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SUMMARY
OF
FINAL REPORT

R-OU-332

NATIONAL EMERGENCY HEALTH PREPAREDNESS STUDY INCLUDING THE DEVELOPMENT AND TESTING OF A TOTAL EMERGENCY HEALTH CARE SYSTEM MODEL

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SUMMARY OF FINAL REPORT R-OU-332

National Emergency Health Preparedness Study Including the Development and Testing of a Total Emergency Health Care System Model

November 1968

Project Personnel

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for

OFFICE OF CIVIL DEFENSE
OFFICE OF THE SECRETARY OF THE ARMY
Washington, D. C. 20310

through

The Public Health Service
U. S. Department of Health, Education, and Welfare

under

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Summary

I. INTRODUCTION

A. General

This research, conducted for the Public Health Service (Office of Civil Defense Work Unit 3432A) under Contract No. PH 110-67, was directed toward the development of a total Emergency Health Care System Model that can be used to study and evaluate the nuclear postattack health posture of a single locality. This total model consists of two submodels and can be used in medical preparedness planning for a single locality; i.e., a town, city, or county. It is capable of analyzing medical system effectiveness, in terms of survivors added as a function of the availability and employment (triage and treatment priorities) of medical resources (facilities, personnel and supplies).

The first submodel, the Immediate Effects Submodel, simulates the first 60 days immediately after the attack and is concerned with the handling of casualties that survive the initial weapon effects. Casualties classified by injury type for a specific attack, along with a list of medical resources available in the target area, are put into the submodel, a treatment priority is established, triage is performed, available medical resources are applied, and a prognosis of continued survival or death is derived. Output from the submodel includes the number of deaths and survivors and the utilization rates for medical supplies and personnel.

The second submodel of the Total Emergency Medical Care System Model is the Disease and Chronic Conditions Submodel. This submodel provides a simulated study of the probable generation and effect of communicable diseases among the survivors from 30 days to one year postattack. Using a prognosis function based on a mathematical model of infection and the availability of required medical resources, the model simulates the treatment of infectives and specifies the consumption rate of medical resources, by five-day periods, for each disease.

The Total Emergency Health Care System Model is written in FORTRAN II and occupies approximately 13,000 words of memory. This program was specifically designed to work on the National Civil Defense Computer Facility's CDC 3600, but it can be processed on any computer with a FORTRAN II Compiler and 13,000 words of core storage available. Segmenting of the program into the Immediate Effects Submodel and the Communicable Disease Submodel results in division of the program into two parts of approximately 8,000 and 5,000 words, respectively.

This report consists of 4 chapters and 13 appendices. Chapter 1 contains an introduction to the study and a summary of the study results. The simulation model of emergency medical care in the immediate postattack period is described in

Chapter 2 and the late postattack or communicable disease period in Chapter 3. The results of a case study in which casualty and resource data for the city of New Orleans were processed by the Total Emergency Health Care System Model are presented in Chapter 4.

B. Background

A postattack medical preparedness program must take into consideration the stockpiling of essential medical supplies, establishment of Packaged Disaster Emergency Hospitals, training of professionals and non-professionals in emergency medical care, triage, etc. The number and complexity of variables associated with these various phases of health planning programs indicates the need for developing new and more powerful methods for studying and evaluating medical preparedness.

The initial phase in the development of such methodologies began in 1965 with the initiation of Public Health Service Contract No. PH-86-65-46, Review and Evaluation of the National Health Preparedness Program. Research under that contract examined the nuclear postattack period in terms of a 60-day "immediate nuclear postattack period" and a "late nuclear postattack period" (up to one year). A computer simulation model was developed to study alternative medical strategies in the immediate postattack period. Work related to the late postattack period was primarily directed towards identifying specific diseases most likely to be problematic and towards development of preliminary estimates of the magnitude of the disease problem in the postattack environment. However, because of the preliminary work performed under this initial contract, and the need for further study on the simulation model and the late postattack disease problem, only a summary report from that research was published.[1/] That report, which had limited distribution, did not contain the details of the development of the model input data and other data concerning communicable and chronic disease and emergency medical planning.

1/ Hallan, J. B., J. L. Colley, W. L. Wells, R. S. Titchen, C. N. Dillard, and A. V. Alhadeff. Review and Evaluation of the National Emergency Health Preparedness Program - Final Summary Report, R-OU-209. Research Triangle Park, N. C.: Research Triangle Institute, 30 November 1966.

II. OBJECTIVES AND SCOPE OF WORK

The broad objective of this research was to continue the development of the simulation model capable of studying in depth the cost and effectivenss of alternative strategies for providing medical care and medical support under various postures of nuclear postattack health situations. The model design was aimed at suitability for analyzing medical system effectiveness measured by survivors, for a range of attack conditions, as a function of:

1) medical supplies,
2) medical personnel,
3) medical facilities (including Packaged Disaster Emergency Hospitals), and
4) doctrine of total system employment (triage and treatment priorities).

Detailed objectives of both submodels of the Total Emergency Health Care System Model are described in Chapters 2 and 3; specific tasks associated with developing this model under Public Health Service Contract No. PH-110-67 are:

1) *The casualty simulation phase of the model should extend to at least 60 days postattack including estimation of prognoses data and treatment requirements for radiation injury. Radiation injury is to be considered an initial effect even though dose accumulation may extend to several days or weeks. Since other contemplated studies will consider the added insult of radiation injuries in combination with mechanical trauma and burns, the model should be so constructed as to accept this potential data.*
2) *The disease and chronic conditions phases of the emergency health system should cover all initial effects survivors (injured and uninjured) and carry them forward to one year postattack. This phase includes the selection of the parameters for the 16 diseases selected for further study as outlined in Table XVI of the Final Report prepared under Contract PH 86-65-46 and estimation of upper and lower bounds on the parameters to be studied. Disease propogation models must be programmed for computer solution and disease caseloads must be generated under a variety of assumptions. The model should provide for acceptance at a later date of data relating to possible synergistic interaction between initial injury and later disease.*
3) *The model should be adaptable to the generation of nationally applicable information.*
4) *The measure of system effectiveness (output) should consider only survivors and deaths.*

5) *The model should be so constructed as to utilize a full range of resource availability values from minimal to maximum.*

6) *One (1) case study shall be performed for (1) city as approved by the Project Officer and using Public Health Service supplied data in a mutually agreeable format consistent with the input parameter requirements of the model within one (1) month after request by the Contractor but no later than eight (8) months after effective date of the contract.*

7) *The model should be adapted to account for complete and full time utilization of medical personnel at those times and places where their efforts would be most effective.*

III. MODEL FORMULATION

The approach of the work reported herein was to consider the immediate and late postattack problems capable of being studied with a single Total Emergency Health Care System Model. This model encompasses as submodels the previously developed Immediate Effects Model (with modifications and expansion) and a second model dealing with disease and chronic conditions (developed under the current contract). These submodels cover: (1) the immediate nuclear postattack period; and (2) the time, up to one year after the nuclear weapons attack, during which the surviving population will be faced with problems of diseases and chronic conditions that partly result from the attack and are complicated by a disrupted postattack environment. Figure 1 represents the overall flow and the functional relationships of the Total Emergency Health Care System Model. Details of the approach will be found in Chapters 2 and 3.

In the Immediate Effects Submodel, casualty types resulting from a specified attack are treated by the medical resources (personnel, facilities, and supplies) according to predetermined rules of triage or treatment priorities. The resources may be varied through input data to test the impact of the level of medical stockpiles, Packaged Disaster Hospitals, etc., on the measure of system effectiveness (survivors added by the emergency medical system). Secondary output, available at the option of the user, includes the utilization rate for medical personnel and other specified resources. The simulated community consists of several geographical areas called grids. For the purpose of the model, one of the grids (the hospital grid) contains the total hospital capability of the community; the others contain emergency medical treatment centers. Casualties originate in all grids. A treatment table, consisting of prognosis data, treatment time for injuries, and priorities, is stored in the computer's memory. The table is consulted and available resources applied to casualties (in batches) in order of their preassigned priorities for treatment. Provision is made for the treatment level to be altered depending upon the availability of personnel. The appropriate prognoses are applied to the injured, deaths and survivors are estimated and recorded, and available resources are depleted. The non-hospital grids are processed first, then the hospital grid, and finally, transfers to the hospital grid from the non-hospital grids. Grand totals for the run are prepared and printed out as well.

The Disease and Chronic Conditions Submodel is designed to model the generation and effects of likely disease threats for a period of about one year postattack. Beginning approximately 30 days postattack, survivors of the Immediate Effects Phase are subjected to the risks of becoming infected by one or more of 16 communicable diseases, using a mathematical model of infection. Remaining medical resources are

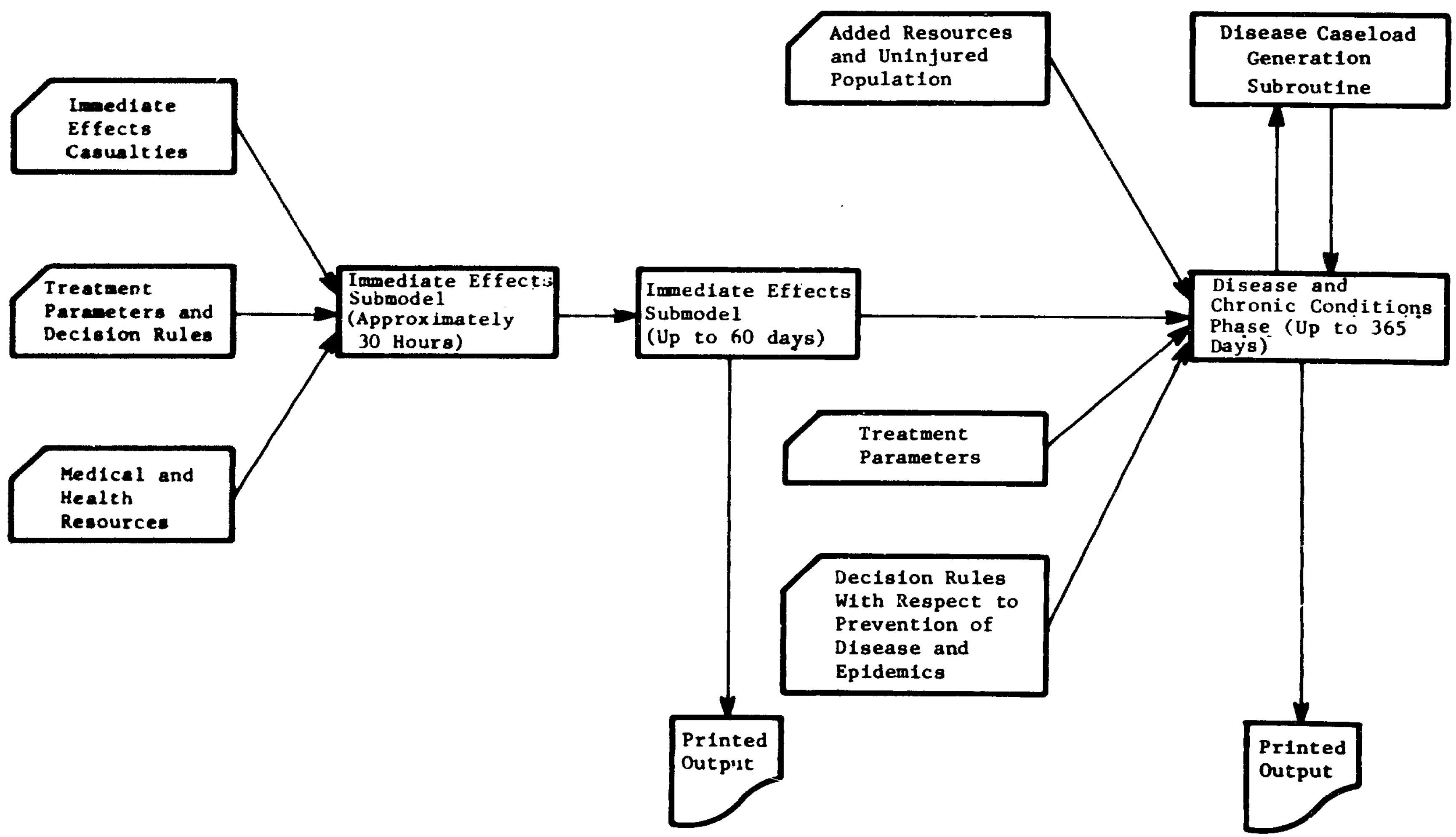

Fig. 1. Overall Flow of Total Emergency Health Care System Model

then applied to the diseased persons, and the health impact created by alternative allocations of the medical stockpiles among the two submodels (Immediate Effects and Disease and Chronic Condition) can be tested by varying the input for these resources. The impact of radiation can be tested by varying the susceptibility to the 16 diseases and the impact of the emergency situation can be tested by varying the intensity of person-to-person contact. A master control card specifies the environmental impact common to the various parameters for each disease. A disease table specifies these parameters for each disease under preattack conditions. The model output specifies the number of fatalities and the consumption of medical resources by 5-day periods.

IV. CASE STUDY

New Orleans, Louisiana (population 1,002,000) was chosen as the test city for the Total Emergency Health Care System Model and the hypothetical attack was a surface burst by a 1.5 MT thermonuclear weapon approximately 9 miles south of the center of the city.

The number and type of injuries expected as a result of the "test case" were obtained by using casualty data from a READY[2/] run and the latest Dikewood injury curves.[3/] Medical supply data were furnished by the Public Health Service and numbers of physicians were supplied by the Office of Civil Defense.

Three simulation runs through the model provided a means of evaluating the postattack health posture of New Orleans (in terms of survivors added) under three assumed levels of medical resources (medical personnel and supplies); i.e., none available, "best" estimates of what would be available, and the required amount for treating all injured at the preferred treatment level (surgeon team level, physician level, allied medical personnel level, or no-treatment level).

Conclusions regarding the findings of the New Orleans Case Study reported in Chapter 4 are as follows:

1) Sophistication of existing medical support systems appears to have little effect in terms of additional survivors during the first 60 days postattack. With the best estimates of the medical resources available in New Orleans, fatalities resulting from the processing by the Immediate Effects Submodel were estimated to be some 48 percent (185,000) of the input caseload (approximately 387,000 people injured by the weapon, either by fallout and/or by direct effects). Processing the model with zero medical resources and total amount for the casualty caseload resulted in 49 percent (188,000) and 47.5 percent (184,000) fatalities, respectively, among the input caseload. Note, however, that better than 90 percent of the fatalities in the New Orleans test case were due directly or indirectly to fallout and medical care did not affect the subsequent deaths. Thus, the conclusion of this case study was that the medical system was not a factor since an expanded medical system would be able to decrease deaths among the initially surviving injured by only 2 or 3 percent.

2/ National Resource Analysis Center, Office of Emergency Planning, READY 1: Summary Analysis, Category HMD, New Orleans SIA With Terrain Shielding (unclassified). Washington, D. C.: Executive Office of the President.

3/ Davis, L. Wayne, et al. Prediction of Urban Casualties and the Medical Load From a High-Yield Nuclear Burst. Albuquerque, N. Mex.: The Dikewood Corporation, December 1967.

2) Medical resources become far more critical in the late postattack period for the nine likely disease threats in the New Orleans area. The results of the Disease and Chronic Conditions Submodel, using maximum, available, and minimum medical resources, indicate that deaths from disease among the population surviving the first 60 days postattack were 2 percent, 4 percent, and 35 percent, respectively.

3) The critical nature of the medical resource problem implies that careful deployment and prudent conservation are needed in the postattack period if the devastating impact of disease threats is to be minimized.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

An operational two phase simulation model of the nuclear postattack total emergency health care system capable of examining the postattack period out to one year has been developed and tested. The Total Emergency Health Care System Model provides a flexible tool for examining in detail the health and medical care problems likely to exist in the immediate postattack period due to the direct effects casualties (Phase 1) and in the late postattack period because of disease and chronic conditions (Phase 2). The model is currently capable of studying problems in areas as large as a metropolitan area.

Injured casualties serve as input to Phase 1; Phase 1 survivors and the uninjured population are input to Phase 2. In both instances a range of medical caseloads (injuries, radiation casualties and disease victims) and resources (personnel, supplies and facilities) can be used in the model. Model output allows examination in detail of personnel and medical supply utilization. Postulated alternative systems can be compared in terms of survivors added by various strategies.

B. Recommendations

Based upon the findings of the current study, it is recommended that further research in this area be continued to (1) improve the existing Total Emergency Health Care System Model, and (2) to develop an appropriate model for study of large geographic areas.

1. Improvements to the Existing Emergency Health Care System Model

a. Input Data Generators

The existing Emergency Health Care System Model is hampered in its application because of the time and effort required to prepare the necessary detailed casualty and medical resource input data. This problem can be overcome by the development of input data generators for casualties and medical resources. Input data generators are in effect computer programs which facilitate preparation of complex data for ultimate use in a separate model.

Currently, casualty input data for the model must be hand generated from existing casualty assessment programs to provide detailed injury estimates by geographic location. This operation is tedious and hampers application of the model. It appears feasible to develop a computer program to prepare output data from existing damage assessment programs for use as direct inputs to the Total Emergency Health Care System Model.

The existing model also requires detailed information concerning the existence and location of medical resources including facilities, personnel and supplies; presently there is no single source which can provide such data. It does appear, however, that by accumulating certain basic medical data concerning a given metropolitan area, the resources of that area and the damage from a range of nuclear attacks to those resources may be synthesized by a computer program into a form usable by the model.

Accordingly, it is recommended that future work include the development of casualty and medical resource input generators to facilitate further study and application of the model.

b. Measures of Effectiveness

There are many practical and conceptual problems surrounding the use of measures of effectiveness in computer simulation models. While such measures are obviously needed to measure system response to various situations being depicted by the model, they are usually incapable of fully describing the response. The effectiveness measure of the current model is that of simple survivors and fatalities that are produced by the system. It is a gross but nonetheless effective measure of the ability of the system to handle complex interaction of demands and resources.

It follows that having once determined the number of survivors which may result from a given system, consideration should be given to the quality of survivorship. It is, therefore, recommended that appropriate measures be examined which are capable of describing the survivor in terms of productivity, efficiency, and disability in a postattack period.

2. Development of an Aggregate Health Care System Model

The current Emergency Health Care System Model is designed for a single city application and is not necessarily directly applicable to studies of larger geographic areas, such as those of a state, regional or national scale. This is due primarily to the necessary assumption that all hospital capabilities are located in one "grid;" i.e., the smallest geographic area in the simulation.

For example, if a state were analyzed, one Standard Location, city, or county would be assumed to contain all hospital facilities. The validity of this assumption relative to transportation of casualties to hospital facilities is questionable when an area larger than a city is simulated.

The methodology and implications of the current model may not be appropriate for studies of a state, regional or national basis even if the current model was "scaled up" to evaluate such larger geographic areas. Therefore, it is recommended that a complete and independent analysis be made within the existing state-of-the-art of the possibilities of modeling the postattack health and medical problems for geographic areas larger than a single city. Such a study should include development of parameters important to national survival and individual implications of a city by city analysis integrated into a study of larger geographic areas.

REFERENCES

Hallan, J. B., J. L. Colley, W. L. Wells, R. S. Titchen, C. N. Dillard, and A. V. Alhadeff. Review and Evaluation of the National Emergency Health Preparedness Program - Final Summary Report, R-OU-209. Research Triangle Park, N. C.: Research Triangle Institute, 30 November 1966.

National Resource Analysis Center, Office of Emergency Planning, READY I: Summary Analysis, Category HMD, New Orleans SLA With Terrain Shielding (unclassified). Washington, D. C.: Executive Office of the President.

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