 - 18 percent, say 15 percent.

Another such estimate is available from the research conducted on OCD Research Project 1341A, Shelter Medical Support System Study, by Drs. Wells and Cromartie of the UNC School of Medicine (Reference 8). In this study, it was estimated that 87.1 percent of the peacetime emergency room caseload of four local hospitals would have survived without care, and that 98.4 percent would survive with "excellent" hospital care.

Both of the above estimates show that treatment can be expected to increase survival among those treated by somewhere in the range of 15 percent.

In the post-nuclear attack situation, nowhere near an additional 15 percent of the wounded could conceivably be saved for the following reasons:

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* This assumes that thermonuclear casualties will be similar to average
  battlefield casualties. Fatality among the wounded varies greatly by
  type of wound. Because a different spectrum of wounds will result
  from a thermonuclear war than for battle injuries in past wars, the
  actual percentages would vary from those given above.

a. The medical skills would be saturated so that timely care could be given to only a very small fraction of the injured. For example, overall doctor/population ratios for the United States are about 143/100,000. There are regional variations and even more substantial rural-urban variations in this ratio. Since shelters are located principally in urban areas, a generous ratio of 300 doctors to 100,000 shelterees is taken for our estimates.

According to Reference 7, a surgeon can treat up to 10.5 severely injured casualties per day for a maximum of 3 days. Again being generous and calling this treatment capability 12, for example, we can see that only about 1 percent of the population conceivably could be treated during the first six hours after injury. Beyond six hours, the proportion of survivors added by treatment drops rapidly, due to the fact that the more severely wounded have already died.

b. Because no organized collection and triage system would exist without intensive peacetime planning, treatment delays would be unusually long and in many cases would be hindered or even precluded by the blocking of routes or by the fallout environment.

c. The types of casualties in nuclear war are different from battle casualties. Large numbers of severely burned, crushed, or irradiated casualties (or combined injuries) would greatly complicate the provision of medical care in comparison with past experience in wars and natural disasters.

Many of these constraints on effective treatment of direct weapons effects casualties are not present in the case of non-casualties whose medical problems arise or are initiated during the shelter stay. In particular, treatment delays are less critical, physicians may be used over a long period, the "payoff" in survivors added per physician hour is greater, and the fallout environment is less constraining because of natural decay, decontamination measures, and so on. The in-shelter health problems are discussed at greater length in Chapter Two.

Summary

The data presented in this chapter have provided a basis for estimating the maximum probable payoff to be expected by providing medical care for the casualty population. These data include the following points: 1) the treatment of casualties should increase their survival (or reduce fatality) by about 15 percent; 2) due to the relatively few physicians necessary to care for the sick and injured population in peacetime there are only about 300 physicians per 100,000 urban population; and 3) the average physician could provide definitive surgery to about 12 casualties in a one day period. From this we can see that at most 540 survivors (300 x 12 x .15) could be added during the first day after attack if no physicians were themselves casualties. Even if we were to assume a physician population ratio of 1,000 physicians per 100,000 population (the approximate ratio if nurses, dentists and veterinarians were counted as physicians), we could see that a maximum of 1,800 survivors would be added, or less than 2 percent of the overall population of 100,000, in the first day after attack.

Beyond this time, the more severely wounded of the untreated casualties will have died; and, the payoff of survivors would be much less.*

Because the payoff of treating casualties will have decreased to a negligible point within several days after the attack, it would be quite feasible to use the remaining medical personnel, facilities, and equipment to provide medical care and preventive medicine to the non-injured population. Such a strategy would neither reduce the number of survivors added by casualty care nor endanger the health of the non-injured population, except in the area of consumable medical supplies. If drugs, antibiotics and other consumable supplies were exhausted in caring for the direct effects casualties, they would not be available for general health maintenance during the early postattack period.

Although the above estimates do not represent a strong case for emphasizing casualty care programs, there are other reasons which do account for this emphasis in current emergency medical planning including:

    a. The problems of mass casualty care are much less familiar to the average peacetime physician than the problems of maintaining the health of the general population; therefore, are given greater emphasis in emergency training programs and simulated attack exercises.

    b. The need for highly coordinated action is much greater in casualty care than in caring for the non-injured portions of the population.

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* We have used this last figure as the maximum estimate of the percentage of survivors that might be added by casualty care. In making such an estimate we are purposely overstating the value of casualty care in order to avoid the more serious error of an underestimate.

Chapter Two

HEALTH STATUS OF THE SHELTER POPULATION

This chapter includes a brief description of the "normal" peacetime
health status of the U. S. population, the probable distribution of health
conditions in shelters as a function of shelter capacity, and a qualitative
discussion of the probable spread of diseases due to shelter environmental
conditions. Detailed background information on the health status of the
peacetime population is included in Appendix A.

Peacetime Health Status

Chronic Conditions

Chronic conditions as defined by the National Health Survey in-
clude a wide variety of health conditions which are either permanent or of
long duration.

Utilizing these definitions, about 40.9 percent of persons living
in the United States have one or more chronic conditions. Table I gives the
prevalence, or equilibrium rate of presence, of the major chronic conditions.
Some of the conditions are relatively minor, while others are serious, such as
heart disease, diabetes, and mental illness. Approximately 10 percent of the
population has reported some degree of limitation of activity due to the chronic
diseases or impairments, with approximately 4 percent of the population re-
porting complete disability.

The information presented on chronic conditions does not indicate
the number of persons involved since a single respondent may have one or more

chronic conditions. Thus these data tend to <u>overstate</u> the extent of the problem.

Table I

PREVALENCE OF SELECTED CHRONIC CONDITIONS PER 100,000 POPULATION

Type Condition	Number per 100,000		
	Total Population	Male Population	Female Population
Heart Conditions	2,950	3,060	2,850
High Blood Pressure	3,080	1,810	4,280
Diabetes	900	800	1,000
Peptic Ulcer	1,440	2,140	700
Arthritis & Rheumatism	6,390	4,610	8,070
Hernia	1,490	2,320	710
Asthma-Hay Fever	5,430	5,510	5,350
Chronic Bronchitis	1,170	1,160	1,170
Chronic Sinusitis	5,850	5,230	6,450
Visual Impairments	1,790	1,790	1,800
Hearing Impairments	3,410	3,970	2,890
Paralysis of Major Extremities and/or Trunk	550	620	490

Source: Adapted from: U. S. Department of Health, Education and Welfare. Public Health Service. National Health Survey. "Geographic Regions and Urban-Rural Residence," <u>Health Statistics</u>, Series C: Number 5 (1961).

Acute Conditions

Acute conditions refer to those diseases, disorders, and disabilities which have lasted for less than three months and which involved either medical attention or one or more days of restricted activity, according to the definition developed by the U. S. National Health Survey. A summary of the major acute conditions which would be expected to occur in a population of 100,000 during a two week period is shown in Table II.

Table II

ACUTE CONDITIONS PER 100,000 POPULATION FOR AN AVERAGE

TWO WEEK PERIOD

Condition Group	Total Acute* Conditions
Total Conditions	8,250
Infectious and parasitic diseases	995
Common childhood diseases	365
The "virus" (not otherwise specified)	458
Other infectious and parasitic diseases	169
Upper respiratory conditions	3,200
Common cold	2,590
Other acute upper respiratory conditions	607
Other respiratory conditions	1,640
Pneumonia	57.7
Bronchitis	61.5
"Intestinal flu"	192
Influenza and other respiratory conditions	1,330
Digestive system conditions	458
Dental conditions	150
Indigestion and similar symptoms	115
Other digestive system conditions	192*
Fractures, dislocations, sprains and strains	390
Fractures and dislocations	112
Sprains and strains	204
Open wounds and lacerations	280
Contusions and superficial injuries	246
Other current injuries	266
All other acute conditions	865
Diseases of the ear	177
Headaches	65.5
Genitourinary disorders	119
Diseases of the skin	104
Diseases of the musculoskeletal system	615
All other acute conditions	226

Source: Adapted from: U. S. Department of Health, Education and Welfare.
Public Health Service. National Health Survey. "Acute Conditions,
Incidence and Associated Disability," Health Statistics, Series B:
Number 18 (1960).

* Specific acute conditions, such as appendicitis, are included in the
data for the respective organ systems of the body.

Expected Prevalence of Chronic and Acute Conditions in Shelters as a Function of Shelter Capacity

The diseases and infirmities expected in the shelter will include chronic and acute conditions existing in the preattack population at the time of attack, in addition to the new cases occurring during the shelter period. Quantitative estimates of these health problems are of interest to the civil defense planner.

Table III shows the probability of at least one case of several specific acute and chronic conditions occurring in a shelter of specified capacity according to observed peacetime incidence and prevalence rates.

These probabilities were calculated assuming that the specific conditions were distributed randomly, that is, in a Poisson distribution pattern. There are limitations in this assumption which must be understood in order to interpret Table III properly. The Poisson distribution is appropriate for expressing the prevalence of chronic diseases. On the other hand, infectious diseases will tend to polarize or at least be distributed in non-random patterns due to the nature of such conditions. This clustering will increase the probability of zero incidence and decrease the probability of one or more cases, as approximated in Table III. Even more important is the variation expected in the actual disease (chronic and acute) characteristics of individual shelters because of variation in age, sex, or color characteristics. Regional and seasonal variation would also cause appreciable changes in the disease distributions.

However, for the purpose of medical planning, the figures cited are the best available and are probably more than adequate for planning use. A discussion of the derivation, use, and limitations of such analyses is found in Appendix B.

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Table III

PROBABILITY OF AT LEAST ONE CASE OF SPECIFIED CHRONIC AND ACUTE
CONDITIONS OCCURRING IN SHELTERS OF GIVEN
SIZES OVER A TWO WEEK PERIOD

Condition	Number of Shelterees								
	25	50	100	200	400	800	1600	3200	6400
Infectious Diseases	.22	.39	.63	.86	.98	1.00	1.00	1.00	1.00
Active Infectious Tuberculosis (Non-hospital)	.01	.02	.05	.09	.18	.32	.53	.78	.95
Upper Respiratory	.55	.80	.96	1.00	1.00	1.00	1.00	1.00	1.00
Other Respiratory	.34	.56	.81	.96	1.00	1.00	1.00	1.00	1.00
Pneumonia	.01	.03	.06	.10	.21	.37	.60	.84	.97
Bronchitis	.01	.03	.06	.11	.22	.39	.63	.86	.98
Intestinal Flu	.05	.10	.18	.32	.54	.79	.95	1.00	1.00
Digestive System	.10	.20	.37	.60	.84	.98	1.00	1.00	1.00
Diabetes	.20	.36	.59	.84	.97	1.00	1.00	1.00	1.00
Peptic Ulcer	.30	.51	.76	.95	1.00	1.00	1.00	1.00	1.00
Heart Condition	.54	.78	.95	1.00	1.00	1.00	1.00	1.00	1.00
Pregnancy	.47	.71	.92	.99	1.00	1.00	1.00	1.00	1.00
Normal Peacetime Death	.01	.02	.04	.07	.14	.26	.45	.69	.90

Source: Derived from Table I and II, and from information included in the final
section of this chapter, "Factors Influencing Health During the Shelter
Period."

Table IV indicates the expected number of specific health conditions as a function of the total number of shelter occupants, based upon peacetime rates, and states qualitatively the increase which can be expected due to shelter living. It was not possible within the time and fund constraints of this research to give more quantitative estimates of the probable increase of communicable diseases. Such estimates, although worthwhile in civil defense planning, would require the construction of mathematical models of disease spread and the gathering of basic epidemiological data. The research project required is discussed in Appendix B.

Appendix B also includes a discussion of the planning and medical stocking implications of the probabilities and expected values presented in Tables III and IV. These lead to objective criteria for non-communicable acute and chronic conditions. Communicable disease criteria must await further research.

Table IV

EXPECTED NUMBER OF CASES OF SPECIFIED CONDITIONS OCCURING IN A SHELTER, BY SHELTER CAPACITY

Condition	Expected Occurrence in Shelters (number of shelterees)								Effect of Shelter Confinement
	25	50	100	200	400	800	1600	3200	
Infectious Diseases	.25	.50	1.00	1.99	3.98	7.96	15.92	31.84	Unknown increase during shelter period
Active infectious Tuberculosis (non-hospital)	.01	.02	.05	.09	.19	.37	.75	1.49	Slight increase during post-shelter period
Upper Respiratory	.80	1.60	3.20	6.40	12.80	25.60	51.20	102.4	Will affect nearly 100% of shelter occupants
Other Respiratory	.41	.82	1.64	3.28	6.56	13.12	26.24	52.48	Marked increase in shelter period
Pneumonia	.01	.03	.06	.12	.23	.46	.92	1.85	Increase as secondary effect of untreated respiratory infections
Bronchitis	.02	.03	.06	.12	.25	.49	.98	1.97	Minor increase
Intestinal Flu	.05	.10	.19	.38	.77	1.54	3.07	6.14	Marked increase in epidemic periods (highly variable)
Digestive System	.11	.23	.46	.92	1.83	3.66	7.33	14.66	Severe increase affecting most shelter occupants when sanitation is disrupted or large scale vomiting and diarrhea occurs.
Diabetes	.23	.45	.90	1.80	3.60	7.20	14.40	28.80	Slight increase
Peptic Ulcer	.36	.72	1.44	2.88	5.76	11.52	23.04	46.08	Possible slight increase
Heart Condition	.74	1.48	2.95	5.90	11.80	23.60	47.20	94.40	Slight increase
Pregnancy	.62	1.25	2.50	5.00	10.00	20.00	40.00	80.00	Moderate increase in births is included in figures presented here
Normal Peacetime Death	.01	.02	.04	.07	.14	.29	.58	1.15	Slight increase due to disease

Source: Derived from Tables I and II, and information included in the text of this chapter.

Factors Influencing Health During the Shelter Period

Introduction

The information in this section of the report has been developed on the basis of the minimum criteria of OCD in marking and stocking shelters under the National Fallout Shelter Survey program. Interpretation as to the sufficiency of NFSS ventilation and water stocking criteria is subject to some controversy. The physical habitability of NFSS shelters is currently being studied by several OCD contractors.

The Shelter Environment

The shelter environment includes such things as temperature, humidity, ventilation, and light. Very clearly, temperature and humidity will be considerably affected by the shelter occupants themselves, but it is unncessary for our purposes to segregate particular causes of the environmental conditions in order to make some estimates, largely presumptive, as to their possible effects on personnel.

Confinement to shelters, per se, is not likely to seriously affect healthy individuals except for the possible psychological factors. Even austere environmental conditions, such as poor ventilation, poor lighting, and insufficient nutrients would have minimum effects on healthy persons under ordinary circumstances. In individuals with various illnesses or impairments, however, environmental factors, which would not affect healthy individuals, may produce severe stresses leading to aggravation of the existing conditions or the development of complicating conditions. For example, certain conditions involving the blood vessels of the extremities can become severely aggravated by exposure to temperatures between forty and fifty degrees Fahrenheit; many skin conditions are

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aggravated by high temperatures, others by low temperatures. For individuals
with severely limited respiratory reserve from such conditions as pulmonary
emphysema, increases in carbon dioxide concentration and decreases in oxygen con-
centration may produce severe disability. The recent work of Hollander (Reference
9) with the Climatron also indicates that environmental changes are associated
with an aggravation in severity of symptoms in rheumatic disorders.

Crowding and Disease

As indicated earlier, we are considering the minimum standards of the
National Fallout Shelter Survey as the baseline. These generally provided for
500 cubic feet unventilated space and 65 cubic feet of ventilated space (3 cfm
per person). Such conditions of crowding will provide a situation favorable
for the spread of infectious disease, and we may consider these diseases under
four categories, more or less in order of importance: (1) respiratory infections;
(2) enteric infections; (3) arthropod-borne infections; and (4)venereal infections.

Respiratory Infections are the most common and troublesome of human
infectious diseases and in general are spread by human contact. Under ordinary
conditions, fortunately, most of these diseases are mild, but under conditions of
stress and without medical care they may become severe and may have serious or
fatal complications. In the Navy shelter habitability trials, Minard (Reference
10) found that during the winter trial there was an incidence of respiratory
infection of 50 percent during the two week period, and that in the summer trial
this rose to 79 percent. Several factors make it unwise to extrapolate directly
from this experience to our postulated situation: Minard was dealing with healthy
young adult males, he had different ventilation factors, adequate dietary and

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water intakes were provided, high quality medical care was available and his population had recently been immunized against the common diseases for which immunizing agents are available. In contrast, our population will consist of a cross-section of the general population harboring a variety of bacterial and viral infectious agents, with varying immunization status, limited caloric and water intakes and indifferent, if any, medical care.

It can, therefore, be predicted that respiratory disease of one sort or another will probably affect virtually every person in the shelter, and this would be true regardless of season. Mild infections such as the common cold and adenovirus infections predispose to infection with more serious pathogens such as the pneumococcus, streptococci, the diptheria bacillus and the meningococcus. Since there are large numbers of apparently healthy carriers of these latter agents in the general population, the organisms will be present in most shelter populations, and it is therefore likely that epidemics may develop in some situations.

In addition to the common cold and related infections, the respiratory diseases which seem most likely to manifest themselves in epidemic form are meningococcal meningitis, hemolytic streptococcal infections, influenza, and staphylococcal infections. In the case of these more serious infections there is a substantial proportion of the population which possesses a greater or lesser degree of immunity, and for this reason it is not anticipated that any of them would occur in such fulminating form as to sweep through the population of a shelter and wipe it out. For example, influenza has about as high an attack rate as any of these diseases and under the worst of "normal" circumstances has not generally affected more than 50 percent of a population (Reference 11). Fortunately, influenza also has a very low case-fatality rate, although this would be

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increased in the shelter situation. Under the worst of circumstances, it seems unlikely that influenza would affect more than 65 percent of any single shelter population or that it would have a case-fatality rate of more than 20 percent.

The most virulent of these four potentially epidemic diseases is meningococcus infection which untreated has a case-fatality rate ranging in different outbreaks from 25 percent to 75 percent. But studies have shown that approximately half of the adult population has a degree of specific immunity against the meningococcus and the attack rate among the remainder of the population would probably not exceed 50 percent. The normal treated case-fatality rate is about 4 percent and if the sulfadiazine tablets available in the shelter medical kit (as presently equipped) were used, the case-fatality rate among those attacked should probably not exceed 10 - 15 percent. Although the quantities stocked would not be sufficient, if epidemics affecting up to half of the shelter occupants occurred. The likelihood of such epidemics could be reduced by prompt diagnosis and isolation of infected individuals.

In all of these estimates we are dealing with average figures. For almost all respiratory infections as well as other diseases, the incidence of complications and the case-fatality rates are much higher in the elderly and the very young, so that shelter populations containing large proportions of such age groups will have higher rates, while those housing adults in the wage-earning age groups will have lower rates. It should also be noted that in shelters housing large numbers of elementary school children there would be the possibility of outbreaks of some of the common childhood diseases such as chicken pox, measles, and mumps. Again, under the relatively austere shelter conditions, these infecions

would become more serious, would have a higher incidence of complications and higher case-fatality rates than under normal circumstances. However, it is not expected that these would reach proportions resulting in large scale deaths.

In summary, then, acute respiratory infections can be expected to be a major source of morbidity within the shelter with virtually every individual being affected. Most of them will have mild infections with cold, cough or flu-like symptoms with or without fever. There will be some serious infections resulting in fatalities and these will be most frequent among the very young and among the elderly. In an unpredictable number of shelters there will be epidemic outbreaks with high morbidity (probably not exceeding 50 percent) and high mortality (probably not exceeding 25 percent). It is not anticipated that most of these acute conditions will have long-term consequences extending into the post-shelter period and involving a significant proportion of the population.

Chronic Respiratory Infections

Tuberculosis is the only acute respiratory infection worthy of consideration in this context. It is estimated by the United States Public Health Service that there are approximately 1.4 cases of active tuberculosis per thousand population in the United States and that there are approximately 3 inactive cases per thousand population. Although it is quite common for inactive cases to become active under conditions of particular stress such as would occur in shelter living, it seems unlikely that within the two week period many such relapses would reach the infectious stage. We may, then, confine our attention to the estimated number of active cases of tuberculosis. Of these about one-third are hospitalized at any given time and therefore would not be expected to be among the general shelter population. Of the remainder, we may estimate that approximately half

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are not in an infectious stage. This distribution will not, of course, be purely random. Because tuberculosis is more prevalent in the elderly and in the lower socio-economic groups, shelters housing large numbers of such persons will have a higher concentration of cases of tuberculosis. Shelter living will be particularly conducive to spread of the tubercle bacillus; accordingly, it can be expected that in shelters harboring active infectious cases new infections will occur. It can also be expected that many inactive cases will become active as a result of the stresses imposed by the shelter period. In only rare instances will these manifest themselves during the shelter period; there may be an occasional case of tuberculous pneumonia or tuberculous meningitis in infants. Rather, symptoms will manifest themselves only weeks or months after the shelter period.

In the light of available information it is impossible to arrive at any quantitative estimate as to what the resultant tuberculosis problem may be in the general population. It can safely be predicted, however, that it will increase markedly during the post-shelter period, and, depending on the extent and length of time of the disruption of normal living, may reach epidemic proportions as it did during the 19th century in Europe and Great Britain, when it was the most deadly disease. The medical items in the shelter kit would not be appropriate for treating tuberculosis.

Enteric Infections. Infections entering the body through and affecting the gastro-intestinal tract will constitute the most serious acute problem after respiratory disease. Ordinarily these diseases are transmitted through water, food or milk and they occur when there are breakdowns in sanitation practices. The organisms causing the infections are excreted in the feces

and it is fecal contamination which starts the chain of infection. Under conditions
of shelter living, the necessities for good personal hygiene will be lacking. There
will be generally insufficient water for hand washing much less bathing; it can
therefore be expected that the environment will very promptly be thoroughly con-
taminated with such micro-organisms as enter the shelter in the gastro-intestinal
tracts of the population. These may include the organisms causing amebiasis
(amebic dysentery), shigellosis (bacillary dysentery), salmonellosis (food poison-
ing), paratyphoid fever, typhoid fever, viral (infecious) hepatitis, the various
enteroviruses (Coxsackie and ECHO viruses), and poliomyelitis. The epidemiology
of some of these infections is not completely understood and it is, therefore,
possible to make only qualitative predictions about their occurrence.

In the case of amebiasis, surveys have shown that carrier rates in the
population vary between 4 and 17 percent, and it is therefore virtually certain
that the organism will be introduced into practically every shelter and that it
will infect large numbers of people. Many persons who are infected, however,
do not develop symptoms and it is not possible to predict an attack rate. Never-
theless, it is certain that symptomatic cases will occur, that some of them will
be serious and that some will develop complications and chronic infections. Many
will not manifest symptoms until the post-shelter period.

Bacillary dysentery is caused by a variety of organisms in the Shigella
family. There are also large numbers of healthy carriers of these organisms.
They likewise will be introduced into the shelter environment and will affect sub-
stantial numbers of people probably in some instances producing disease in epidemic
form. The severity of symptoms varies and the case-fatality rates in various out-
breaks have ranged from zero to 15 percent. If it safe to predict that substantial

numbers of cases will occur in shelter populations and that in some shelters there will be fatalities from shigellosis.

Salmonellosis is not anticipated to be a major problem in the shelter environment. It is a mild disease spread usually by foods of a type (egg dishes, cream dressings, gravies, etc.) which will not be available within the shelter.

Typhoid and paratyphoid fevers are likewise not expected to constitute major problems within the shelter. They are largely spread by carriers and the incidence of carriers in the general population is low at the present time. Their incubation periods also are such that it is unlikely that an outbreak could gain much momentum within the shelter period. In the unusual situation in which a carrier enters a shelter, however, he will have the opportunity to infect large numbers of his contacts and the consequences for the post-shelter period may be significant, especially with the anticipated breakdown in community sanitation. Since 10 percent of recovered typhoid patients continue to excrete the organism for three months or more and 2 - 5 percent become permanent carriers, and since most of the population of the United States does not have any appreciable immunity to the disease, there is no doubt but that typhoid fever can become a major problem following a thermonuclear attack. The shelter period will play a very key role in providing an opportunity for wide dissemination of the organism.

Viral hepatitis is another of the enteric diseases whose epidemiology is not completely defined. It is known that there are in the general population many healthy carriers of the virus who continually excrete it in their feces. Thus, it is likely that the virus will occur and spread in many, if not most, shelters. The incubation period for the disease, however, is two to six weeks and it will

therefore not be a serious problem within the shelter, but like typhoid fever, will probably become a problem during the post-shelter period.

The Coxsackie and ECHO viruses appear to cause a number of syndromes ranging from the mildest of symptoms to severe paralysis, myocarditis and death. Many of them appear to be spread by contact and they have a wide but unknown distribution in the population. Their effects on shelter population cannot be predicted.

Poliomyelitis will not be a major problem either during the shelter period or afterward. Paralytic poliomyelitis is a disease of low incidence, the average incidence even in severe outbreaks being about 3 per 1,000 population. The occurrence of a case within a shelter population would constitute a greater psychological than real hazard.

In recapitulation, with respect to enteric diseases, it can be expected that there will be within the shelter a high incidence of the diarrheal and dysentric diseases with short incubation periods, such as shigellosis and amebic dysentery. These will cause a fairly high degree of discomfort and disability and may result in a few fatalities. Some of these will persist into the post-shelter period. The shelter period will also serve as an occasion for the dissemination of pathogenic organisms such as the typhoid bacillus and the hepatitis virus, the effects of which will not be apparent until the post-shelter period, but which then may become major problems.

Arthropod-borne Infections. The principal arthropod-borne infections which might have some significance with relation to the period of shelter living are typhus fever and plague.

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Typhus fever occurs in several forms. Classical epidemic typhus fever is transmitted by the human body louse. Brill-Zinsser disease is recrudescent typhus occurring in relatively mild form some years after an attack of epidemic typhus. Murine typhus is transmitted by the rat flea. It is not to be expected that typhus will increase significantly within the shelter (the incubation period is usually 10 - 12 days; the life cycle of the louse is a minimum of 12 days). But the shelter period may contribute to later development of epidemic typhus. It is during the close contact of this period with its poor personal hygiene that the louse may begin to spread widely among the population and with the disruption of normal hygiene during the post-shelter period may continue to be widely prevalent. Since there is evidence (Reference 12) that the carrier state persists for very long periods of time in a high percentage of individuals who have had typhus or who have lived in areas of the world where typhus occurs, there is no doubt that a reservoir of infection exists in the United States. It therefore seems likely that epidemic typhus will manifest itself, if there is an extended period of time without normal personal hygiene among large segments of the population or if steps are not taken to control the body louse.

Sylvatic (wild rodent) plague exists in the western third of the United States. It is not anticipated that human plague would manifest itself clinically in any numbers within the shelter, but where human and rat populations share the same shelter, as will be the case in many instances, an opportunity will be provided for the spread of the flea and the plague organism from rat to man and from man to man creating a potential post-shelter epidemic situation.

Venereal Infections. Although a number of individuals will enter shelters with venereal disease in the infectious stage it is again not expected that it will manifest itself as a major health problem during the shelter period. If any kind of shelter discipline is maintained, the wide dissemination of venereal disease during this period is most unlikely. If there was exposure, disease would not manifest itself until later. With social disruption during the post-shelter period and the lack of adequate case finding and treatment facilities, it is certain that venereal disease will show a marked increase later on.

To summarize the disease situation, it can be said that within the shelter environment there will be a fairly high degree of crowding, especially within the more heavily populated shelters, and that the principal health hazard associated with this crowding will be in connection with infectious diseases.

There will probably be a nearly universal incidence of mild respiratory diseases. More serious respiratory diseases will occur in most shelters with epidemic situations developing in some.

There will be a very wide occurrence of more or less mild enteric disease within the shelter with the way being paved for the dissemination during the postattack period of more serious enteric disease such as typhoid fever and amebiasis.

Arthropod-borne disease will not be a problem within the shelter, but the lack of facilities for good personal hygiene will lead to wide-spread louse and flea infestation which may well lead to the later development of epidemic typhus fever and plague in some parts of the country.

It is not expected that venereal disease will be an immediate problem.

Shelter Medical Kit

The medical kit contains two drugs which will be of limited effectiveness in treating the diseases mentioned in this report -- sulfadiazine tablets and penicillin G. tablets. Generally, these drugs would be of some value in treating the bacterial diseases -- meningococcal mengitis, salmonellosis, venereal infections, etc. They would, however, be of little value in treating the viral and ricketsial diseases --influenza, viral hepatitis, Coxsackie and ECHO viruses, poliomyelitis, typhus fever, etc.,(Reference 22).

Other medical supplies will be of some effectiveness in alleviating the symptoms of many of the diseases. These items include: aspirin; cascara sagrada, a laxative; kaolin and pectin, for treating diarrhea; and phenobarbital tablets, a sedative (Reference 22).

The quantities of these drugs available would provide normal dosage for the number of cases expected in a peacetime situation; however, these drugs are of limited effectiveness and virulent epidemics could still occur. The quantities of drugs stocked would not be sufficient in the event of such in-shelter epidemics.

The detailed review of the adequacy of medical stocking was beyond the scope of this project, although the analysis in Appendix B does lay the groundwork for research on this subject.

Reduction in Nutrients

Food and water stores in shelters are expected to provide slightly more than 700 calories and one quart of water per day per person. The source of calories will be flour-based biscuits somewhat resembling graham crackers. The nutrients provided will consist largely of carbohydrate with minimal amounts of protein and fat,with more or less adequate amounts of calcium and phosphorus for normal individuals, and that they will be somewhat deficient in iron and many of the vitamins.

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In healthy individuals there is no reason to believe that dietary deficiencies will occur on this ration during the two-week shelter period. For individuals with febrile or other illnesses the diet will be inadequate in protein and other nutrients and this dietary deficiency will serve as a complicating factor in patients suffering from such illness. The total caloric intake will also be low even in veiw of the limited activity which will be imposed by shelter living. It will be particularly low for women in the third trimester of pregnancy (for whom an average daily caloric requirement has been estimated at 2600 to 3000 calories) and for lactating women(average caloric requirement estimated at 3500 calories or more), as indicated in Reference 13.

Perhaps the most serious effect of the shelter diet will be in individuals suffering from metabolic diseases, the most conspicious among which is diabetes mellitus. It is estimated that approximately 1.5 percent of the general population have diabetes although only about half of these are known and under treatment. Many individuals with known diabetes are able to keep their disease under control by diet alone when their intake of carbohydrate, fat, and protein is properly balanced. Others require insulin or other medication in addition to a dietary regime. It can be anticipated that numerous diabetics in these two categories will become seriously ill in the shelter situation with a limited caloric intake consisting largely of carbohydrate. IL can also be anticipated that some undiagnosed diabetics may manifest themselves as a result of the limited dietary allowance. The numbers of such individuals, however, will not be large -- an estimate of one-half of one percent of the shelter population is probably generous.

As to the water ration, the minimum allowance of one quart per person per day is considerably less than the 2.5 liters (2.37 quarts) which is considered to be a suitable allowance under normal circumstances. In the Navy shelter habitability trials the mean intake during the winter trial was 1.313 liters and 2.272 liters during the summer, (Reference 10). It is significant that during these trials the mean urine output and evaporative loss was about 18 percent in winter and 13 percent in summer, greater than the water intake. This suggests that there was some net loss of body water despite the fact that there was a minimal amount of water in the diet of solid food over and above that counted in the water ration. Although the nutritional studies conducted during these trials have not yet been fully reported, no grossly detectable ill effects were noted, although the mean weight loss for the two week period was 5.4 pounds in the winter trial and 4.8 pounds in the summer trial.

The other essential nutrients are sodium and chlorine, usually furnished in substantial measure by salt (sodium chloride). The average daily intake of sodium chloride for the normal adult is 7 to 15 grams, which more than meets normal requirements. The requirement is higher in very hot environments and could be expected to increase in shelter situations in hot summer climates where there is excessive sweating. On the other hand, the body soon acclimates itself to a diminished salt intake and the salt content of sweat decreases so that little is lost. In the Navy trials it was not found necessary to add salt to the regular shelter ration. In the situation which we envision the salt ration will be considerably diminished, but it is not expected that salt deficiency in the diet will be a serious health problem.

In short, reduction in nutrients is not expected to have serious consequences for healthy individuals, and the number of persons with disabilities likely to be affected adversely by the shelter diet will probably be small.

Limitations on Medications and Medical Care

In keeping with the assumption of a stocked and marked shelter situation, it is assumed that the standard medical kit will be available. It is also assumed that physicians will be present in only a limited number of shelters and that ancillary health personnel of one sort or another will probably be available in most of the 300 person shelters.

For the healthy population and those affected by most of the acute infectious diseases described previously, the limitations on therapeutic agents and medical care should be of little significance. For individuals who become victims of the more severe acute infectious diseases such as meningococcal, streptococcal and pneumococcal infections, the shelter medical kit, properly used, should provide adequate therapy in the absence of major in-shelter epidemics. Most of these infections will respond to treatment with penicillin or sulfadiazine as suggested in the instructions accompanying the shelter medical kit. In a limited number of instances, there will be infections with organisms resistant to these drugs and in other instances, individuals will be sensitive to the medications and will be unable to take them. These will not constitute large numbers of cases.

More serious consequences may occur, though, for individuals with pre-existing disease requiring special medications and who enter the shelter without these medications or with limited amounts of them. Severe diabetics may become

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very ill and develop serious or even fatal complications. Patients with heart

disease who are taking digitalis, may develop heart failure, although in some

measure this will be automatically controlled by the limitation of activity en-

forced by shelter life. Neither insulin nor digitalis are included in the present

shelter medical kits.

As indicated above there will probably be some shelters which will ex-

perience epidemics of respiratory illness of a more or less serious nature. In

such cases, if the infectious agent is a particularly virulent one, limitations of

therapy will no doubt result in a considerably higher incidence of complications

and fatalities than would normally be encountered. As previously noted, however,

it would be a most extraordinary situation in which those affected would exceed

50 percent of the shelter population or that mortality would exceed 25 percent

of those affected.

Radiation Exposure

In connection with radiation exposure, two factors may be considered:

(1) the effect of low doses (less than 100 r) on immunity mechanisms; and (2)

radiation sickness itself.

If low doses of radiation adversely affect the immunity mechanisms of

the body, then it could be anticipated that there would be a higher incidence of

infectious disease with higher fatality rates in population groups exposed to such

radiation. There is evidence that moderate or large doses of radiation do increase

the susceptibility of laboratory animals to infection and this is confirmed in

human experience. Evidence concerning the effect of small doses either in

animals or humans is very limited. Boche, (Reference 14) after a survey of the

available literature, concluded: "The state of our knowledge is such that the

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results of radiation on the susceptibility of a particular species to a particular infection or parasite are not predictable...". A wide range of opinion on this point can be found in References 14 through 21.

With respect to radiation sickness itself, the evidence is a little more clear. We can make some estimates of probable effects under various assumed conditions.

We are presented with three hypothetical situations (Reference 2) which are shown schematically in Figures 1 and 2. Table V shows the radiation doses received by shelter occupants in these three situations and under varying protection factors.

With our population in shelters having a protection factor of 100, it is estimated that in situation 1 (Reference 2, Table III-2) the cumulative two week dose of radiation would be 16 r and in situation 2 it would be 68 r. It is not expected that this level of dosage would have very extensive observable effects. In situation 2 some individuals would no doubt experience minor blood changes and a few might experience some nausea and vomiting.

In situation 3, however, the estimated dosage is 200 r after one day, 270 r after four days, and 320 r cumulative for the entire period. These dosages are sufficient to cause symptoms in most people and death in significant numbers. At this level nausea and vomiting would probably occur among all individuals by the fourth day followed by other symptoms of radiation sickness. A few would die within the two week period, and within six weeks death would have claimed up to 30 percent of those exposed. Without adequate medical care, with poor nutrition and other complications, the death toll might be even higher. Those surviving would require up to three months to recover.

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IDEALIZED FALLOUT CONTOUR SHOWING THE ASSUMED LOCATIONS

IN SITUATIONS 1, 2 AND 3

ASSUMPTIONS:

(a) 5 MT SURFACE BURST
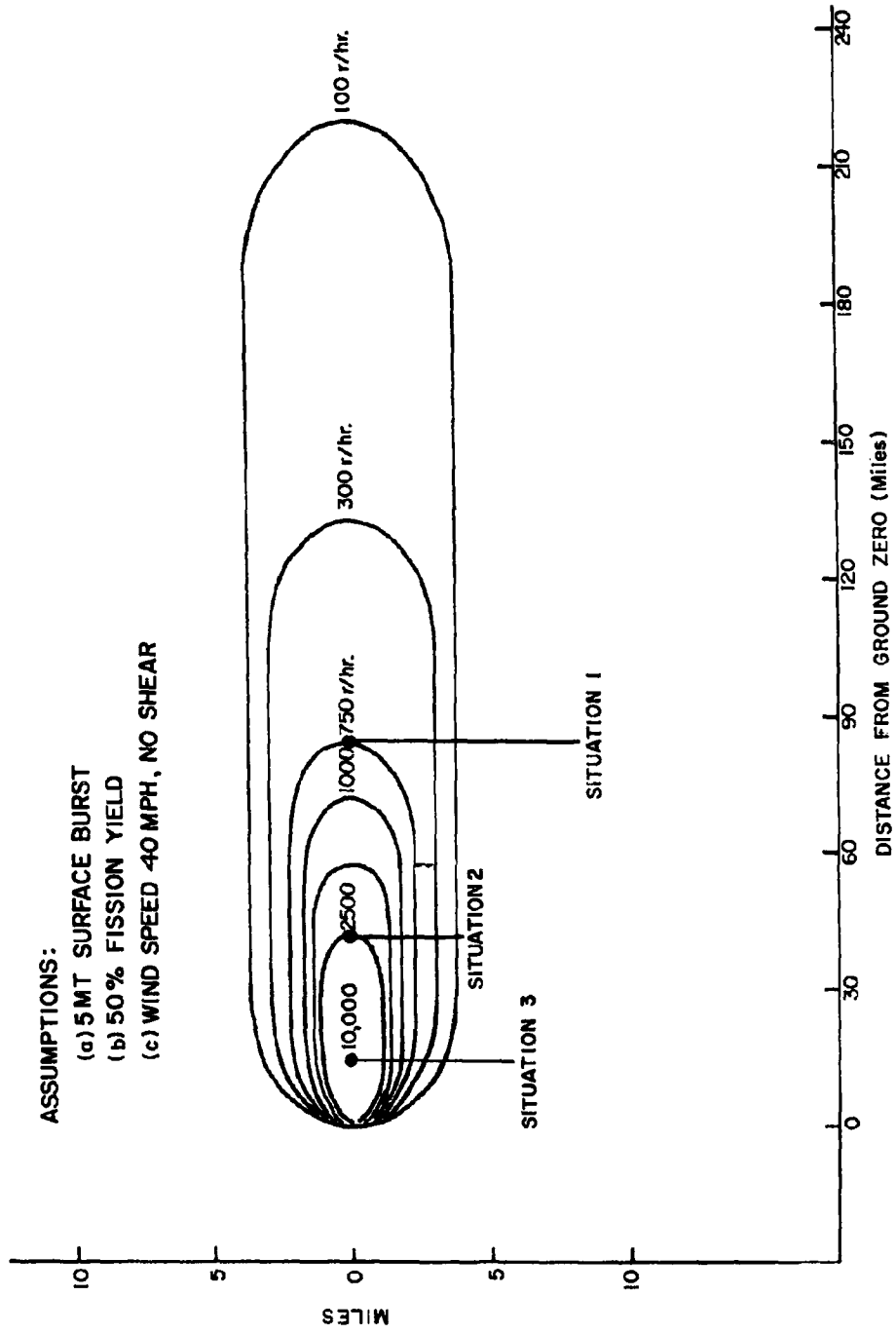(b) 50% FISSION YIELD
(c) WIND SPEED 40 MPH, NO SHEAR

FIGURE 1

SCHEMATIC SIDE VIEW OF SITUATIONS A–C

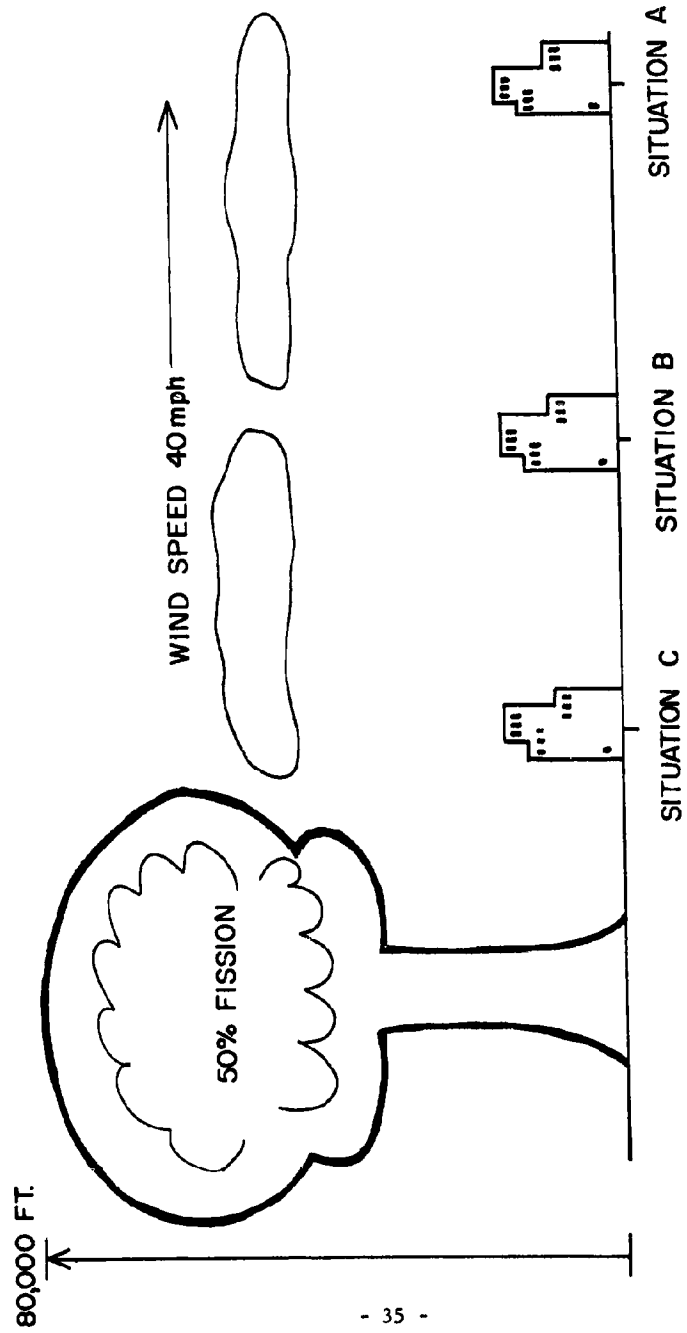80,000 FT.

50% FISSION

WIND SPEED 40mph

SITUATION C   SITUATION B   SITUATION A

FIGURE II

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Table V

SUMMARY OF TOTAL DOSE RECEIVED BY SHELTER OCCUPANTS
ACCORDING TO SHELTER DISTRIBUTION
FOR SELECTED TIMES

Situation	Time After Attack	Protection Factor of Shelters*					
		2	14.5	29.5	49.5	79.5	100
		Number of Persons					
		11,376	1,264	35,040	20,240	8,640	23,440
		Total Dose Received (roentgens)					
1	1 day	470	65	32	20	12	9
	4 days	650	90	44	26	16	13
	12 days	800	110	54 ·	32	20	16
2	1 day	2,100	290	140	85	53	42
	4 days	2,800	385	190	113	70	56
	12 days	3,400	470	230	137	85	68
3	1 day	10,000	1,380	680	400	250	200
	4 days	13,500	1,850	910	540	340	270
	12 days	16,000	2,200	1,800	650	400	320

* This table was derived from Table II-4, p. 15, "SCENARIO OF A STANDARDIZED URBAN AREA: Baseline Data for Community Civil Defense Health Operations Analysis" by W. T. Herzog, Research Memorandum OU-106/107-1, Research Triangle Institute, Durham, North Carolina. In order to obtain a maximum estimate of radiation casualties, the lower limits of PF categories 2 and 100 were used to compute total dose. The midpoint was used in the other categories.

Under these circumstances (situation 2), obviously, radiation sickness becomes the single major health problem among the otherwise uninjured shelter population, and its effects are felt not only during the shelter period, but extend far beyond it. To put it in proper perspective, however, it should be recalled that other problems would also be comparably more acute in situation 3. The effects of blast and fire would result in large numbers of direct casualties and the disruption of normal facilities such as communications, power, etc., would be comparably greater.

As the fallout radiation protection factor of the shelter is lowered, the radiation sickness problem obviously becomes more acute. At PF's below 50, there would probably be no survivors in situation 3, and at PF below 30 none in situation 2.

Summary

In this chapter we have identified the peacetime health problems of the population, and reviewed numerous factors which would contribute to the spread and severity of diseases during the shelter period. Generally, disease will not cause a major problem in terms of survival for the vast majority of the shelter population, although major epidemics can be expected in a few isolated shelters.

In the literature surveyed, no documented situation was found that showed a two week death rate due to disease that exceeded 1 percent of the population. Records from past wars show that even during the Civil War, the two week death rate due to disease was about .13 percent of all troops (Reference 6). Even in the Black Death plague of London during 1664-1665 the averaged two week death rate was less than 1 percent of the total population (Reference 23). It must be

pointed out that this is not a negligible death rate. In the United States today
the annual death rate is normally about 1 percent of the total population.

The above figures indicate that the overall death rate due to disease
during a two week period, if no care were provided, is similar to the added deaths
which might be expected if no care were provided to weapons casualties.

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Appendix A

HEALTH STATUS OF THE PEACETIME POPULATION

Introduction

The information in this appendix has been extracted from the report to
RTI developed by the sub-contractor on this project, the UNC School of Public
Health. The team at UNC consisted of Dr. Robert E. Coker, Jr., M.D., M.P.H.,
Chairman of the Department of Public Health Administration; Dr. Charles M.
Cameron, Jr., M.D., M.P.H., Professor of Public Health Administration; and
Miss Constance S. Beardsley. The research was conducted under OCD Contract No.
OCD-OS-62-250. The mutual responsibilities of RTI and UNC are further discussed
in the Introduction of the text.

This appendix includes detailed information on the prevalence of chronic
health conditions and incidence of acute conditions in the peacetime population
of the United States during an average two week period. The general implications
of shelter living for certain types of diseases are discussed where applicable
in this appendix. The specific implications of shelter living for certain
diseases, such as heart disease and diabetes, are discussed further in Chapter
Two of the text.

Data Source

Residents of the United States at the present time enjoy one of the highest
levels of health recorded since the dawn of civilization.

Crude death rates, life expectancy, and other general measures of health
have reached their most satisfactory point in the history of the nation. With
the refinements in health made possible by a variety of different factors

operating in this country in the past half century, the task of obtaining reliable measures of the health status of the population has become increasingly more difficult.

In times past, single indexes such as the typhoid mortality rate, the infant death rate, or the maternal mortality rate served as general indicators of the overall status of health of the community. Now that many of these rates have approached or reached zero, they are no longer sensitive barometers of total health status.

Objective ratings of collective health status are difficult to obtain because much of the visible evidence of ill health is subjective in nature. For example, certain information about the health status of a population could be obtained from reviewing those illnesses or disorders which require hospitalization or professional treatment by a physician. Yet, there is a significant variation in the extent to which individuals seek out physicians' services. Some individuals, seriously ill, may shun medical assistance while others will seek aid for even the most trivial of indispositions. Studies have shown that admission to a hospital or other organized health facility is a function not only of health status, but also is influenced by the custom of the attending physician, the economic status of the patient and a host of other factors which largely invalidate the use of such information as an index of health.

Thus, studies of health status based on utilization of physicians, hospitals, and other services may be a measure only of the past consumption of given services rather than a true measure of the health/disease status of the population. Such studies are useful in measuring the demand for service. In the Shelter Medical

Support System Study (OCD Project No. 1341A), conducted concurrently by RTI, such demand data is developed and used in estimating the demand for services on a medical support system.

Determination of health state also is difficult due to the lack of any centralized repository for detailed information about the total health needs of any state, county, city, or other population group. Death data generally are recorded, tabulated and available through official health agencies, but these findings are representative only of the terminal event for those diseases which generally carry unfavorable prognoses.

While there are certain diseases required by law to be reported by the physician to health authorities, these reportable diseases are limited to those with some possible communicability to the uninvolved segments of the neighborhood or community. The validity of the data derived from this reporting procedure is now considered minimal due to poor reporting compliance on the part of the physicians and the fact that many such patients may not seek professional aid in the management of the less complicated communicable diseases.

An additional approach to determining the health state of the population involves the examination of a large number of persons by professional health manpower with recording and analysis of results. This was done on a broad scale in connection with the operation of the Selective Service System in World Wars I and II; however, the results are of no significant value in connection with the current research because: 1) only males in specified age intervals were examined; 2) the examinations were conducted by a large number of different examiners whose procedures and techniques were not precisely standardized; and 3) standards for acceptance and rejection have varied.

Further, it is well established that consumption of health services is not so much a factor of scientifically determined medical status as it is a factor of subjectively defined "felt" need for services on the part of the actual individual involved. In a very real sense, a person is ill, handicapped, or disabled when he feels that he is so involved.

Thus, it appears that the more precise determination of the health status of the population entering fallout shelters in event of an emergency would be determined by obtaining information of subjective health status utilizing a standardized systematic technique from a sample representative of the entire United States population.

Fortunately, since 1956 such an operation has been in effect in the United States. The U. S. National Health Survey, a household survey of health, sickness, disability and related health parameters, was activated under Public Law 652 of the 84th Congress. It is described as measuring the extent of illness and disability, the number, age, sex, ability to work and usual activity status of persons afflicted with diseases or handicapping conditions, the length of time that afflicted persons have had varying degrees of disability, the amounts and types of care sought or received, and the economic and social impact of illness and disability.

The Survey may be characterized as a data collection method which provides for continuous sampling of the civilian non-institutional population. Technical aspects of the statistical methods employed are detailed in reports of the U. S. National Health Survey (See Series A-1, "Origin and Program of the U. S. National Health Survey," Series A-2, "The Statistical Design of the Health Household Interview Survey," and Series A-3, "Concepts and Definitions in the Health Household Interview Survey").

Chronic Conditions

Chronic conditions as defined by the National Health Survey are those conditions which are listed on the N.H.S. Check List described in Reference (15) or which was first noticed by the respondent more than three months before the interview.

About 40.9 percent of persons living in the United States have been reported to have one or more chronic conditions. Some of the conditions are relatively minor while others are serious conditions such as heart disease, diabetes and mental illness. Approximately 10 percent of the population has reported some degree of limitation of activity due to the chronic diseases or impairments, with approximately 4 percent of the population reporting complete disability.

The information presented on chronic conditions does not indicate accurately the number of persons involved since a single respondent may have one or more chronic conditions. These data thus tend to overstate the extent of the problems. Table A-1 presents the prevalence of several selected chronic conditions as reported by the National Health Survey. Because, by definition, chronic conditions are present for long periods of time, these data in Table A-1 represent a reasonable approximation of the proportion of the population affected at any given point in time.

Table A-1

PREVALENCE OF SELECTED CHRONIC CONDITIONS PER 100,000 POPULATION

Type Condition	Number per 100,000		
	Total Population	Males	Females
Heart Conditions	2,950	3,060	2,850
High Blood Pressure	3,080	1,810	4,280
Diabetes	900	800	1,000
Peptic Ulcer	1,440	2,140	700
Arthritis & Rheumatism	6,390	4,610	8,070
Hernia	1,490	2,320	710
Asthma-Hay Fever	5,430	5,510	5,350
Chronic Bronchitis	1,170	1,160	1,170
Chronic Sinusitis	5,850	5,230	6,450
Visual Impairments	1,790	1,790	1,800
Hearing Impairments	3,410	3,970	2,890
Paralysis of Major Extremities and/or Trunk	550	620	490

Source: Adapted from: U. S. Department of Health, Education and Welfare. Public Health Service. National Health Survey. "Geographic Regions and Urban-Rural Residence," Health Statistics, Series C: Number 5 (1961).

Heart Conditions and High Blood Pressure: Heart conditions and elevated blood pressure demand particular attention in medical planning for shelter living because of their serious nature which may be aggravated by periods of emotional stress and apprehension. The prevalence of heart conditions and high blood pressure increases as age increases as shown in Table A-2 below.

HEART CONDITIONS BY AGE CATEGORY

Age Categories	Number per 100,000 population in each age category		
	Total	Heart Condition	High Blood Pressure Without Heart Involvement
All ages	6,010	2,880	3,130
Under 25	730	480	250
25 - 44	3,180	1,210	1,970
45 - 54	8,480	3,430	5,050
55 - 64	16,290	7,490	8,800
65 - 74	25,970	12,980	12,980
75 +	31,680	18,580	13,100

Source: Adapted from: U.S. Department of Health, Education and Welfare. Public Health Service. National Health Survey. "Heart Conditions and High Blood Pressure," Health Statistics, Series B: Number 5 (1960).

An estimated 10 million persons in the United States reported some form of heart condition or elevated blood pressure, about 98 percent of those reported having been medically attended. One fifth were confined to bed for one or more days over the 12 months before being interviewed. Persons with heart conditions reported an average of 18 days of bed disability per year and persons with high blood pressure reported an average of 6 bed days per year. The influence of in-shelter conditions on the survival of persons with heart conditions is discussed in Chapter Two of the text.

Diabetes: There are approximately one and one-half million known diabetics in the United States with an estimated equal number of persons with the disease who may not have come to medical attention.

Table A-3

NUMBER OF DIABETICS PER 100,000 PERSONS
IN EACH AGE CATEGORY, BY SEX

Age	Both Sexes	Male	Female
All ages	900	800	1,000
0 - 24	90	100	70
25 - 44	430	490	390
45 - 54	1,240	1,120	1,360
55 - 64	2,830	2,490	3,150
65 - 74	4,290	3,440	5,010
75 +	3,540	3,110	3,880

Source: Adapted from: U. S. Department of Health, Education and Welfare. Public Health Service, National Health Survey. "Diabetes," Health Statistics, Series B: Number 21 (1960).

Approximately 90 percent of the diabetics reported no chronic mobility limitation and 75 percent were not chronically restricted in normal daily activities.

Peptic Ulcer: The prevalence of peptic ulcers reaches a peak of twice the average number in the 45 - 54 age group (2,070). The prevalence among persons below age 25 is 160 per 100,000 population. About 85 percent of ulcer patients are not normally limited in their activites, while 3.3 percent reported being completely unable to carry on their major activity.

Hernia: Hernia, or rupture, involving a weakness in some portion of the wall of the abdomen is a health condition particularly common among older male members of the population. The total annual prevalence for the country is estimated at about two and one-half million cases, 75 percent of which are among males. It has been estimated that approximately 450,000 surgical repairs of hernias are performed in the United States in the average year. The rate of hernia is higher for males than for females in every group.

Each person with hernia has been estimated to incur some 15½ days of restricted activity each year and about one-third of the total of these restricted activity days were classed as bed-days of disability.

Arthritis and Rheumatism: The several types of disorders of the joints known as arthritis and allied disorders (commonly referred to as "rheumatism") are of considerable importance in an assessment of the major chronic disorders of the population.

The impact of these conditions is felt not only in terms of the great prevalence, but also in terms of the prolonged periods of disability. Coupled with the very low death rate from this group of conditions this results in significant numbers of victims in the population at any one time. Although experts in this field have been hesitant at making estimates of the total number of cases in the population, reports from the U. S. National Health Survey place this total in excess of 12 million cases.

Survey reports have recognized the difficulty in setting precise diagnostic limits on cases classified as arthritis or rheumatism in household surveys, but it is generally accepted that such reported cases represent those persistent pains and disabilities involving the joints and muscles which have progressed to the point of being of concern to the individual.

Data from the survey reveals an increase in reported prevalence with increase in age for both males and females with the prevalence higher generally among females. A higher proportion of the cases among females, some 42 percent, were under the care of a physician as compared with about 35 percent of the cases among males. About 17 percent of females with arthritis and rheumatism had never been seen by a physician while approximately 22 percent of the males had never had medical attention for their condition.

About 25 percent of persons with these conditions were either unable to carry on their major activity or were limited in the amount or kind of major or outside activities in which they could engage.

Visual Impairments: Approximately 28 percent of those persons with visual impairment have severe trouble in seeing even with the aid of glasses. "Visual Impairment" excludes those who have simple refractive problems which can be corrected with glasses. Two-thirds of these persons are 65 years of age and older. Seventy-eight percent of those under age 65 are not limited in activities because of their visual impairment.

The National Health Survey information currently available does not indicate the percentage of the population which would have severe difficulty in seeing without the aid of glasses due to refractive disorders. This, however, should not seriously effect survival during the shelter period.

Hearing Impairments: It is generally estimated that one out of five persons with a hearing impairment has a hearing aid.

Impairments Requiring Specified Types of Aid: Table A-4 shows the proportion of the population which require specific types of aids due to chronic impairments.

Table A-4

PARALYSIS OF MAJOR EXTREMITIES AND/OR TRUNK

| | Number of persons requiring specified type of aid per 100,000 | | | | | |
| | | | | Braces | | |
Characteristic	Hearing Aid	Wheel Chair	All Types	Leg or Foot	Other	Artificial Limb
All Persons	680	150	410	120	290	80

Source: Adapted from: U. S. Department of Health, Education and Welfare. Public Health Service. National Health Survey. "Distribution and Use of Hearing Aids, Wheel Chairs, Braces and Artificial Limbs," Health Statistics, Series B: Number 27 (1961).

Summary of Chronic Conditions

In interpreting these data as t.. their possible significance for emergency health planning, it should be emphasized that the information represents the prevalence of conditions under normal circumstances in which human and environmental stresses may be minimal and during a period in which routine medication, appliances, medical care, nursing care and other factors essential to the well-being, if not the welfare, of the patient are available.

While there is some feeling that during World War II persons with minimal complaints were able to perform satisfactorily under the pressure of the emergency war effort, and indeed in some ways may actually have been benefited in terms of their subjective health, the fact that many conditions may be aggravated by emergency conditions, particularly in a period of continuous shelter existence, must be acknowledged.

Accordingly, it is suggested that the prevalence data here presented should be considered as the minimal level of chronic illness in the population at the onset of any major emergency.

Acute Conditions

Acute conditions as defined in National Health Survey reports refer to those diseases, disorders, and disabilities which have lasted for less than three months and which involved either medical attention or one or more days of restricted activity.

Certain conditions which are always considered to be chronic, such as asthma, heart trouble, diabetes, or cerebral palsy, are excluded even though the condition had its onset during the three months prior to the time of enumeration.

Data from the U. S. National Health Survey concerning acute conditions were tabulated to reveal the quarterly calendar variation in prevalence with particular reference to the disability resulting from disease during these different time periods.

During an 18 months interval from January, 1960 through June, 1961, the days of disability resulting from acute conditions were greatest during the January - March quarter and lowest during the July - September quarter. The effect was generally due to the single group of respiratory infections which experienced their peak during these same quarters in sufficient volumes to influence the total acute disease disability experience.

The effect of age on seasonal variation is such that for the youngest age group there is less relative rise and fall in the age-specific incidence rates than for the older age groups.

Table A-5 presents the average number of acute conditions which could be expected in a population of 100,000 during a normal two-week period. Although the total number of conditions would vary slightly by season and region of

- A-12 -

the country, a considerable variation can be expected in the specific types of acute conditions. Specific conditions, such as acute appendicitis, which are of widespread concern to civil defense planners are included in the figures given for the respective organ systems of the body, e.g. digestive system.

Table A-6 shows the number of days of bed disability which results from acute conditions, as adjusted to a population of 100,000 for an average two week period. Because a total of 13,800 bed disability days are listed for 8,250 acute conditions, we can estimate that the average number of bed days per condition is about 1.7. Table A-7 presents the total number of days of restricted activity expected in a population of 100,000 over a two week period.

Table A-5

ACUTE CONDITIONS PER 100,000 POPULATION FOR AN AVERAGE
TWO WEEK PERIOD

Condition Group	Total Acute Conditions
Total conditions	8,250
Infectious and parasitic diseases	995
Common childhood diseases	365
The "virus" (not otherwise specified)	458
Other infectious and parasitic diseases	169
Upper respiratory conditions	3,200
Common cold	2,590
Other acute upper respiratory conditions	607
Other respiratory conditions	1,640
Pneumonia	57.7
Bronchitis	61.5
"Intestinal flu"	192
Influenza and other respiratory conditions	1,330
Digestive system conditions	458
Dental conditions	150
Indigestion and similar symptoms	115
Other digestive system conditions	192
Fractures, dislocations, sprains & strains	390
Fractures and dislocations	112
Sprains and strains	204
Open wounds and lacerations	280
Contusions and superficial injuries	246
Other current injuries	266
All other acute conditions	865
Diseases of the ear	177
Headaches	65.5
Genitourinary disorders	119
Deliveries	...
Disorders of pregnancy and the puerperium	...
Diseases of the skin	104
Diseases of the musculoskeletal system	615
All other acute conditions	226

Table A-6

DAYS OF BED-DISABILITY ASSOCIATED WITH ACUTE CONDITIONS
BY CONDITION GROUP PER 100,000 FOR A 2 WEEK PERIOD

Condition Group	U. S. Total
All acute conditions	13,800
Infectious and parasitic disease	2,100
The "virus" (NOS)	779
Other infectious and parasitic diseases	1,260
Respiratory conditions	7,300
Common cold	2,540
Other upper respiratory	959
All other respiratory	3,820
Digestive system conditions	640
Injuries	1,880
Fractures, dislocations, sprains and strains	1,030
Open wounds, lacerations, contusions and superficial injuries	572
Other injuries	276
Other conditions	1,940

Source: Adapted from: U. S. Department of Health, Education and
Welfare. Public Health Service. National Health Survey.
"Acute Conditions - Geographic Distribution," Health
Statistics, Series B: Number 23 (1960).

Table A-7

DAYS OF RESTRICTED ACTIVITY ASSOCIATED WITH ACUTE CONDITIONS
BY CONDITION GROUP PER 100,000 FOR A 2 WEEK PERIOD

Condition Group	U. S. Total
All acute	32,400
Infectious and parasitic diseases	4,550
The "virus" (NOS)	1,540
Other infectious and parasitic diseases	3,040
Respiratory Conditions	15,700
Common cold	6,830
Other upper respiratory	2,000
All other respiratory	6,870
Digestive system conditions	1,440
Injuries	6,050
Fractures, dislocations, sprains and strains	3,200
Open wounds, lacerations, contusions and superficial injuries	1,980
Other injuries	905
Other conditions	4,660

Source: Adapted from: U. S. Department of Health, Education and
Welfare. Public Health Service. National Health Survey.
"Acute Conditions - Geographic Distribution," Health
Statistics, Series B: Number 23 (1960).

Appendix B

THE USE OF HEALTH STATISTICS IN MEDICAL PLANNING

Applications of Available Health Statistics

In Chapter Two we discussed the expected occurrence of diseases in shelters according to observed peacetime incidence rates and prevalence data. In this appendix we will discuss two possible applications o.' these data to medical planning: (1) estimating the probability of a given number of cases of a particular communicable disease as a basis for determining the likely spread of disease in shelters; and (2) estimating the probability of a given number of cases of a chronic, non-communicable disease as a basis for medical stocking of the larger shelters. Analysis of the spread of communicable disease within shelters is a complex mathematical problem beyond the scope of this project. Research in this area is recommended below. The following paragraphs discuss the much simpler problem of analyzing medical stocking of shelters for treatment of non-communicable chronic conditions.

The Poisson Approximation: Applicability Limited Generally to Chronic Diseases

Table III of Chapter Two shows the probability of at least one case of several specified conditions existing in a shelter of specified capacity. These probabilities were calculated assuming that the specified conditions were distributed randomly, so that the number of cases in a shelter could be approximated by a Poisson distribution. Under the Poisson distribution the probability $Pr(X=k)$ that exactly k cases of a certain condition occur in a shelter containing t persons is given by

$$Pr(X=k) = \frac{(pt)^k e^{-pt}}{k!} \; ; \; k = 0,1,2\ldots \qquad (B\text{-}1)$$

where p = probability that a person has the condition under consideration. There are serious limitations in this assumption which must be understood, however, in order to interpret Table III properly. The Poisson distribution is most appropriate for expressing the prevalence of non-communicable, chronic diseases because: (1) they are not subject to severe increase during the shelter period; (2) by definition, they are less subject to rapid fluctuation in occurrence. In order to use probabilistic techniques for medical planning certain value judgements will be necessary. For example, persons with severe diabetes will require insulin in order to survive two weeks of shelter confinement. It can be shown statistically that it is almost certain that at least one diabetic can be expected in a 1,000 person shelter, but a value judgement is necessary to determine the acceptibility of this risk and the resulting stocking plans.

Several questions, as yet unanswered, will influence the accuracy of using probabilistic techniques to estimate the expected occurrence of diseases in shelters. The questions include the following:

1. Will persons suffering from certain infirmities enter shelters in proportion to their actual numbers?

2. Will persons in the various age categories (e.g , the average age group) enter shelters in proportion to their actual numbers?

3. Assuming that large shelters will be concentrated in the center of a normal large city, will persons suffering from infirmities be close to the downtown area in proportion to their actual numbers?

These questions are difficult to answer precisely but probably have little influence on the numerical results as applied in planning methods described below.

Inadequate Information Regarding the Nature of Occurrence of Acute Conditions and the Extent of Disease Spread

It was pointed out in the preceding section that, whereas the Poisson distribution adequately describes the occurrence of chronic diseases in shelters (conditional on the answers to the questions posed), the use of this distribution to describe the level of disease in the shelters during the shelter period cannot be similarly justified. This situation is indeed unfortunate, for it is with acute conditions that we are primarily interested, because it is with such conditions that the health situation can become catastrophic if epidemics occur. Table III of Chapter Two shows that almost all shelters of size 200 or more will contain one or more types of infectious disease, so the possibility of extensive spread of disease is indeed present. In fact, using Table III and NFSS data (Figure B-16) it can be shown that 94 percent of the total shelter population will be exposed to some infectious disease.

To obtain an accurate picture of the health status of the shelter community, it is necessary to construct realistic epidemiological models of the situation. The situation is a complex one, however, and extensive data are necessary to quantitatively describe these models. In view of the considerations, we recommend that the following research be performed concerning the specific survival related diseases present in the shelter population.

(1) Determine the communicability of such diseases and the portion of the shelter population susceptible. In particular, account insofar as possible for the effect of austere shelter conditions and of radiation on susceptibility.

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(2) Construct a mathematical model describing the propagation of

disease through shelters.

The above approach, if successfully carried out, would lead to probability
statements about communicable disease analogous to those made above for chronic
disease; similar analysis of shelter medical stocking policies could then be
made.

Use of Health Data in Medical Stocking

Figures B-1 through B-15 show a plot of number of persons (t) in a shelter
vs. the probability $P_s(t)$ of at least s cases of the specified condition in a
shelter containing t persons. The points on the curves are obtained in the same
manner as were the entries in Table III of Chapter Two, i.e., by using formula (B-1).
These curves illustrate clearly how increasing the shelter size increases the
probability of a single incidence of the specified condition. The curves are use-
ful in computations concerning the need for certain medical supplies as a function
of shelter size, e.g., the stocking of medicines and the assignment of physicians
to shelters.

The following example is illustrative of their use as indicators of the
necessity for storing certain medical supplies in a shelter: Suppose that it
is desired to have insulin available in a shelter, if there is at least .5
probability of at least one diabetic present in the shelter. Figure B-1 then
shows that shelters of capacity greater than 75 persons should stock insulin.
Carrying the example further, Figure B-3 shows that the shelter capacity would be
at least 300 for the probability of at least 3 cases of diabetes to exceed .5.

A more refined technique is available, however, for determining amounts
of medical supplies to stock. If medical supplies are placed in shelters in
amounts sufficient to provide care for exactly the expected number of cases shown
in Table IV of the text, about half of the shelters would have insufficient supplies
for their caseloads; whereas, the remaining shelters would have an excess of
supplies. This situation is due, of course, to the random manner in which cases
occur in shelters. The way in which this difficulty may be overcome is by
overstocking the shelters with supplies. For example, in a shelter of given
size, we can determine the number of cases, n, for which we should provide supplies
in order that the probability of having too few supplies is less than, say, .10.
This number is determined by the formula

$$Pr(X > n) < .10 \qquad\qquad (B\text{-}2)$$

where $Pr(X=k)$ is given by (B-1). As an illustrative example, let us consider
the case of supplying insulin to diabetics. Table B-1 shows, for shelters of
specified capacities, the number of cases of diabetes for which insulin should be
stocked, if the probability of having too few supplies is to be less than .10.
For purposes of comparison, the table also includes the corresponding numbers for
the procedure of supplying drugs in quantities adequate for the expected number of
diabetics. It is noted that the overstocking procedure results in relatively
larger amounts of supplies in small shelters than does the "expected value" pro-
cedure, but the relative difference decreases as the shelter capacity increases
(except for rounding errors). Thus, larger shelters make more "efficient" use
of resources (greater protection at the same percent excess, or less percent ex-
cess for the same assurance of adequacy).

COMPARISON OF THE STOCKING REQUIREMENTS OF

TWO TECHNIQUES FOR STOCKING INSULIN

	25	50	100	200	400	800	1600	3200
Expected Number of Diabetics*	.23	.45	.90	1.80	3.60	7.20	14.40	28.80
Number of diabetics for whom insulin should be provided, if supply is based on expected number of diabetics	0	0	1	2	4	7	14	29
Number of diabetics for whom insulin should be provided, if supply is based on overstocking technique	1	1	2	4	6	11	19	35

* Derived from Table 4 of the text.

Figure B-16 is a histogram showing the number of existing shelters vs. the number of shelter spaces available in the United States at the time of the Phase I NFSS. It is interesting to note that the median shelter is approximately 200, and Table III (Chapter Two) reveals that at least one case of almost all major conditions (chronic and acute) would be likely in a shelter of this size.

From this fact, it can be concluded that a wide variety of medical supplies would be required to have reasonable assurance of being able to treat all the cases occurring. For chronic conditions, the methods sketched herein allow the tradeoff between stock level and probability of shortage to be seen quite clearly. To consider again the specific case of insulin and diabetes: the assumption of a "shortage cost" (in terms of human life) on the insulin stock would
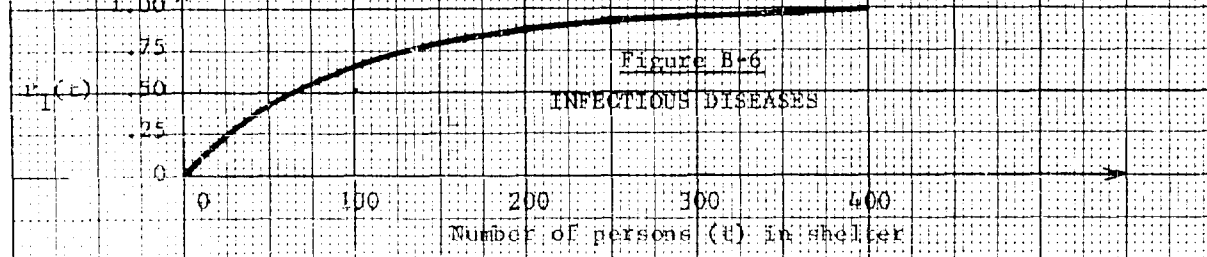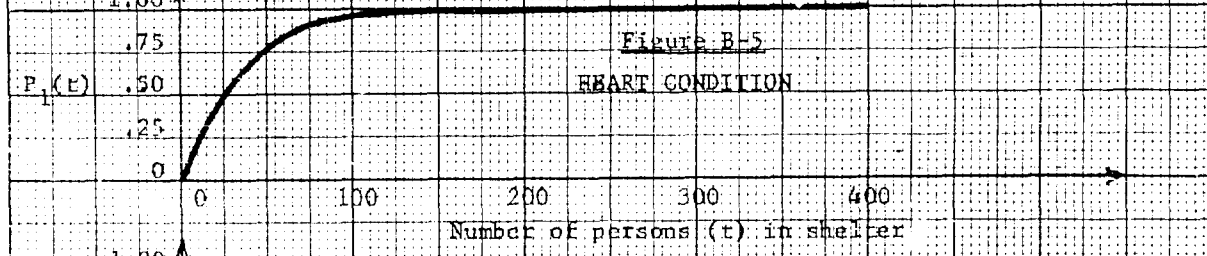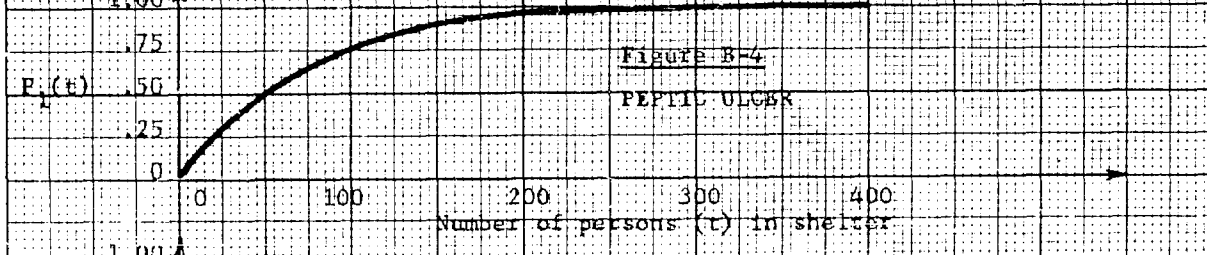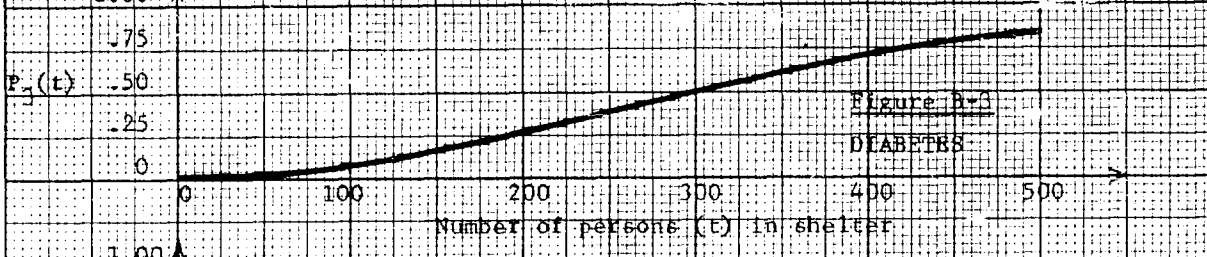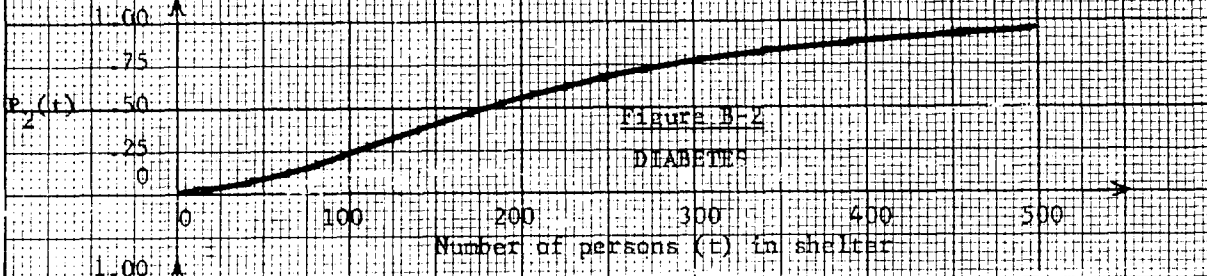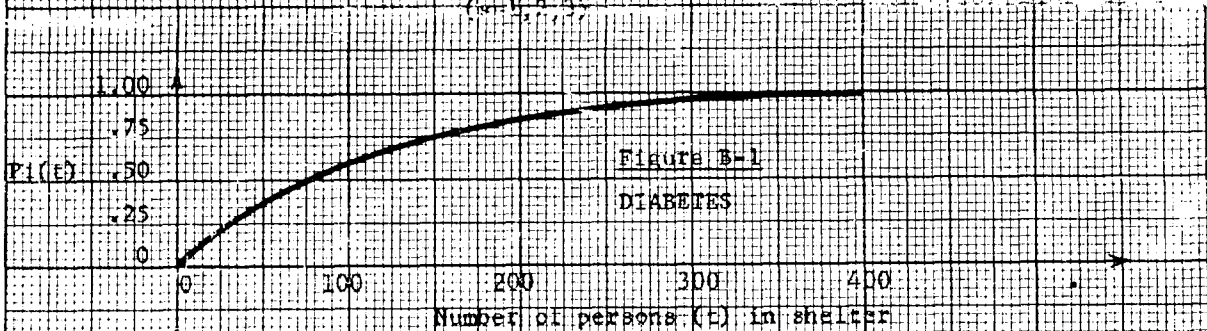
be a classical inventory problem. However, it is infeasible to place a dollar value on human life, so the allocation of insulin among shelters may be regarded as a problem in allocating scarce resources. The insulin (or analogous item) will always be a "scarce resource," because to have 100 percent assurance of covering all diabetics would require stocking enough insulin in every shelter to cover 100 percent of the shelter capacity, a clearly infeasible policy. To apply the policy of allocating the available insulin (where one unit is defined as that amount required to treat one diabetic for the shelter stay of 14 days) in a way to insure that the maximum expected number of diabetics has insulin (or conversely, that the minimum expected number of diabetics are without insulin), allocate the first unit to the largest shelter; for that shelter obviously has the highest probability of needing at least one unit. The second unit is then allocated either to the largest shelter once again, or to the next largest, depending upon whether the probability of at least two diabetics in the largest shelter is greater than the probability of at least one diabetic in the next largest shelter. Proceed in this manner throughout the shelters until the entire supply is allocated. The optimality of this procedure is discussed in Reference 24, where the analogous problem of designing an optimal spare parts kit (weight or volume limited) for military aircraft is treated.
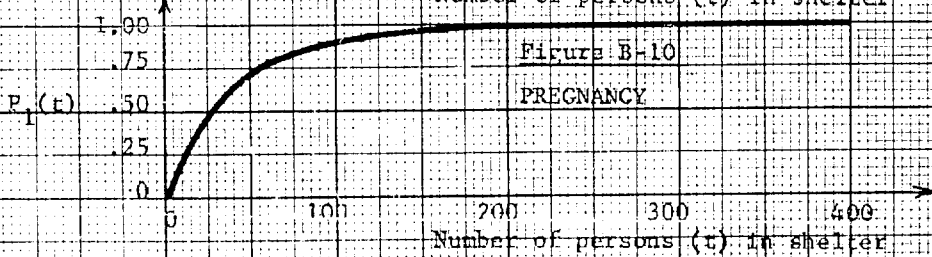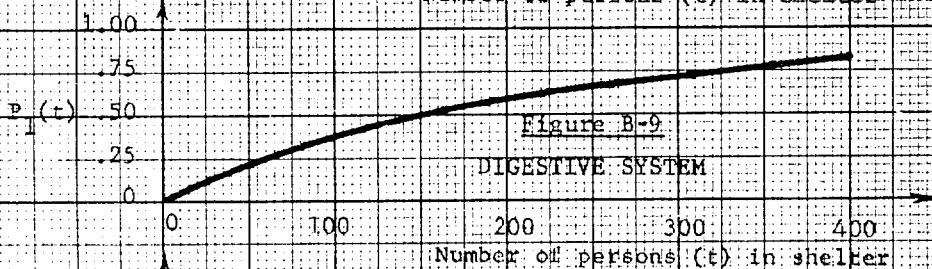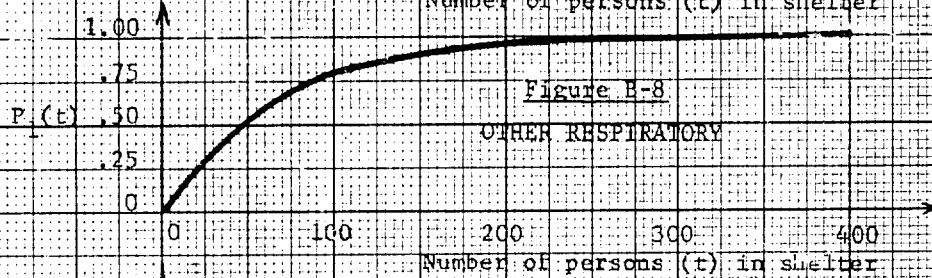
Summary

Peacetime incidence and prevalence of acute and chronic non-communicable disease can be used to develop rational medical resource allocation policies for fallout shelters. Examples of the decision rules so derived are shown. Similar

data on prevalence and incidence of communicable disease are not presently
available because of the complexity of analyzing the propogation of communicable
disease among shelter groups. Recommendations for such communicable disease
studies are made. If such analysis of communicable disease is successfully con-
cluded, analogous rules for allocating shelter medical resources to combat these
diseases may be used.

Plots of number of persons (t) in shelter versus the probability $P_s(t)$ of at least s cases of the specified condition in a shelter containing t persons.

$$P_s(t) = \sum_{x=s}^{t} \binom{t}{x} p^x q^{t-x}$$

Figure B-1
DIABETES

$P_1(t)$

Number of persons (t) in shelter

Figure B-2
DIABETES

$P_2(t)$

Number of persons (t) in shelter

Figure B-3
DIABETES

$P_3(t)$

Number of persons (t) in shelter

Figure B-4
PEPTIC ULCER

$P_1(t)$

Number of persons (t) in shelter

Figure B-5
HEART CONDITION

$P_1(t)$

Number of persons (t) in shelter

Figure B-6
INFECTIOUS DISEASES

$P_1(t)$

Number of persons (t) in shelter

Plots of number of persons (t) in shelter versus the probability $P_s(t)$ of at least s cases of the specified condition in a shelter containing t persons.

Figure B-7

UPPER RESPIRATORY

Number of persons (t) in shelter

Figure B-8

OTHER RESPIRATORY

Number of persons (t) in shelter

Figure B-9

DIGESTIVE SYSTEM

Number of persons (t) in shelter

Figure B-10

PREGNANCY

Number of persons (t) in shelter
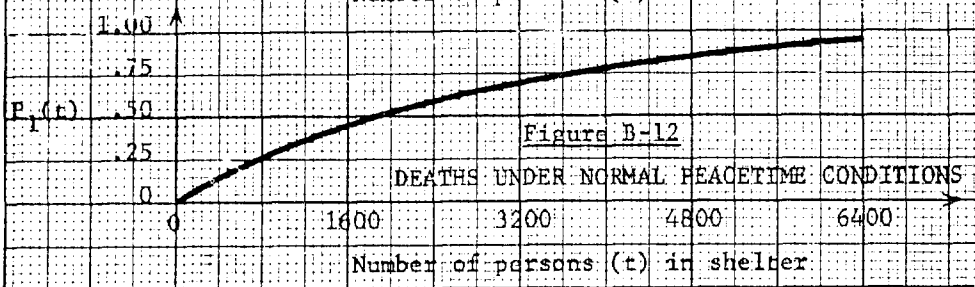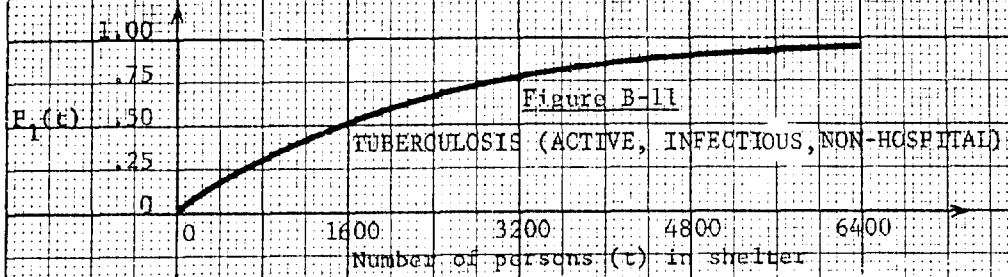
Plots of number of persons (t) in shelter versus the probability $P_s(t)$ of at least s cases of the specified condition in a shelter containing t persons.

Figure B-11

TUBERCULOSIS (ACTIVE, INFECTIOUS, NON-HOSPITAL)

$P_1(t)$

Number of persons (t) in shelter

Figure B-12

DEATHS UNDER NORMAL PEACETIME CONDITIONS

$P_1(t)$

Number of persons (t) in shelter

Partial breakdown of 'Other Respiratory'
(pneumonia, bronchitis, and intestinal flu)

Figure B-13

PNEUMONIA

$P_1(t)$

Number of persons (t) in shelter

Figure B-14

BRONCHITIS

$P_1(t)$

Number of persons (t) in shelter

Figure B-15

INTESTINAL FLU

$P_1(t)$

Number of persons (t) in shelter

Figure B-16

Histogram of Shelter Size versus Number of Shelter Spaces (NFSS Data) —

(One small square represents .02x10⁶ shelter spaces)

(class interval = 50)