A POLICY MODEL OF PREPAID GROUP PRACTICE GROWTH POTENTIAL

by

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ABSTRACT

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Submitted to the Alfred P. Sloan School of Management on May 9, 1975 in partial fulfillment of the requirements for the degree of Master of Science.

An aggregate policy model of the United States health care delivery system is developed to explore the potential for growth of the prepaid group form of care. The model is aggregate in that the U.S. population, physicians, hospitals, and demand for health care are represented by a system of non-linear differential equations which includes only fourteen principal state variables. Policies examined are subdivided into two groups: those which affect the health system as a whole, such as national health insurance and expansion of the medical schools; and those which are particular to prepaid groups, such as increased advertising effectiveness and the effects of the 1973 Health Maintenance Organization (HMO) Act. The dynamic behavior of the system in the fifty year period beginning in 1970 is simulated for all policy options using the tools of System Dynamics which have been developed at M.I.T.

At present, prepaid groups serve less than five per cent of the population. However, discussion of their merits has intensified because the per capita cost of health care has risen rapidly since 1950, and prepaid groups are a possible approach to controlling future cost increases. The prepaid group form derives its revenues from fixed monthly charges to its subscribers as opposed to the fee-for-service payment system which is predominant. The prepaid group form may reverse the financial incentives of the fee-for-service system which include stimulating demand for expensive health care services which are of only marginal benefit to the health of the recipients.

Accordingly, the model is subdivided into two major sectors: one describing the operation of doctors and hospitals who are paid on a fee-for-service basis and the other describing prepaid group operation.

The model's behavior suggests that current major policy trends may yield undesirable results. The passage of national health insurance may unleash a surge of demand for health care of questionable utility. The present trend of rapid
expansion of medical schools may only serve to increase demand for physicians without materially improving the nation's health.

The growth of prepaid groups is found to be limited most significantly by their inability to attract a large enough percentage of community population to enable economic operation except in large urban areas. The model indicates that growth to about ten per cent of the population may be an upper limit for prepaid groups as presently constituted. The 1973 HMO Law is found to be an ineffective stimulus to prepaid group growth.

A modified policy set is suggested based on the value judgment that the average level of health care available today is sufficient to the maintenance of health, provided that essential care is available at all income levels. This policy set includes reducing the growth rate of medical schools, increasing the perceived cost of care, and improving the ability of prepaid groups to serve smaller subscriber populations. The simulated outcome is a reduced per capita health care cost and a controlled total national expenditure.
ACKNOWLEDGEMENTS

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I am personally indebted to Prof. Edward B. Roberts for suggesting this topic which has been of continuing fascination to me and to Dr. Kenneth R. Britting for help with occasional modeling problems.

Most particularly I acknowledge the mathematical sophistication of my wife, Linda, and children, Greg and Shelley, in grasping why eight hundred and twenty-five is sometimes equal to zero.
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CHAPTER I
INTRODUCTION AND SUMMARY

Purpose of the Study

Within the time it has taken the population of the United States to double, health care expenditures per person have increased by a factor of seventeen, and health care may consume one-tenth of our gross national product by the end of this decade.\footnote{Falk, p. 671} Although our people live longer and are less disease-ridden, the demand for health care continues to increase, and there is an increasing level of criticism of existing health care institutions.\footnote{Somers, Health Care in Transition, p. 25} We now have a growing number of better-trained doctors than ever, and yet there is apparently an increasing imbalance between supply and demand that is producing tremendous pressures on doctors and public hostility toward the medical profession.\footnote{Ibid., p. 13} Increases in hospital facilities per capita have been accompanied by skyrocketing costs and lower apparent accessibility. Rapid increases in the comprehensiveness and extensiveness of insurance have been negated by price increases. Public policy has largely been directed toward defining new programs designed to extend coverage to groups who cannot afford the rising costs and toward finding the means of funding such
programs.

A part of these problems may be traceable to the predominant form of purchase of health care, which we may call fee-for-service (FFS). In this system, individuals purchase and pay for health care as they consume it. More than 90 per cent of health care in the U.S. comes within this definition. The FFS system is highly prized by health care providers. They assert that it is most consistent with a free-market approach, that it maximizes quality of care, and that it protects an individual's right to free choice of physician. However, an opposing view may be taken. It may be asserted that the FFS system causes a major incentive among providers to be the expansion of demand for their services. This does not necessarily arise from invidious motivation on the provider's part, but is simply the natural consequence of the structure of the FFS approach.

An alternative basic structure is a small, but growing, part of the U.S. health care system: the prepaid group practice (PPG). A PPG consists of an organization of physicians and facilities which agrees to provide comprehensive health care services to subscribers in return for fixed monthly payments. In contrast with the FFS incentives, the net return to a PPG is maximized by providing the minimum amount of service necessary to maintain a sufficient quality level.
The objective of this thesis is to assess the growth potential of this form of care by means of a computer simulation model. The specific modeling approach utilized is System Dynamics, which is a methodology developed at M.I.T. to allow the long term behavior of complex social and industrial systems to be simulated and understood.

The steps in the modeling process include 1) studying and describing the system in terms of its structural elements and their interactions; 2) quantifying the description in the form of non-linear differential equations supported by an easily understood computer language; 3) exercising and refining the resulting program; 4) testing alternative policies to predict system behavior modes under various conditions; 5) devising a preferred system design; 6) submitting the results to the harsh glare of informed scrutiny and criticism; and 7) iterating the design accordingly. All but the final two steps are presented here.

Scope of the Model

The model focuses on the delivery of physician and hospital services to the civilian population of the United States. This scope encompasses about 60 per cent of all health care expenditures, but excludes such items as prescription drugs, dental care, mental hospitals, homes and schools for the medically handicapped, homes for the
aged and dependent, tuberculosis hospitals, and other chronic
disease hospitals. Coincidentally, the model also encom-
passes about 60 per cent of all physicians, while excluding
physicians engaged in federal service, basic medical research,
teaching, administration, and other professional activity.

The model includes two principal sectors: one describing
the fee-for-service sector and the other describing the prepaid
group practice sector. Each includes a population which is
served, and newly-trained physicians are supplied to each
sector from domestic medical schools. The supply of care
in each sector is provided by its physicians and short-term
hospital beds. The demand for care is derived basically
from the population, but it is influenced by the providers
(doctors and hospitals).

The fundamental difference in the structure of the two
sectors is the incentive system which governs the supply and
demand of health care. In the fee-for-service sector,
doctors are motivated to stimulate demand in order to increase
income. Hospitals encourage their own use in an effort to
reduce the average cost of care by maintaining high occup-
pancy rates. Third-party payments reduce the direct cost
to consumers thus encouraging both consumers and providers
to utilize the available coverage. In the prepaid group
sector, subscribers have no cost incentive to limit demand,
but the supply is limited by available physicians and hospital
beds. The group revenue pool is substantially fixed by the
monthly payments of subscribers. Therefore, the incentive of the group is to limit demand since physician incomes are essentially fixed and hospitalization is an expensive and carefully metered resource.

The model simulates operation of the health care system over the interval from 1970 to 2020. The initial values of the variables in the fee-for-service sector are based primarily on generally available data describing the U.S. health care industry, while the prepaid group sector parameters are based largely on the Kaiser-Permanente Medical Care Program. 4

In addition to the standard model run, approximately fifteen policy alternatives were simulated in two groups. The first group considers variations which might affect the total health care system including changes in the supply of physicians, the direct cost of care, physician productivity, mortality rates, and hospital construction rate. The second group deals with policies directly affecting prepaid groups including advertising, physician and facility availability, age distribution of subscribers, and the 1973 Health Maintenance Organization (HMO) Act.

Ten model variables were monitored to measure the effects of policy alternatives. These include 1) total U.S. health care cost; 2) number of U.S. trained physicians; 3) per cent of population enrolled in prepaid groups; 4) medical school

4. Somers, The Kaiser-Permanente Medical Care Program
undergraduate enrollment; 5) number of short term hospital beds; 6) physician visits per person per year; 7) hospital bed days per person per year; 8) relative physician load in the fee-for-service sector; 9) relative physician load in the prepaid group sector; and 10) health care cost per capita.

The results of the standard model run are given in Chapter III. Policy runs are documented in Chapter IV, and a hypothetical hybrid set of policies is presented in Chapter V.

Conclusions

The model which is the product of this thesis represents only an initial attempt. The next steps in the system dynamics modeling process would be for the model to be subjected to criticism and debate by experts in the field and then refined accordingly. Regrettably, such a step is impossible within the time frame of a master's thesis. Therefore, the conclusions offered should be viewed accordingly.

The essential conclusion pertinent to the growth of prepaid group practices is that their growth potential is most limited by the geographic dispersion of the American people and by their inability to attract large percentages of community population. In spite of the high degree of U.S. urbanization, more than 75 per cent of us live in areas with total population of less than 250,000. Since
a typical upper bound of prepaid group population penetration is 20 per cent, and since most PPGs are not economically viable with enrollments of less than 30 to 50 thousand, then the bulk of the population is foreclosed from the PPG option. Thus, for example, the hope of the Nixon administration that 90 per cent of the population would have an HMO option available to them by 1980 is a particularly forlorn one.  

The development of PPG forms which would enable economic operation at lower levels of organizational complexity would seem to be one approach to overcoming these obstacles. The typical present view that a PPG requires at least 30 physicians and a 200 bed hospital would have to be altered. The feasibility of this line of thought is not developed herein.

The model's FFS sector is as complete as the PPG's, and therefore the model also serves as a general policy model for the U.S. health care system. Policies which were examined include the rate of education of physicians, changes in comprehensiveness of public and private medical insurance, and changes in rate of construction of new facilities.

The model indicates that, within very broad limits, physicians can stimulate sufficient demand for their services.

5. Havighurst, p. 720
to create the continuous impression of a shortage. The resulting effect is to further increase the number of physicians in a futile attempt to eliminate the apparent shortfall.

This effect is heightened if the direct cost of consumption is reduced by further expansion of medical insurance. At present, the direct cost of hospitalization net of insurance is only about 20 per cent of the total, and the direct cost of physician service is about 50 per cent. Cumulative demand for care within the model is extremely sensitive to changes in these values. Although this may represent a valid criticism of the model, the effect is also strong in reality.

An essential step in developing a system dynamics model is to search for goals that are inherent in the system under study, because such goals serve to specify the limits of dynamic behavior. Within the U.S. health care system, no such goals have been articulated concerning the levels of consumption which are needed or which should be available. Thus our experience has been a gradual increase in expectations of health care benefits accompanied by increases in average care provided. As medical technology has advanced, near miraculous procedures, such as organ transplants, have become common in occurrence, but uncommon in cost. We have been reluctant to face the possibility that such advanced treatments cannot become commonly available because of their
tremendous costs. Thus, much public rhetoric has been devoted to the view that all citizens are entitled to the highest levels of care. Such a view may not be sustainable within the limits of cost that we are willing to bear.

We have also paid insufficient attention to the distinction between health and health care. Health refers to how long we live and how well we feel; health care refers to how much we spend to feel well and to extend our lives. If our objective is to improve national indices of health, then added expenditures on physician services and hospital care may rank far down the list in benefit/cost ratio when compared with such alternatives as reduced pollution, improved diet, increased exercise, and basic medical research.
Overview

The predominant mode of payment for health care in the United States is fee-for-service (FFS). An individual perceives that he requires medical attention and proceeds to acquire it by such means as scheduling an appointment with his family doctor, by contacting a specialist if he has cause to suspect that he requires one, or by proceeding to the emergency room of a nearby hospital. Upon examination, the physician contacted diagnoses the difficulty and recommends a course of action which the individual normally accepts. The treatment may involve hospitalization, diagnostic tests, prescription drugs, referrals to other doctors, and subsequent rechecks. The individual is billed for each item of service as it is provided with the actual payment being made by the individual, his insurance company, and public funds with the distribution of payment depending on the individual's circumstances. More than ninety percent of our population purchases health care service in this way.

Other basic forms are possible. One is to nationalize health care services and to make health care provision the responsibility of the government. Alternative forms of this approach may be seen in Great Britain, Sweden, and
CHAPTER II

STRUCTURE OF THE UNITED STATES HEALTH CARE SYSTEM

Overview

The predominant mode of payment for health care in the United States is fee-for-service (FFS). An individual perceives that he requires medical attention and proceeds to acquire it by such means as scheduling an appointment with his family doctor, by contacting a specialist if he has cause to suspect that he requires one, or by proceeding to the emergency room of a nearby hospital. Upon examination, the physician contacted diagnoses the difficulty and recommends a course of action which the individual normally accepts. The treatment may involve hospitalization, diagnostic tests, prescription drugs, referrals to other doctors, and subsequent rechecks. The individual is billed for each item of service as it is provided with the actual payment being made by the individual, his insurance company, and public funds with the distribution of payment depending on the individual's circumstances. More than ninety percent of our population purchases health care service in this way.

Other basic forms are possible. One is to nationalize health care services and to make health care provision the responsibility of the government. Alternative forms of this approach may be seen in Great Britain, Sweden, and
the Soviet Union. Such an approach is not under serious discussion in this country and is not discussed further.

The alternative form which is the subject of this thesis is the prepaid group (PPG) form of medical practice. In this arrangement, an individual enters into a contract with a health care plan which agrees to supply all covered services for a fixed dollar amount. Comprehensiveness of coverage varies from plan to plan but typically includes physician office visits, hospitalization for acute illness, obstetrical care, and routine examinations. The plan may or may not include such items as prescription drugs, dental care, and mental health care.

The objective here is to explore the potential for growth and expansion of the prepaid group form of care in the United States. This is a significant area of exploration because of the rising percentage of our GNP which is consumed by health care and because of the national debate concerning the rights of all individuals to medical care and the means of financing it. The prepaid group practice form may play an increasing role in total health care if it can provide quality care to a satisfied enrollment at controlled costs.

The technique used for conducting the investigation is System Dynamics. System dynamics was developed at M.I.T. by Professor Jay W. Forrester and others as an extension to the optimal control theory which emerged from the second
world war.\(^1\) It provides a means for modeling the behavior of complex social systems by means of computer simulation. A system dynamics model is developed through study and discussion of the factors which are believed to be important in determining system behavior and of the influences which these factors have on each other. These interactions are described in terms of feedback loops, which are the basic structural elements of a system dynamics model. The total system structure is thus described and translated into an appropriate computer language for simulation. The viewpoint of system dynamics is that the behavior of complex systems is largely determined by their structure, and that measures or policies which are designed to alter system behavior are likely to succeed only if that structure is well understood.

The resulting computer simulation not only describes the possible future behavior of the system, but also allows potential effects of policy or strategy alternatives to be determined. Policies which may lead to desired outcomes can then be selected with more confidence.

The previous two paragraphs describe the process which is followed in this thesis. In the remainder of this chapter, a description of the feedback structures relevant to prepaid group practice growth is given. Then in Chapter III,

\(^1\) Forrester's *Industrial Dynamics* is the field's basic work.
the resulting simulation model is described. In Chapter IV, the effects of various policy alternatives are measured, and finally Chapter V describes a possible preferred system and suggests possible refinements of the model.

Since relative growth of the PPG form of care implies relative loss to FFS care, it has been necessary to model the FFS structure in the same detail as for PPGs. Thus the resulting model may also be viewed as a general U.S. health care policy model.

Health and Health Care: Some General Observations

The distinction between health and health care is an important one to clarify, and one which is notably absent from much public discussion. By health we mean to refer to the general well-being of the population and the individuals within it. Health has various measures such as life expectancy and days per year confined to bed. Some factors which affect health positively include a balanced diet, exercise, and low body weight; negative factors include obesity, smoking, and exposure to pollution. By health care we mean the acquisition of professional services which are hoped to correct a deviation from health or to maintain health. Health care is measurable in dollars expended for physician services, hospitalization, and drugs.

The fact is that the correlation between increases in health and health care is weak. In the period from 1929
to 1956, the life expectancy at birth in the U.S. increased by 15.5 per cent while health care expenditures remained nearly a constant 4 per cent of the GNP. From 1956 to 1970, life expectancy increased by 2.7 per cent while health care as a fraction of the GNP increased by more than 75 per cent. This suggests that the marginal cost of improved health via health care is very high. It has also been shown that there is no relationship between mortality and physicians per capita among the nations of the Western hemisphere. Thus it would seem that if the national issue is improved health, then expanded health care is a poor way to seek it (although a redistribution of care may be in order to provide comparable care at all income levels).

If health care is too expensive at the margin, then we must address the questions of how much health care is enough and how much health care would be demanded if it were free. These are vital questions which normally fail to enter policy discussions perhaps because the issues involved are so difficult. (For example, should there be an economic or age barrier to life saving procedures such as organ transplants because of their great cost?) Thus, although we can specify with some confidence how much

2. Klarman, p. 8
3. ibid., p. 30
4. Stewart and Siddayao, p. 59
protein per day is sufficient for good health, we have no measure of how much health care is enough. However, the fact is that health care consumption per capita has greatly increased. In thirty years, yearly physician visits per person doubled from 2.5 to 5 and short term hospital days per person rose by 50 per cent. Moreover, there is no convincing moderate upper limit to the care which might be sought if it were cheap or plentiful enough.

This discussion has significant relevance to the structure of our health care model. First, we may reasonably assume in the model that the supply and cost of health care in either FFS or PPG form have no significant impact on birth and death rates (and therefore population). Second, the model must simulate demand for health care without an explicit upper or lower bound on the amount of care sought.

The Health Care Consumer

For the purposes of the model, we are interested in understanding the factors which affect the level of demand for health care and those which affect the choice of FFS versus PPG care. In this chapter, we deal primarily with qualitative effects, leaving parameterization of the model until Chapter III.

Most obviously, people seek health service care when they perceive a need for it. This basic demand factor is modulated by others, however. One is the individual's
ability to pay for the service he receives. Ability to pay depends on both personal income and the availability of applicable insurance. Insurance coverage is particularly significant in demand for hospitalization, with demand as a function of ability to pay varying by more than a factor of two. It is not difficult to identify untapped sources of latent health care demand which are inhibited by costs. It has been estimated that at least 40 per cent of the American people are in categories requiring relatively large amounts of medical care but with inadequate resources to purchase it. Moreover, half the population has never had a thorough physical exam and only one-quarter are examined on a regular basis.

However, once an individual decides that his problem warrants seeking care, then a different set of demand determining factors emerges. Most persons have the dual characteristics of being ignorant about medicine and reluctant to take risks concerning their health. Thus the consumer is likely to ask the physician to take all available precautions, no matter what the expense. Thus control over the level of demand effectively leaves the consumer's

5. Feldstein, p. 17
6. Somers, Health Care in Transition, p. 20
7. Greenberg and Rodburg, p. 897
8. Lave and Lave, p. 259
hands upon entry to the doctor's office. Ordinarily the costs of service are not known until after the fact. Probably less than five per cent of surgery patients know the fee before they agree to have surgery performed. A patient who is concerned about his well-being and existence may psychologically welcome and actually seek excessive care. Thus an individual may have, or want, little defense against the high expense of a major illness.

There are several significant factors that limit the likelihood that an individual will seek care in a PFG. First, one appeal of the PFG is that it fixes the cost of care and lowers the risk of disastrous loss. However most people, when healthy, underestimate the risk of such an occurrence. Second, FFS is the predominant form of care, and in general people tend to be satisfied with their present health care approach, no matter what its deficiencies. There is also widespread respect for the notion of freedom of choice in choosing a physician and a romantic attachment to the Marcus Welby style image of physician-patient relationship. The goal of having a personal physician is an item of prestige associated with a rising

9. Kessel, p. 280
10. Havighurst, p. 790
11. Klarman, p. 54
12. Donabedian, p. 7
standard of living. Thus, many people are reluctant to accept anything "less".

Finally, many people are precluded from selecting PPG care simply because such a plan is unavailable to them. PPGs at present are viable only in large metropolitan areas, and their enrollment comes almost entirely from employee groups.

However, these factors do not eliminate the potential for significant PPG growth. The one-to-one physician-patient tradition is in fact declining, and Donabedian asserts that the PPG becomes acceptable to consumers to the extent that they become alienated from traditional practice. With that proviso, he believes that consumers are able to judge rival plans on their merits and will select the plan which best meets their needs if they have sufficient information.

The FFS Health Care Providers

Although the number of specialties essential to health care is increasing, the physician remains the fundamental unit of manpower. He requires the most extensive training, controls the way in which service is provided, and is the principal regulator of price. In return for his average work week of over 50 hours, the physician receives a high degree of independence, professional acceptance, community

13. ibid., p. 25
standing, and an average net income of $62,500 (1972).\textsuperscript{14,15} He is conscious of these benefits and is willing to work through his professional society to maintain them. Like professionals of other types, he displays a preference for interesting and challenging work at the expense of the commonplace. He is typically pleased with the FFS mode of care and is hostile to any form which would make him a salaried employee. The model must capture these dimensions if it is to give a plausible structure of the health care system.

We have attributed to the physician an important role in determining demand for health care service. Bergen and Hirsch have catalogued the physician's short-term dimensions of flexibility in this regard.\textsuperscript{16} These include 1) the rate of accepting new patients; 2) the rate of scheduling follow-up visits; 3) rate of referral to other doctors; 4) rate of hospitalization; 5) the time allotted per visit; 6) the number of appointments scheduled; and 7) the utilization of supporting personnel.

He may also alter his fee schedule. Feldstein believes that the physician is a price setter, but that

\textsuperscript{14.} Phelan and Erickson, p. 863
\textsuperscript{15.} \textit{Statistical Abstract of the United States} (1974), p. 75
\textsuperscript{16.} Bergen and Hirsch, p. 21
he does not seek to maximize profits. Rather, he maximizes utility including income, leisure, and work characteristics.\textsuperscript{17} His prices adjust with a lag to increases in the consumer price index, the prevailing extent of insurance coverage, the average per capita income, and volume of practice inputs.\textsuperscript{18}

These dimensions of flexibility enable the productivity per physician to vary over wide ranges. The most common unit of productivity is the physician office visit. According to \textit{Medical Economics}, 22 per cent of the general practitioners in solo practice provide fewer than 100 visits per week while 19 per cent provide over 250.\textsuperscript{19} This indicates that in spite of the high average physician work week, there remains the potential for significant increases in service measured in terms of physician visits. As Fein has pointed out, "a given number of physicians could deliver an increased number of visits with an unrecognized decline in quality."\textsuperscript{20}

There remain two additional factors which are central to the supply and demand for physician services. These are the increased tendency toward specialization and the

\begin{itemize}
\item \textsuperscript{17} Feldstein, p. 50
\item \textsuperscript{18} \textit{ibid.}
\item \textsuperscript{19} \textit{Medical Economics}, May 13, 1974, p. 90
\item \textsuperscript{20} Fein, p. 91
\end{itemize}
geographical distribution of physicians. In 1950, less than 50 per cent of physicians were specialists, while by 1965, 64 per cent considered themselves to be in specialty practice. The number of family physicians (GPs, pediatricians, and internists) per 100,000 population was 94 in 1931 and 50 in 1965.\textsuperscript{21} Conversely, there is an apparent surplus of some specialists, notably general surgeons. In 1971, the A.M.A.'s physician placement service had five times as many surgeons seeking positions as there were vacancies.\textsuperscript{22} The suspicion that much surgery is performed unnecessarily is widespread.

Physicians tend to cluster in urban areas where facilities are best, more interesting cases appear, and cultural opportunities are broader. Only 12 per cent of the physicians practice in rural areas where 30 per cent of the population is.\textsuperscript{23} Moreover, this trend has accelerated. The decrease in doctors in isolated rural areas between 1950 and 1960 was six times greater than the decrease in population.\textsuperscript{24}

The implications of these factors on the cumulative demand for physician services are significant. Family

\textsuperscript{21} ibid., p. 72
\textsuperscript{22} Schwartz, p. 15
\textsuperscript{23} Carlson, p. 859
\textsuperscript{24} Stewart and Siddayao, p. 32
physicians will tend to be subject to a high demand from the population for basic care. Specialists over-congregate where population densities are highest and the ability to stimulate demand is largest. The apparent scarcity of physicians in rural areas creates an image of unequal care and results in pressure to educate more physicians to reduce the imbalance.

Thus the latent demand for care that we identified within the population is supplemented by strong stimuli for demand by the nature of FFS practice and the distribution of U.S. physicians by location and specialty. This demand structure will intensify when we examine the supply of physicians and the effect of third party payments.

The Supply of Physicians

To this point, we have largely focused on the mechanisms of demand for health care. However, the factors governing the supply of physicians are also important, and these are now examined. There are two key questions to address: 1) Are there enough physicians in the U.S.? and 2) Is the rate of physician output from the medical schools adjusting to any discrepancy?

Since, as previously discussed, there is no well-defined measure of need for health care, it follows that there is no clear definition of how many doctors are needed. As observed in an A.M.A. publication, "the,
determination of the presence and magnitude of a physician shortage is a thorny problem that has been subject to widespread controversy arising from differing normative views of what medical care consumption patterns ought to be."  

A Presidential commission developed six estimates of physician requirements with the estimates ranging from a surplus of 6000 physicians to a shortage of 59,000.  

Many estimates of need have been based on goals for physicians per 100,000 population and the belief that such goals should be satisfied in all states. Others have asserted that an economic shortage obviously exists and is evidenced by rising physician incomes, large demand for admission to medical schools, and long queuing times.  

Yet a third basic view is that there are more doctors than needed but that demand is stimulated beyond sensible levels because the direct price of care (total price minus insurance) is too low. Thus the supply of physicians in the health care model cannot be based on the presence of a widely accepted need criterion.  

We can, however, gain a clearer view of the historical pattern of supply and the present trend. This century

26. Fein, p. 9  
27. Feldstein, p. 57  
28. Schwartz, p. 14
has seen two broad trends in physician supply. From 1910 to 1945, the supply of physicians was constricted, largely under the influence of the medical profession. Since 1945, an increase has occurred, largely due to legislative influence.\textsuperscript{29} Between 1900 and 1930, the number of accredited medical schools dropped from 160 to 76 and the number of yearly graduates decreased from 5200 to 4500.\textsuperscript{30} However, by 1973, the number of U.S. medical school graduates had increased to 9,300 and the number of medical schools now exceeds one hundred.\textsuperscript{31} The domestic medical school capacity has expanded by more than 50 per cent since 1960, and this trend is continuing. In addition, the domestic supply is supplemented by a large number of foreign trained physicians. In 1973, a robust 45 per cent of newly licensed doctors were foreign-trained.\textsuperscript{32}

The tendency toward increased production of specialists is also discernible in the medical schools. In 1967, sponsored research provided 43 per cent of U.S. medical school operating funds. This is in contrast with the three per cent which was derived from teaching hospitals. The financial stability of many major medical schools is

\begin{itemize}
\item 29. Kessel, p. 267
\item 30. Fein, p. 67
\item 32. \textit{ibid.}, p. 77
\end{itemize}
dependent upon their ability to attract research scholars and research grants.

The ability of this rapid increase in physician supply to meet the demands which will be placed on it (and which it will create) is problematical. Stewart and Siddayao are concerned that "we may soon have a chronic surplus of physicians as a consequence of these federal programs and an enormous overuse of medical resources as the surplus doctors try to generate demand for their service."^33

The FFS Hospital

In 1971, hospital care expense was 18 per cent greater than the total spent for physician services. In the interval from 1950 to 1970, hospital daily charges rose by an average factor of 5.6 while the consumer price index rose only by a factor of 1.7. That is, in 1950 an average day of hospital care cost about 15 dollars while in 1970 the average daily cost had risen to 81 dollars. By 1972, the cost had risen to 105 dollars per day.^35 In addition, the average American spent about 25 per cent more days per year in hospitals in 1970 than he did in 1950.

To what can we attribute these radical changes? Four

33. Stewart and Siddayao, p. 26
34. ibid., p. 20
principal factors can be identified: 1) Hospital care is qualitatively different and more costly than in earlier years; 2) the wages of hospital workers have increased by more than the consumer price index; 3) the number of hospital beds per capita has increased; and 4) the consumer price index accounts for part of the increased cost.

The first effect is the most significant. From today's vantage point, it is difficult to realize that hospitals were historically founded to serve the medical needs of the poor, and that prior to 1930, utilization of hospitals was only for terminal illness or major surgery. However, modern medical technology has greatly increased the resource inputs to hospital care. This technology has raised the expectations of consumers that hospital care will bring greater benefits. Such intensive forms of care as cancer chemotherapy, renal dialysis, and open heart surgery have produced only marginal improvements in health indices, but have required large input of physician time and physical resources. In addition, there has been substantial duplication of these expensive resources among nearby hospitals.

36. Feldstein, p. 31
37. Cantor, p. 914
38. Chapman and Talmadge, p. 343
39. Stewart and Siddayao, p. 9
The availability of such capabilities has served as a further stimulant to demand for health care. As capabilities have been developed, hospitals have been compelled to implement them in order to avoid obsolescence and loss of reputation. The result has been the increase in average care of cost which we have observed. This makes the larger hospital more attractive because marginal costs are low relative to the average. The average number of beds per short term hospital increased from 101 to 151 between 1950 and 1972. 40 Minimizing average cost then necessitates that the bed occupancy ratio be maintained at an appropriately high level (perhaps 80 per cent). This situation implicitly encourages that hospitalization and surgery of marginal value be performed. As Feldstein has pointed out, "when additional hospital beds are constructed, they are soon fully occupied. . . . The substantial interstate variation in the per capita supply of hospital beds appears to have almost no impact on their utilization rate." 41

Thus there are strong tendencies to overbuild hospital capacity and once it is built, to use it. As we shall see below, this tendency is accelerated by the structure of private and public medical insurance.

41. Feldstein, p. 19
Third Party Payments: Private and Public

As health care has increased in cost, a lower fraction of the direct cost has been borne by the consumer. In 1950, direct private payments accounted for 68 per cent of personal health care; but by 1971, direct payments had decreased to 37 per cent. In this interval, the contribution of private sources increased from 11 per cent ot 27 per cent, while the public share has increased from 20 per cent to 36 per cent.\textsuperscript{42} Hospital insurance has become ubiquitous, with more than 90 per cent of Americans covered in 1970.\textsuperscript{43} The growth of hospital insurance has proceeded at such a rate that the real, direct net cost of hospitalization to the consumer was nearly constant from 1950 to 1970.\textsuperscript{44} The coverage of physician office visits has been less extensive, however. In 1971, private insurance covered 79 per cent of hospital expenses but only 45 per cent of physician expenses.\textsuperscript{45}

Feldstein has described the effect on demand for health care in exactly the way that the system dynamics modeler would describe a positive feedback loop.

\textsuperscript{42} Stewart and Siddayao, p. 14
\textsuperscript{43} Schwartz, p. 118
\textsuperscript{44} Feldstein, p. 30
\textsuperscript{45} Social Indicators, 1973, p. 25
The interdependence of price and insurance - i.e., more insurance raises the price of care while a higher price of care induces the purchase of more complete insurance - raises the question of whether the combined market for hospital care and insurance is stable or whether the rapid increase in both insurance and prices is part of an explosive spiral. 46

The most obvious and explicitly stated objective of insurance is to protect the insured from inability to purchase needed care. However, there are other key effects. One is that the average price for care increases. Physicians who formerly upheld a tradition of charging the aged and the poor lower fees, now find such a practice unnecessary. 47 It has been alleged that the principal reason for the formation of Blue Cross was to help protect hospitals against uncollectible debts. 48 After the institution of Blue Shield, there were four times more tonsillectomies and twice as many appendectomies, mastectomies, and hysterectomies as previously. 49

Shortly after the passage of Medicare and Medicaid in 1965, the public share of the nation’s health care expense jumped from about 20 per cent to about 35 per cent. The explicit goal of these programs and the more recently

46. Feldstein, p. 71
47. Stewart and Siddayao, p. 20
48. Schwartz, p. 122
49. Stewart and Siddayao, p. 40
proposed national health insurance programs is to more nearly realize a national goal of providing comprehensive health care to all, with a method of financing to make this care universally accessible. To date, the implicit results have been less appealing. Stevens and Stevens assert that physicians have been guilty of extensive profiteering, fraud, and tax evasion resulting from these programs.\textsuperscript{50} Falk states that under Medicare and Medicaid, there are no incentives to supply a given health service at the most economical price.\textsuperscript{51} Rather, physicians and hospitals can spend money on virtually anything and be reimbursed for it. Havighurst believes that Medicare "simply pumps more money into existing fee-for-service channels and operates as a counter-incentive to any approach not in the fee-for-service mold."\textsuperscript{52}

Feldstein gives a good summary of the broad effects of both private and public insurance.

First, the insured gain from risk spreading, i.e. from paying a fixed premium to reduce the risk of very large expenditures. Second, the insured also lose because insurance introduces a wedge between the gross cost of health services and the net price they pay as patients and therefore distorts their consumption decisions. Third, an increase in insurance permits hospitals to sell a more sophisticated service and physicians to charge higher fees. These represent

\textsuperscript{50} Stevens and Stevens, p. 410
\textsuperscript{51} Falk, p. 701
\textsuperscript{52} Havighurst, p. 811
gains to the providers but losses to the consumers. Fourth, there is a net welfare loss due to the use of resources in the sale and administration of insurance. Finally, there those who remain uninsured and suffer a welfare loss because their risks are increased when prices rise and because they are now required to purchase a more sophisticated product than they would prefer.53

The Prepaid Group Practice: An Incremental Description

It was necessary to first describe the structure of the FFS health care sector in order to understand the differences which characterize the prepaid group form. The prepaid group practice, as we have noted, is a rather small segment of the total U.S. health care industry. In 1970, there were approximately 20 plans in operation which served about five million members.54 There were only six plans with more than 50,000 members of which the two largest plans were the Kaiser-Permanente Plan, with over two million subscribers, and the Health Insurance Plan of New York with almost seven hundred thousand members.55

These plans are not allied, and so their structure is not uniform. However, they are in general organized systems which undertake to provide or arrange for comprehensive health care services to a voluntarily enrolled population in exchange for periodic and fixed payments.

53. Feldstein, p. 71
54. Somers, The Kaiser-Permanente Medical Care Program, p. vi
55. Schwartz, p. 159
In contrast to private insurance premiums, the PPG payments are based on community ratings rather than experience ratings. That is, each member is charged at the same rate as all others, regardless of his age, sex, or previous health record. Rates are set to cover anticipated total demands and to provide for generation of capital for expansion. Physicians are compensated on a per capita or salary basis, perhaps plus a bonus plan. Subscription contracts are generally written annually and payments made monthly. A subscriber may withdraw from the plan by discontinuing his payments.

The physician staff generally consists of family practitioners and specialists, although some required services may be procured from outside specialists on a contract basis. It has been suggested that the minimum effective group size is 25 to 30 physicians at a ratio of one physician per one thousand subscribers.\(^\text{56}\) The most successful groups own and operate their own hospitals and clinics. Non-hospital based prepaid groups have been largely unsuccessful in making special arrangements with established hospitals.\(^\text{57}\) Plans without their own hospitals usually display higher premium rates.\(^\text{58}\)

As the costs of health care have spiralled, the PPG

\(^{56}\) Greenberg and Rodburg, p. 905

\(^{57}\) ibid., p. 915

\(^{58}\) ibid., p. 907
form has received wide attention because of its possible alteration of the FFS demand structure which we have analyzed. The PPG physician has no remunerative incentive to provide marginal service, because his income will not increase as a result. Rather, his interest is best served by providing the most efficient treatment which will yield the earliest cure. In addition, the PPG physician has a more positive incentive to encourage preventive measures such as exercise and weight loss because a healthier subscriber group will reduce the demands on his time without lowering his income. Similarly, the group incentive is to husband the use of expensive hospital resources.

On the other hand, the subscriber, having paid his premium, has little financial bar from seeking care. Some PPGs minimize this effect by charging a small fee per visit (for example two dollars). Marginal demand may also be retarded by the delay involved in securing an appointment.

Earlier in this chapter, we identified a number of factors which discourage enrollments in PPGs. There have been other significant factors inhibiting PPG growth; perhaps the most notable is opposition from organized medicine. Shortly after the Kaiser plan began operation, the A.M.A. labeled participation in group plans as unethical behavior.59 So-called "Blue Shield" laws were

59. Spooner, p. 40
passed in more than thirty states which effectively made FPGs illegal by requiring medical society approval and open access of facilities to all licensed physicians.\textsuperscript{60} Many of these laws have been repealed, and many observers believe that organized medicine is no longer an obstacle to FPG growth. I am un convinced, however. In 1970, the A.M.A. warned President Nixon that emphasis on developing prepaid group practice would drive doctors out of active practice, inflate costs, and lower physician productivity.\textsuperscript{61} In 1972, the A.M.A. stated that it "opposes governmental intervention on behalf of any one method of practice over all others or any unfair advantage given such a system."\textsuperscript{62} This is a transparent statement in favor of present laws which are strongly biased toward the FFS form. Even a casual reading of relevant articles in journals such as Medical Economics reveals a strong anti-FPG tone.\textsuperscript{63} It may thus be no accident that the 1973 Health Maintenance Organization (HMO) act carefully preserves the right of HMO physicians to operate on an FFS basis.

\textsuperscript{60} Havighurst, p. 782
\textsuperscript{61} Greenberg and Rodburg, p. 955
\textsuperscript{62} Nation's Business, December 1972, p. 54
\textsuperscript{63} For example see the articles on Health Maintenance Organizations in the October 29, 1973 and 8/19/74 issues.
An additional factor retarding PPG growth is the difficulty they face in raising capital for needed facilities. A new PPG cannot accept enrollments until facilities are available. Then, it typically takes from one to five years before enough subscribers are attracted to make operations profitable. Greenberg and Rodburg feel that this inability to generate capital is the most significant deterrent to the growth of the prepaid group form. 64

However, the popular view that PPGs deliver clinic medicine of low quality appears to be unfounded. Re-enrollment rates have typically been high, and Donabedian states that PPGs have an enhancing effect on the quality of care as perceived by their subscribers. 65 However the limitations on PPG growth imposed by membership accessibility, availability of physicians, and facility constraints are ones which are explored by the model.

Causal Loop Diagram

The preceding description of the health care system now enables us to describe graphically its structure in terms of the feedback paths which are the basis of the model. Such a description, called a causal loop diagram, is shown in Figure II-1. It shows the principal variables

64. Greenberg and Rodburg, p. 953
65. Donabedian, p. 8
Figure II-1. Causal Loop Diagram

FFS SECTOR

SECTOR TRANSFERS

FFS POPULATION

THIRD PARTY PAYMENTS

PERCEIVED COST OF CARE

QUALITY OF CARE

DEMAND FOR PHYSICIAN SERVICE & HOSPITAL CARE

EXCESS DEMAND

SUPPLY OF PHYSICIANS & HOSPITAL BEDS

FACILITY CONSTRUCTION RATE

RELATIVE SECTOR NEED

INTERNS & RESIDENTS

MEDICAL SCHOOL CAPACITY

PROJECTED PHYSICIAN NEED
which are used in the model. The sign at each arrow indicates the direction of influence of an increase in the originating variable on the terminating one. As examples from the figure, an increase in population produces an increase in demand for health care. An increase in third party payments produces a decrease in perceived cost to the consumer.

The model is divided into two principal sectors, FFS and PPG, which are similar but not identical in structure. Each sector includes its population which is the source of demand for health care. That demand also depends on the cost and quality of care. These are influenced by the available supply of physicians and hospitals. The supply of physicians is derived from the medical schools while hospitals are constructed at a rate determined by the projected demand.

There are key differences in the structure of the two sectors. On the FFS side, physicians and hospitals are also sources of demand. Increases in third party payments drive down the perceived cost of care which further stimulates demand. PPG subscribers demand a share of their care from FFS providers, but the converse is not true in significant amounts. These sources of demand are absent from the PPG sector, but because the FFS sector is predominant, the unit costs of PPG care are largely determined in the FFS sector.
CHAPTER III
DESCRIPTION OF THE HEALTH CARE DYNAMICS MODEL

OVERVIEW OF THE MODEL STRUCTURE

This chapter presents the detailed description of a system dynamics model that attempts to capture the structure of the United States health care system as described in the previous chapter. It includes descriptive material that serves as the basis of the model documentation given in the Appendices. A reader who wishes to evaluate the reasonableness of the policy results given in Chapter IV should measure his general concurrence with the structure by reading the descriptions, but the equations need not be studied. However, the table functions which appear in this chapter in the form of graphs should be reviewed, because they contain much of the subjective judgment inherent in the model. The dynamic behavior of the model is not sensitive to minor changes in these functions, but in some cases there is room for major disagreement with the forms presented.

As much as possible, the jargon of system dynamics has been omitted from the descriptions with two exceptions: the use of the terms "level" and "rate". A level can be thought of as an observable quantity which would remain even if social change were to stop entirely. Examples
FIGURE III-1
OVERVIEW OF MODEL STRUCTURE

FFS SECTOR

PPG SECTOR
in the present model are numbers of hospital beds, doctors, and the inclination of people to see their family doctors. Rates are then simply the tendency of levels to change with passing time, such as the percentage increases in physicians' fees in a year's time.

The overall structure of the model is indicated in Figure III-1. It is divided into two major sectors (Fee For Service-FFS, and Prepaid Group-PPG) with both sectors depending on the medical schools for their supply of physicians. The U.S. population is segregated into two groups; those who are prepaid group subscribers and those who are not. People transfer from one sector to the other based on various factors such as their satisfaction with their present form of health care and cost differences. Within each sector, the population places demand for care on the available physicians and hospitals, who constitute the available supply of services. The physicians and hospitals also play an important role in determining demand since they ordinarily determine the amount of service needed by individuals who come to them. This interface of supply and demand, and the projected U.S. population growth are ultimately the principal sources of dynamic change in health system attributes such as cost and availability of service.
POPULATION SECTOR

The demand for health care arises from the United States population. The total population in 1970 was 205 million of whom approximately 5 million were enrolled in prepaid group plans. Thus the total population is the sum of prepaid group enrollees and those whose needs are served on a fee for service basis. Several patterns of health care usage are identifiable based on race, income, location of residence (e.g. urban, suburban, rural), and sex distributions. However, by far the predominant influence on health service utilization is age. For example, the average person of age 65 or over sees a physician 1.4 times as often and requires 4.4 times as many bed-days per year of hospitalization as a person in the 15 to 44 age group. Thus, the population in the FFS and PPG sectors is further disaggregated into four age brackets (0-14, 15-44, 45-64, and greater than 65). Therefore, the population sector includes a total of eight system levels.

Initial values of the FFS sector levels are based on the 1970 census, while the PPG initial levels are based on the 1970 age distribution within the Kaiser-Permanente plan. These distributions are distinctly

1. Most of the PPG sector parameters given in this Chapter are from Somers, *The Kaiser Permanente Medical Care Program: A Symposium*
different. Among the population at large, 9.8 per cent was age 65 or over as compared with only 4.3 per cent in the Kaiser plan. (The cost advantage to a PPG in minimizing its percentage of elderly enrollees is apparent.)

Population growth between 1970 and 2020 depends principally on the birth rate, barring dramatic reductions in the death rate among the elderly. Presently, the Census Bureau projects a 2020 population of 300 million based on an annual immigration of 400,000 per year, a slight reduction in death rates, and an average of 2.1 births per woman in her child-bearing years (15-44). These effects are aggregated in the model by raising the fertility rate to 2.75 births per woman, which yields a 2020 population of 301 million. The effects of other population projections can be simulated simply by varying the births-per-woman parameter. The birth rate within each sector is taken to be the product of the female population (age 15 to 44) and the number of births per woman per year.

Each of the eight population levels is increased by entries from the next lowest age bracket and transfers from the same age bracket of the other health care sector, and it is decreased by transfers to the other sector, exits to the next highest age bracket, and deaths. Most essential to this study are the transfer terms between
sectors. Their structure is described later in this chapter.

**PHYSICIAN EDUCATION SECTOR**

The provision of health care in the United States is personified by its domestically trained physicians. Although ancillary personnel may become increasingly important, they will remain under the direction and control of the licensed M.D. Foreign-trained physicians presently comprise a significant percentage of newly-licensed physicians with over 40 per cent of new licentiates in 1973 receiving their training outside the United States and Canada. Nevertheless, the model assumes that U.S. medical schools are the only source of physician supply for two principal reasons. First, it is questionable whether long-term planning should be based on an assumption of continued subsidy to U.S. medicine by other nations. Second, foreign trained physicians presently play a relatively small role in providing direct outpatient care in either the FFS or PPG sector.

The factors underlying changes in U.S. medical school capacity are not well understood. Possible factors include supply of qualified applicants, desire of the medical profession to restrict supply, and pressure to increase physician supply in response to perceived needs.
for more doctors. The first factor has probably not been significant in this century. Over the last 20 years, the ratio of qualified applicants to medical school admissions has never been lower than 1.9. Moreover, no shortage of applicants should be anticipated as long as medicine remains a relatively remunerative profession. The second factor was predominant between 1910 and 1940 when the number of medical schools and graduates remained virtually constant. However, recent expansion of medical school capacity, partially in response to the stimulus of legislation, suggests that the third factor is currently dominant.

Thus, medical school capacity is modeled as consisting of two principal terms. First, schools admit sufficient students to stabilize their average enrollment over the short term. However, in the long run, this average increases or decreases depending on whether the projected long-term need for physicians is greater or less than the anticipated supply. The short-term averaging time is taken to be four years (the time for a class to move through the curriculum) while the long term horizon is taken to be thirty years (approximately the career horizon of a class). The training time for a new physician corresponds to current practice: four years of undergraduate medical education and three years of internship and residency.
The estimate of long term need for physicians is clearly central to the long-term capacity of medical schools and to the supply of health care services. It is also one of the areas of greatest debate and uncertainty. The algorithm used in the model is best described in the following section describing distribution of physicians to the FFS and PPG sectors.

**PHYSICIAN DISTRIBUTION SECTOR**

Physicians may be involved in other careers than directly providing patient care, including government service, teaching, research, administration, other professional activity, or they may leave medicine entirely. This model is concerned only with those who are direct providers of patient care to the public which includes office-based general practitioners and specialists, and full-time hospital staff. In 1970, 60 per cent of all M.D.'s in the U.S. were in these categories. Although this percentage has been declining, it is taken to be constant in the model. It may continue to decline if medical research continues to expand, if medical schools consume more M.D.'s in faculty, and if the average active career time decreases. Conversely, it could increase if the pressure for more patient care providers increases sufficiently.

Physicians may also move from one of these classifications to another as their career progresses. In particular,
a provider of care in the FFS sector may join a PPG or vice versa. Although such transfers probably occur in significant numbers, they are not important in modeling the dynamic behavior of the system. Thus, in the model when a new physician makes an intial career choice, he remains in that sector for the duration of his career. Forty per cent of physicians completing residency are essentially removed from the model, while the remaining sixty per cent are distributed to the FFS and PPG sectors.

A system level is provided for the number of physicians in FFS service and in PPG service. Initial values, based on 1970 data, are 204,000 physicians in the FFS sector and 4,650 in the PPG sector. Each level is augmented by new physicians entering and decreased by deaths and retirements. The rate of deaths and retirements is based on an average career time of 35 years.

Had this model been designed twenty years ago, it would have been necessary to indicate a restriction on the supply of physicians entering PPGs because of opposition from organized medicine. However, at present this is not a major factor in the ability of PPGs to attract new physicians. Thus the model of the fraction of new physicians entering PPGs is quite simple: it is the product of the current physician fraction in PPGs and the relative indicated demand in the PPG and FFS sectors. These demands are the quotients of indicated physicians
and actual physicians in each sector. Thus as a shortage of physicians is perceived in each sector, a greater supply will be forthcoming provided that there is a lower relative shortage in the other sector.

The indicated need for physicians in each sector is based on the 1970 physician/population ratio, a projection of population growth, and a factor which modifies desired physician/population ratio based on perceived quality of care. The population projection is a simple ten-year linear extrapolation based on current population growth rate. The 1970 physician/population ratio in both sectors was almost exactly 0.001. As time passes, this ratio may increase or decrease based on the quality of care (which in the model varies inversely as the number of patient visits per year which each physician must provide). That is, if quality rises, society may elect to provide fewer physicians per capita. This quality factor is implemented using the two table functions which follow. (Figures III-2 and III-3).

Note that in both tables, the desired physician supply is assumed to increase rapidly as quality falls, but it decreases less slowly as quality rises. The behavior is assumed to be somewhat more rational within the PPG sector. The effect is probably not significant in the model since quality in most model runs varies between 0.9 and 1.1.
FIGURE III-2

TABLE FUNCTION RELATING

DESIRED PHYSICIAN/POPULATION RATIO TO QUALITY (FFS)
FIGURE III-3

TABLE FUNCTION RELATING

DESIRED PHYSICIAN POPULATION RATIO TO QUALITY (PPG)
The physician growth rate in the PPG sector is constrained to be no more than 10 per cent per year to recognize that physician recruitment in PPGs reflects a substantial amount of planning, commitment of funds, and matching to facilities growth rate. Similar constraints do not exist within the FFS sector.

PHYSICIAN DEMAND-FEE FOR SERVICE SECTOR

As was discussed in Chapter II, an objective definition of the population's need for physician services is not available. However a ready measure is available of the level of demand for service: the frequency of visits to physicians. The following table gives the average number of physician visits per person in 1970 for the total population and for the members of the Kaiser Plan.\(^2\)

<table>
<thead>
<tr>
<th>Bracket</th>
<th>Total Population</th>
<th>Kaiser Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>15-44</td>
<td>4.6</td>
<td>4.4</td>
</tr>
<tr>
<td>45-64</td>
<td>5.2</td>
<td>4.9</td>
</tr>
<tr>
<td>65 &amp; up</td>
<td>6.3</td>
<td>6.0</td>
</tr>
</tbody>
</table>

2. The visit rates for the Kaiser Plan were estimated indirectly. That is the average visit rate among the plan's subscribers in 1970 was 4.2 visits per person per year as compared with a national average of 4.43. This apparent 5.1 per cent reduction in demand was then applied uniformly across the four age groups.
This level of demand has increased steadily over the years as the population has become more affluent, as insurance coverage has become widely available, and as legislation aimed at widening medical care coverage has appeared. Medicare and Medicaid are of course the most notable examples of the third factor. Modeling this demand for service in a system dynamics model is especially subjective since there is little agreement on such basic issues as an upper limit of average demand, and the mechanisms by which physician prices are established. However, a system dynamics model allows the best available subjective judgments to be applied, and the resulting implications for policy to be explored. (This last sentence is not a claim that the subjective effects described below are necessarily the best available. At best, they would not be denounced as incompetent by every competent observer.)

A system level is used to measure the physician visit demand in each age bracket. Initial values are based on the 1970 population and the visit rates in the table above. The total demand for FFS physician services is the sum of these four levels plus a term reflecting demand on FFS physicians by PPG subscribers. The rate of change of each level is proportional to the current demand, to the rate of population change within each age group, and to a visit demand factor. This visit demand factor (VDF) reflects modulation of demand based on the quality of
care, the cost of care as perceived by the patient, (i.e. after insurance payments), and the need for additional visits as determined by the physician. Thus VDF is formed as the sum of three terms.

If an individual feels positively about the quality of care he is likely to receive, then he is more likely to seek a physician when the need arises. Quality in the model is taken to be proportional to the time a physician can grant per visit. This is the reciprocal of the number of visits which the physician provides per year. Based on initial conditions, the average FFS physician provides 4550 visits per year. At this level, the quality of care is taken to be unity. As he provides increased care, his average load increases and the actual quality decreases. After a two year averaging time, the public perceives the change in quality and modulates its visit rate accordingly. (An identical quality measure is implemented in the PPG sector.) The table function governing this effect is shown in Figure III-4.

The level of physician service demand also depends on how much that service will cost the individual. As third party payments have become more comprehensive, the consumer has paid a decreasing percentage of the physician's fee. In 1970, third party payments covered 45.2 per cent of total national physicians fees, so that the perceived cost was 54.8 per cent. The table function relating
FIGURE III-4

TABLE FUNCTION RELATING

VISIT RATE FACTOR TO PERCEIVED QUALITY (FFS)
physician demand to perceived cost is shown in Figure III-5A. Perceived cost is a model policy variable whose level is determined exogenously. (For example, a comprehensive national health insurance program could further decrease the perceived cost.) In the basic model it is fixed at 0.5 which has no tendency to change 1970 demand level.

The final factor determining physician demand is the physician himself. Once an individual has initiated contact, it is primarily the physician who determines the level of service which is then provided. This level depends both on the physician's perception of the medical need and on his own convenience and interest. If the doctor is comfortably busy or if his schedule is light he may recommend additional visits or may stimulate visits for purposes unrelated to the original contact (such as encouraging annual physical exams). Conversely, if he is very busy the doctor will reduce demand by scheduling only essential revisits, limiting contact with some patients to telephone calls, and refusing to accept new clients. (He may also increase his fees in an attempt to lower demand, but due to the widespread availability of insurance this is an ineffective demand suppressant.) The table function relating demand to physician loading is shown in Figure III-5.

Prepaid group members also visit FFS physicians for some of their needs. Such visits result from emergencies,
FIGURE III-5A

TABLE FUNCTION RELATING

FPS VISIT RATE FACTOR TO PERCEIVED COST
FIGURE III-5

TABLE FUNCTION RELATING

VISIT RATE FACTOR TO FFS PHYSICIAN LOAD

![Graph showing the relationship between VRSFT and PHFL (Physician Load). The graph illustrates a decreasing trend as PHFL increases.]
from an inability to see the PPG doctor as rapidly as desired, or from a partial use of FFS physicians for special needs. Little data are available on the level of this demand, except that one study has indicated that the total physician demand among PPG enrollees is the same as in the FFS sector. Accordingly, the initial visit rate to FFS physicians has been set at 5 per cent of the total visit demand in the PPG sector. This demand increases as the average load on PPG physicians increases as indicated by the table function in Figure III-6.

**PHYSICIAN DEMAND - PREPAID GROUP SECTOR**

The level and rate structure of physician demand within the PPG sector is identical to that in the FFS sector. The vital difference is in the incentives for varying the demand rate. Thus, four system levels describe total physician visit demand with initial values based on the 1970 visit rates and population in the PPG sector. Total visit demand is the sum of these four terms. (The visit rate to PPG doctors by non-subscribers is taken to be zero. This is not precisely true because some emergency care is provided, but it amounts to less than one per cent of the demand.)

The demand rate change within each age bracket is

---

3. Fein, p. 103
FIGURE III-6

TABLE FUNCTION RELATING

FFS VISIT RATE TO PPG PHYSICIAN LOAD

![Graph showing relationship between VGFFT and PHGL](image)

- **VGFFT**
  - 0.3
  - 0.2
  - 0.1

- **PHGL**
  - 0.5
  - 1.0
  - 1.5
  - 2.0

Physician Load
proportional to the population change rate and to a visit demand factor. This factor is based on the average visit load carried by the PPG physicians and on the necessity for the PPG to supply a competitive level of care with standards adopted in the FFS sector.

Since the PPG physician's income does not depend primarily on the number of visits he delivers, he has little incentive to stimulate added demand. The model assumes that the lower 1970 visit rates in the Kaiser Plan are a reflection that the PPG physician has some tendency to discourage visits which would otherwise be made. Also, this tendency would increase as the patient load imposed on him increases. This effect is governed in the model by the table function in Figure III-7.

However, the PPG must provide a level of service generally compatible with that in the FFS sector. If the average visit rate in the FFS sector increases, then the PPG must adapt its practices accordingly in order to avoid a widespread belief that its level of service is inadequate. It is assumed that average number of visits per person in the PPG sector would not fall below 80 percent of the visit rate in the FFS sector.

It might be argued that the model should incorporate a factor reflecting a difference in PPG and FFS doctor productivity. However, based on 1970 data, a significant difference does not exist, at least if visits per year is
FIGURE III-7

PPG VISIT DEMAND FACTOR FROM PPG PHYSICIAN LOADING

VRSGT

PHGL

Physician Load
used as the productivity measure. The average number of visits per Kaiser Plan physician was 4,516 visits per year as compared with the national average of 4,550. Thus, although the PPG physician may utilize more support personnel and have a lower burden of administrative detail than his FFS counterpart, he may also work fewer hours per week.

HOSPITAL BED SUPPLY - FEE FOR SERVICE SECTOR

The number of available beds in short-term hospitals is a basic measure of the supply of inpatient care facilities. In 1970, there were 4.2 beds per 1,000 population or a total of 840,000 in the fee for service sector. This supply increases to the extent that new construction occurs and decreases as facilities become obsolete and are retired from service. An average useful life of 40 years is assumed; that is, the yearly demolition rate is one-fourtieth of the current supply. The bed construction rate is that required to replace obsolete facilities plus or minus a construction rate adjustment to meet projected needs.

A key parameter in estimating future need for facilities is the current bed occupancy rate. For most of the last twenty years, this figure has been between 75 and 80 per cent. If average occupancy is higher, then short term overcrowding can occur, while at lower occupancies, the average cost of care increases rapidly. The model assumes
that 80 per cent occupancy is desired.

To estimate future needs, the projected population is multiplied by the current bed utilization per person to determine the estimated total number of bed-days per year needed at some future time (taken to be six years). The number of beds indicated is that number which corresponds to an 80 per cent occupancy rate. The bed construction rate is adjusted to a rate which would yield that number of beds six years hence. The model includes a constraint on the total construction rate which precludes it from becoming negative even if a great surplus of beds occurs.

HOSPITAL BED SUPPLY - PREPAID GROUP SECTOR

The one generally accepted source of reduced costs in prepaid groups is the demonstrated reduction in hospital bed utilization. In 1970, the Kaiser plan operated with only 1.6 beds per thousand persons (as compared with the previously referenced 4.2 beds per thousand for the country as a whole). The plan acknowledged some overcrowding, as its occupancy rate was over 90 per cent. However, their target of 1.8 beds per thousand is still less than half that of the FFS sector. The model is initialized to reflect the 1970 Kaiser Plan status, and so 8,000 beds are indicated to serve the 5 million PPG population.

The scheme for projecting future bed requirements is the same as that described for the FFS sector, except for
two parameters given different values. First, a target occupancy rate of 85 per cent is assumed to reflect the belief that the PPG has a greater incentive to achieve full resource utilization. Second, the time to adjust to future needs is taken to be eight years instead of six to reflect that more capital must be generated from internal operations than for new FFS construction. The construction rate for new facilities is also developed in the same manner as in the FFS sector except that the maximum growth rate is constrained to be 10 per cent per year. This factor is imposed because even in the presence of large growth opportunities, PPGs are limited in ability to respond because of planning delays, capital restrictions, and limited ability to quickly recruit large numbers of physicians and other staff.

It might be argued that this formulation understates the number of PPG beds, since groups frequently use hospital facilities which they do not own. Also, when such facilities are used, the group must pay the prevailing rate to the hospital. On the other hand, the use of such beds constitutes 100 per cent occupancy to the PPG. Also, the cost may serve as an added incentive to reduce inessential hospitalization.

Finally, it would have been possible to develop transfer terms to reflect the sale of FFS hospitals to PPGs and vice versa. However, this effect would not be
significant unless a surplus were to appear in one of the sectors.

**HOSPITAL BED DEMAND - FEE FOR SERVICE AND PREPAID GROUP SECTORS**

The basic structure of demand for short term hospitalization parallels that of the demand for physician service. Eight system levels represent the demand in total bed days per year for each age bracket in the FFS and PFG sectors. Initial values in the FFS sector are based on 1970 bed usage rates and population distribution. The PPG sector is initialized based on Kaiser Plan data. The following table gives 1970 bed utilization rates in bed days per person by age bracket. Note that the general population used about 80 per cent more hospital care that Kaiser Plan subscribers in all age brackets.

<table>
<thead>
<tr>
<th>Age Bracket</th>
<th>Total Population</th>
<th>Kaiser Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td>0.32</td>
<td>0.18</td>
</tr>
<tr>
<td>15-44</td>
<td>0.87</td>
<td>0.47</td>
</tr>
<tr>
<td>45-64</td>
<td>1.54</td>
<td>0.82</td>
</tr>
<tr>
<td>65 &amp; up</td>
<td>3.86</td>
<td>2.15</td>
</tr>
</tbody>
</table>

Bed usage changes in each level are proportional to the current level, to population change rate, and to a bed-day demand factor. It is in this latter factor that the differences in the two sectors appear, because of the
different incentives which operate.

In the FFS sector, factors which affect bed demand include cost as perceived by the patient, the hospital's need to maintain bed occupancy at efficient levels of operation, and the role of the physician in determining whether an individual should be hospitalized.

Major medical insurance has become extremely effective in covering the expense of hospitalization. In 1970, private insurance payments covered 78.6 per cent of consumer expenditures for hospital care. Thus, the direct cost to the patient is only about 20 per cent of the total. This enables most patients and doctors to consider hospitalization under circumstances which would be financially impossible except for insurance coverage. This factor is assumed to have a strong effect on bed utilization as indicated in Figure III-8. However, perceived hospitalization cost is held constant in the standard model. The possible effects of policy changes which would alter this parameter are presented in Chapter IV.

Once a hospital has been constructed, its efficient operation (i.e. minimum average cost per day) depends on maintaining a high bed occupancy rate. The desired occupancy rate in FFS hospitals is taken to be 80 per cent. As occupancy falls below this level, elective hospitalization of marginal benefit increases. Conversely, if hospitals are overcrowded, hospitalization must be deferred
FIGURE III-8

HOSPITAL UTILIZATION RATE VERSUS PERCEIVED COST (FFS)
in some cases. The table function describing this phenomenon is shown in Figure III-9. Similarly, the FFS physician plays an important role in determining hospitalization rates. As the average physician becomes less busy, he is more inclined to sponsor hospital admittance for patients who can possibly benefit from it. The table function in Figure III-10 shows the assumed strength of this effect as a function of average FFS physician visit load.

Subscribers in Prepaid Groups also are a source of demand for FFS beds. This demand may result from emergencies which occur far from the PPG facility or from a desire to have elective surgery not covered or not recommended by the PPG. In 1970, this usage rate is taken to be 25 per cent of the total PPG bed demand. Moreover, this tendency increases as PPG hospitals become overcrowded, as governed by the table function of Figure III-11.

Within the PPG sector, the incentives are strong to carefully control the utilization of hospital services and to limit facilities to those which are most essential. Since reducing total cost is more important than reducing average cost (in contrast to the FFS incentive), there is less tendency to increase the utilization rate when the bed occupancy rate is low. (See Figure III-12.)

However, the PPG inclination to limit bed usage is restricted by the need to remain competitive with FFS sector performance, since a very great difference in hospital utilization would become associated with poor quality by
FIGURE III-9

HOSPITAL UTILIZATION RATE VERSUS BED OCCUPANCY RATE (FFS)
FIGURE III-10

HOSPITAL UTILIZATION RATE VERSUS PHYSICIAN LOAD (FFS)
FIGURE III-11

FFS HOSPITAL UTILIZATION BY PPG SUBSCRIBERS

BGFFT

0.4

0.3

0.2

0.1

0.2 0.4 0.6 0.8 1.0

3GOR

PPG Bed Occupancy Ratio
FIGURE III-12
BED UTILIZATION VERSUS BED OCCUPANCY RATIO (PPG)
the public. The model assumes that the average number of bed-days per person per year would therefore not fall below 50 per cent of FFS utilization rates.

The usage of PPG beds by FFS sector persons is not significant, and is taken to be zero in the model.

**PRICE MECHANISMS IN THE MODEL**

This model does not attempt to provide an econometric forecast of future price levels for physician and hospital service. It does, however, attempt to predict the general direction of prices in response to policy alternatives. In doing so, various quantities are computed and labeled with the dimension of "dollars". When such quantities are encountered, they should be interpreted only relative to the same quantity for other policies with little or no reference to their absolute magnitude.

A price per FFS physician visit is calculated in terms of its net income contribution to the physician. The 1970 value is calculated by multiplying the number of physicians in the FFS sector (204,000) by their median net income ($41,500) and dividing this product by the total number of visits during the year (927.9 million) which yields a value of $9.13. The future price is then postulated to increase when the average visit demand on the physician increases as the physician tries to ration his services on a price basis. The table displaying this effect is shown in Figure III-13. The average FFS physician net
FIGURE III-13

PHYSICIAN VISIT PRICE FACTOR (FFS)

PHYSICIAN LOAD

PRRFT

0.5 1.0 1.5 2.0

0.5 1.0 1.5 2.0
income is then the product of the current net income per visit and the average number of visits per physician per year.

In 1970, the Kaiser plan was experiencing a rather high rate of physician resignations, and they believed that the cause was the gap in income between their physicians and the FFS sector physicians. Accordingly physician income in the PPG sector is modeled as being governed by the FFS average income, but with a two year lag, and starting at $37,500. An equivalent net income contribution per PPG visit can then be calculated from the total number of PPG physicians and visits.

In 1970, the average cost per day of hospital care was 81 dollars. The model assumes that the price of hospital care is determined solely in the FFS sector. The rationale is that both FFS and PPG hospitals must remain competitive in wage scales and they must provide comparable facilities and equipment. Price is assumed to increase in proportion to total demand for hospitalization which corresponds most closely to the effect which technology has had on hospitalization prices in the past twenty years. That is, as total demand increases, it becomes more feasible for society to support organ transplant teams, open heart surgery teams, renal dialysis units, and other extremely costly facilities and personnel.

The total cost per person of physician service and hospitalization is calculated for each sector. The total
price of a physician visit is assumed to be twice the return to his net income.\textsuperscript{4}

The total cost of the health delivery system is then calculated as the sum of the FFS and PPG sector totals divided by a factor of 0.62 which reflects that 38 per cent of the nation's health care bill in 1970 was consumed by drugs, dentists, and other factors not included in the model.

Note in particular that there is no attempt in the model to account for inflationary price increases.

**POPULATION TRANSFER BETWEEN SECTORS**

Since one of the main goals of the model is to assess the impact of various policies on PPG growth, a careful formulation of the factors affecting enrollment is essential. Urban and Houser have identified four principal factors in selection of PPGs which include quality, value, personalness, and convenience.\textsuperscript{5} An attempt has been made to explicitly include all of these factors, as well as those which cause enrollees to become dissatisfied and to terminate their enrollment.

From a macroscopic viewpoint, PPGs have been able to sustain a 10 per cent growth rate through the 1950s

\textsuperscript{4} Feldstein, p. 49
\textsuperscript{5} Urban and Houser, p. 26
and 1960s. It has also been the case that reenrollment rates have hovered around 90 per cent. Therefore, the normal rate of new enrollments has been about 20 per cent to achieve the net growth rate. Thus, the model includes a normal growth rate factor of 0.2 and a normal attrition factor of 0.1 applied to the PPG population. Subsumed within these constants are the net attractiveness of PPGs given the state of health care in 1970.

The model includes five factors which can alter the rate of new enrollments with passing time: quality of care, cost, population distribution, PPG marketing, and PPG physician load. The formulation is multiplicative with each factor equal to unity under initial (1970) conditions.

The rate of enrollment is positively affected when the quality of service is perceived by potential enrollees to be higher than that which they are actually receiving in the FFS sector. This factor is derived from a table function based on the ratio of perceived quality in PPGs to actual FFS quality, as shown in Figure III-14.

Potential subscribers are presumed to be very sensitive to the cost associated with changing their health care provider. For example, if an employee of a large firm is offered PPG membership under a dual choice option, he is likely to reject it if his payroll deduction increases
FIGURE III -14

EFFECT OF RELATIVE QUALITY ON NEW ENROLLMENT RATE (PPG)
by very much. An attempt to model this effect is based on the costs of care which are developed within the model. A cost ratio is formed as the difference in average yearly cost per person in the two sectors, divided by the cost per year in the FFS sector. As this ratio increases, persons who have the opportunity to join a PPG become more likely to do so. The table function measuring this effect is shown in Figure III-15.

It is no accident that virtually all successful PPGs have originated in large, metropolitan areas (most notably San Francisco, Los Angeles, Seattle, New York, and Washington D.C.). There are two factors which have dictated this. First, in order to operate economically, a large subscriber population is needed. (Estimates of minimum viable subscriber populations range from 10,000 to 50,000.) Second, since the PPG concept involves inducing large numbers of persons to change well-established habits, the initial penetration of the population is normally low (about 10 per cent after an extended period of operation is typical). Thus, if 25,000 is a minimum acceptable subscriber population and only 10 per cent penetration is attainable within an allowable time, then clearly PPGs are not viable in communities of less than 250,000 population.

This effect is especially significant when the population distribution of the United States is considered.
FIGURE III-15

EFFECT OF RELATIVE COST ON NEW ENROLLMENT RATE (PPG)
The percentage of the population residing in communities of greater than 250,000 was 20.7 per cent in 1970 while the percentage living in areas of less that 10,000 was 36.8 per cent. Moreover, the pace of urbanization has slowed, and the population distribution is relatively stable. Thus as the percentage of the population enrolled in PPGs increases, it becomes increasingly difficult for them to enroll new members. The table function measuring this effect is shown in Figure III-16.

Within many PPGs, new enrollments may be closed if the physicians and facilities become overtaxed. PPG physicians have more latitude in this regard than FFS physicians since they are not normally turning away an individual with immediate needs, but rather one who is seeking a yearly contract for health care. The corresponding table function is shown in Figure III-17.

Improved marketing has been suggested as a way in which PPGs could improve their market penetration. A factor has been included to allow policy testing on this point, but it is held constant (and equal to unity) in the basic model. The combined enrollment rate resulting from these factors is applied in common to all age brackets of the fee-for-service population except the 65 and up age group. The new enrollment rate for the elderly is taken to be zero. This is consistent with the Kaiser Plan policy in 1970 of not allowing any new enrollments
FIGURE III-16

EFFECT OF POPULATION DISTRIBUTION ON NEW ENROLLMENT RATE
FIGURE III-17

EFFECT OF PHYSICIAN LOAD ON NEW ENROLLMENT RATE (PPG)
after age 60. It can also be regarded as illustrating the reluctance of an individual to change his health care delivery pattern after a lifetime of depending on the FFS sector. The effects of other recruitment policies vis a vis the elderly are explored in Chapter IV.

The factors which can induce a PPG subscriber to return to FFS care are similar qualitatively, but different quantitatively, to those which initially induced him to enroll. The basic formulation is identical to that used to model new enrollment rate, which factors modeled including quality, cost, and population distribution. As the quality of service delivered by the PPG falls below what an individual perceives is available to him elsewhere, he becomes likely to terminate his enrollment, as reflected by the table function in Figure III-18. Conversely, if the cost of PPG premiums relative to those for FFS care decreases, the rate of departures should decrease, as shown in Figure III-19. Finally, as the percentage of the total population enrolled in PPGs increases, the rate of terminations should decrease because of the generally greater acceptability of the PPG and because persons who relocate would be more likely to seek and find a satisfactory PPG. (See Figure III-20.) However, this effect is not nearly as pronounced as the effect of population distribution on new PPG enrollees.
FIGURE III-18

EFFECT OF QUALITY ON TERMINATION RATE (PPG)
FIGURE III-19
EFFECT OF COST RATIO ON TERMINATION RATE (PPG)
FIGURE III-20
EFFECT OF POPULATION DISTRIBUTION ON TERMINATION RATE (PPG)
The resulting combined attrition factor is applied to all age brackets of the PPG population except the elderly, where the transfer rate is taken to be zero. This assumption is made because of the large cost advantage to an older person of remaining in the PPG and because of his presumed commitment to this delivery style after prolonged satisfaction with it.

STANDARD MODEL RUN

The overall purposes of this model are twofold: First, to explore the growth potential of prepaid groups within the context of the currently defined health care system and second, to observe the possible impact on that growth potential and on the United States health care system of various policies which have been adopted recently or which might be adopted in future years. The time horizon modeled is the period from 1970 to 2020. Ten of the model variables have been singled out to measure the effects of policy alternatives. These include 1) total health care costs; 2) number of United States trained physicians; 3) percent of population enrolled in prepaid groups; 4) medical school undergraduate enrollment; 5) number of short term hospital beds; 6) physician visits per person per year; 7) hospital bed days per person per year; 8) relative physician load in the fee-for-service sector; 9) relative physician load in the prepaid group sector and 10) health
cost per capita.

The dynamic behavior of these variables as predicted by the model described in this chapter is shown in Figures III-21 and III-22. The outcomes in 2020 are not at variance with trends identifiable in 1975. A continuing increase in per capita demand and cost is indicated. Growth of the PPG form of care continues but serves only a total of about 10 per cent of the population. The number of physicians increases by 81 per cent to serve the demands of 50 per cent more people. Medical school capacity increases rapidly until about the year 2000 and then begins to decrease as the supply of physicians finally surpasses the demand. The per capita requirement for hospitalization shows no great tendency to change, and therefore bed capacity increases at a slightly lower rate than the population. Initial and final values of the ten key variables in the standard model run are shown in Table III-3.

Assuming the general accuracy of these projections were accepted (which admittedly it is not), then the question becomes one of evaluating whether the resulting health care system is the one the nation wants or whether alternative policies might yield a preferable outcome. The following chapter addresses this question.
### Table III-21

**STANDARD MODEL DYNAMIC BEHAVIOR  PART 1**

<table>
<thead>
<tr>
<th></th>
<th>B - Total Hospital Beds</th>
<th>C - Total Health Care Cost</th>
<th>D - Doctors</th>
<th>G - % Population in PPGs</th>
<th>M - Medical Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>200.0T</td>
<td>400.0T</td>
<td>600.0T</td>
<td>800.0T</td>
<td>D</td>
</tr>
<tr>
<td>0.05</td>
<td>125.0</td>
<td>25.0</td>
<td>375.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>37.5T</td>
<td>75.0</td>
<td>112.5T</td>
<td>150.0T</td>
<td>M</td>
</tr>
<tr>
<td>0.05</td>
<td>300.0</td>
<td>600.0T</td>
<td>900.0T</td>
<td>1200.0T</td>
<td>B</td>
</tr>
<tr>
<td>0.05</td>
<td>37.5B</td>
<td>75.0</td>
<td>112.5B</td>
<td>150.0B</td>
<td></td>
</tr>
</tbody>
</table>

#### 1970

- G - M - C - D - B -
  - G - M - D - C - B -
  - G - M - D - C - B -
  - G - M - D - C - B -
  - G - M - D - B - MC -
  - G - D - C - M - B -
  - G - D - C - M - B -

#### 1990

- G - D - M - B - DC -
  - G - D - M - B - DC -
  - G - C - D - M - B -
  - G - C - D - M - B -
  - G - C - D - B - DM -
  - G - C - M - D - B -

#### 2010

- G - M - D - B - MC -
  - G - M - C - D - B -
  - G - M - C - D - B -
  - G - M - C - DB -
<table>
<thead>
<tr>
<th>Year</th>
<th>B (Bed Days/person/year)</th>
<th>C (Per Capita Cost of Care)</th>
<th>F (Relative FIS Physician Load)</th>
<th>G (Relative FFG Physician Load)</th>
<th>V (Physician Visits per Person per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>87.5</td>
<td>175.</td>
<td>262.5</td>
<td>350.</td>
<td>6. V</td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1970 Values</td>
<td>2020 Values</td>
<td>Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Care Cost Per Person</td>
<td>284</td>
<td>377</td>
<td>Dollars per person per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total U.S. Health Care Cost</td>
<td>58</td>
<td>113</td>
<td>Billion dollars per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>Per cent of U.S. non-military population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Physicians in U.S.</td>
<td>348</td>
<td>667</td>
<td>Thousands of M.D.'s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physician Visits per Person/Year</td>
<td>4.62</td>
<td>6.77</td>
<td>Physician Visits per Person per Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Students</td>
<td>40</td>
<td>95</td>
<td>Undergraduate Med. Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>Visits per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>Relative to 1970 Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital Beds in U.S.</td>
<td>848</td>
<td>1018</td>
<td>Thousands of Short Term, Non-military Beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.97</td>
<td>Bed Days per Person Per Year</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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CHAPTER IV

EFFECTS OF POLICY ALTERNATIVES

Use of the model in testing policy options

The development of a system dynamics model which reflects the structure of a social system serves to predict system behavior modes over extended time periods. Although this prediction may itself be of intense interest (for example the growth and collapse of population projected by World Dynamics), the more significant use is as a test bed for social system design through simulation of possible policy alternatives. The model provides an extremely inexpensive means of testing policy alternatives, and may provide the would-be policy maker with improved insights concerning the behavior of the real world system. Testing of the policy options described in this chapter required approximately 20 hours at an interactive computer terminal, and the total charges for use of the computer were less than seventy-five dollars.

The United States health care system, and this model which attempts to describe it, are both complex systems. A complex system includes the following characteristics: 1) It is of high order; that is the number of level variables within it is large. 2) It is an interlocking structure of feedback loops; 3) It includes both feedback loops which

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1 Forrester, World Dynamics, p. 9

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tend to promote growth and those which tend to retard growth; and 4) It is non-linear; that is the extent of a change in response to a given stimulus depends on the current state of the system. These characteristics combine to produce behavior characteristics which are beyond the capacity of the unaided human mind to predict. Thus, the most conscientious policy-making efforts of the best-intentioned men have only a coincidental relationship with success, because they cannot hope to predict the consequences of policies which they implement.

Forrester has summarized the behavior characteristics displayed by complex systems.

Complex systems have many important behavior characteristics that we must understand if we expect to design systems with better behavior. Complex systems 1) are counterintuitive; 2) are remarkably insensitive to changes in many system parameters; 3) stubbornly resist policy changes; 4) contain influential pressure points, often in unexpected places, from which forces will radiate to alter system balance; 5) counteract and compensate for externally applied corrective efforts by reducing the corresponding internally generated action (the corrective program is largely absorbed in replacing lost internal action); 6) often react to a policy change in the long run in a way opposite to how they react in the short run; 7) tend toward low performance.

It should be added that a model is not a replacement for the policy maker, but is a potential extension of his

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2 This quote and the substance of the previous paragraph are from Chapter 6 of Forrester, *Urban Dynamics*, pp. 107-114. This chapter is highly recommended as a short summary of system dynamics models.
intellect. A model is itself the product of the judgment and analysis of one or more observers of the real system, and the model may be well or poorly designed. However, once the structure is generally believed, then the model can be of great value in revealing unsuspected long-term behavior consequences. With this preamble, we may turn to examine various policy options with respect to the U.S. health care system. The primary interest of the model is in the implications of policy for growth of prepaid group practices. Policies of interest fall into two general categories: 1) those which may be applied to the health care system in general either by governmental action or by private influence and 2) those which may be unilaterally attempted by the PPGs. Within the first category, we will consider changes in the supply of physicians, changes in physician productivity, the effect of reduced mortality, changes in the amount of payments of third parties, and changes in hospital construction rates. Within the second class, the policies tested include increased PPG advertising, removal of physician hiring and construction rate constraints, variation in new enrollments by age group, and the effects of changes in minimum number of PPG subscribers. Finally, the cumulative effects of the 1973 HMO legislation are tested.

The results for each policy area are summarized in
a table which includes the 1970 and 2020 values of the key variables for the standard model as well as the 2020 values resulting from the policy change. In this way, the long-term changes produced by the policy implementation are readily apparent.

VARYING THE SUPPLY OF PHYSICIANS (Table IV-1)

As we saw in Chapter II, there is no general agreement about whether or not there is a doctor shortage in the United States. Although there are sufficient doctors to provide much more care than was available thirty years ago, the supply still seems insufficient to the demands which are made. To some extent, this is a result of physician-stimulated demand and to patient stimulated demand enabled by third party payments.

The standard model is initialized in 1970 with a ratio of one direct care physician per one thousand population (which is a close reflection of 1970 reality). The model allows this ratio to increase or decrease depending on perceived quality of care. The outcome is a physician/population ratio in 2020 of 0.0013, which indicates that unregulated demand stimulates in increased ratio of physicians per person. (These figures can be reconciled with the entries in Table IV-1 by recalling that only 60 per cent of the total number of physicians are engaged in FFS or PPG patient care.)
An alternative policy would be to restrict the supply of physicians to a fixed proportion, which would serve as a demand deterrent. This restriction could be at a ratio equal to, greater than, or less than the 1970 level. The behavior of the model with three such ratios is shown in Table IV-1. Notice that even with a 25 per cent increase in desired physician ratio, the outcome in 2020 is 18 per cent fewer physicians than with a demand-regulated supply. Also notice that even if the desired physician ratio is reduced by 25 per cent, there are sufficient doctors in 2020 to provide more physician visits per person per year than were provided in 1970. (This outcome is dependent on the assumption that physicians are willing to provide 13 per cent more visits per year per physician they did in 1970.) Also note that the total cost of the health care system decreases by ten to sixteen billion dollars per year.

One of the more provocative suggestions of these results is that the widely criticized policy of restricting the physician supply in the U.S. in the period from 1910 to 1950 may well have been instrumental in the fairly constant share of the GNP claimed by health care in that era.

A policy of rationing physician supply is not necessarily in conflict with a social goal of approximately equal medical care for all citizens. Although inequitable
### TABLE IV-1

**EFFECTS OF VARYING PHYSICIAN SUPPLY**

<table>
<thead>
<tr>
<th>Metric</th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Physician Ratio Fixed (0.001)</th>
<th>Physician Ratio Fixed (0.0025)</th>
<th>Physician Ratio Fixed (0.0008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care Cost Per Person ($)</td>
<td>284</td>
<td>377</td>
<td>331</td>
<td>342</td>
<td>322</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^7)</td>
<td>58</td>
<td>113</td>
<td>99</td>
<td>103</td>
<td>97</td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>10.1</td>
<td>10.2</td>
<td>10.0</td>
</tr>
<tr>
<td>No. of Physicians in U.S. (x 10^3)</td>
<td>348</td>
<td>667</td>
<td>535</td>
<td>565</td>
<td>511</td>
</tr>
<tr>
<td>Physician Visits per person/year</td>
<td>4.62</td>
<td>6.77</td>
<td>5.42</td>
<td>5.73</td>
<td>5.17</td>
</tr>
<tr>
<td>Medical Students (x 10^3)</td>
<td>40</td>
<td>95</td>
<td>84</td>
<td>73</td>
<td>93</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.04</td>
<td>1.03</td>
<td>1.04</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.13</td>
<td>1.13</td>
<td>1.13</td>
</tr>
<tr>
<td>Hospital Beds in U.S. (x 10^3)</td>
<td>848</td>
<td>1018</td>
<td>1014</td>
<td>1014</td>
<td>1012</td>
</tr>
<tr>
<td>Bed Days per Person per year</td>
<td>1.13</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
</tr>
</tbody>
</table>
care would surely result from a rationed physician supply and a patient-funded fee-for-services system, the inequities might be greatly reduced by an insurance system which equalized the perceived cost of care over a broad income range.

Finally, note that the enrollment of PPGs and PPG physician load is insensitive to the physician supply policy.

EFFECTS OF CHANGES IN PHYSICIAN PRODUCTIVITY AND REDUCED MORTALITY (Table IV-2)

Variations in physician productivity and mortality rates are not policy variables which can be controlled. However, consideration of the effects of changes in these variables may further sharpen our insight into possible behavior modes of the system.

It is clear that the ability of the physician to provide patient visits has increased over the past half century. Some contributing factors include virtual elimination of home visits, use of more supporting personnel, and centralization of hospital/office locations. Future trends in productivity are not clear, however. Productivity may continue to increase as use of supporting personnel becomes more widespread and as technology advances. On the other hand, physicians may display a tendency to translate their current high earnings into more
leisure time and less patient care.

The response of the model was tested under both circumstances. First, it was postulated that the normal number of visits per physician per year would increase by 2.5 per cent per year between 1970 and 1980 and then remain constant. Thus, by 1980 the normal number of visits per physician per year would increase from 4550 to 5687. The results are a significant increase in overall demand for physician services and a corresponding increase in health care costs by the year 2020. That is, the model suggests that the response of the system to added physician productivity would be to expand the care delivered per person rather than reducing the number of physicians.

Conversely, when a cumulative 25 per cent reduction in physician productivity occurs, the effect is to retard demand relative to the standard model while maintaining a nearly constant rate of physician education.

Life expectancy at birth in the United States increased rapidly in the first half of the twentieth century, increasing from 47.3 years in 1900 to 68.2 years in 1950. However, the rate of increase has slowed since 1950 and had risen only to 70.9 years in 1970. Thus, the standard model assumes that death rates remain constant in each age bracket between 1970 and 2020. However, the greatest opportunities for reductions are in diseases which primarily
<table>
<thead>
<tr>
<th>Health Care Cost Per Person ($)</th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Increased Productivity</th>
<th>Decreased Productivity</th>
<th>Reduced Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>5.8</td>
<td>1.13</td>
<td>1.30</td>
<td>1.00</td>
<td>1.27</td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>9.8</td>
<td>10.7</td>
<td>10.5</td>
</tr>
<tr>
<td>No. of Physicians in U.S. (x 10^3)</td>
<td>348</td>
<td>667</td>
<td>664</td>
<td>668</td>
<td>719</td>
</tr>
<tr>
<td>Physician Visits per Person/year</td>
<td>4.62</td>
<td>6.77</td>
<td>8.42</td>
<td>5.43</td>
<td>6.66</td>
</tr>
<tr>
<td>Medical Students (x 10^3)</td>
<td>40</td>
<td>95</td>
<td>97</td>
<td>93</td>
<td>106</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.02</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.13</td>
<td>1.13</td>
<td>1.12</td>
</tr>
<tr>
<td>Hospital Beds in U.S. (x 10^3)</td>
<td>848</td>
<td>1018</td>
<td>1026</td>
<td>1010</td>
<td>1104</td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.37</td>
<td>0.97</td>
<td>0.96</td>
<td>0.96</td>
</tr>
</tbody>
</table>
affect the elderly including heart disease, cancer, and stroke. Thus, a test model run was made with death rate among the elderly reduced by 50 per cent.

It is probably no surprise that this improvement in health would add significantly to the demands placed upon the health care system. The reduction in elderly death rate increases the total U.S. population in 2020 and also increases the percentage of the population who require high yearly levels of health care.

These results, of course, do not imply an opposition to lengthening the average life span, but they are presented to point out that increased longevity will almost certainly increase demand for health care.

VARYING THE LEVEL OF THIRD PARTY PAYMENTS (Table IV-3)

The level of third party payments (insurance and government) for hospital and physician services has steadily increased. Between 1965 and 1970, private insurance protection rose by 1 per cent per year, from 30 to 35 per cent of private costs for health care services. The Medicare and Medicaid programs have provided many billions of dollars of care for the aged and the poor. However laudable the objectives of such private and public programs in expanding health care coverage and reducing individual exposure to the catastrophic

3. Falk, p. 672
cost of major illness, the benefits have been mixed. Of the total dollar increase in expenditures for health services since 1966, approximately 50 per cent can be attributed to price increases alone. Additional effects which have been noted include occasional abuses by physicians, excessive use of surgery because of high insurance coverage, and other inefficiencies encouraged by cost reimbursements.

Still, the need for equitable availability of medical care exists. At present, the debate over the form of a national health insurance plan is continuing in Congress. Were it not for the present recession, the probability of the passage of such a program in 1975 would have been high. One effect of any of the plans being considered is to lower the costs of care borne directly by the recipient. These perceived costs, at 1970 levels, were 50 per cent for physician services and 20 per cent for hospitalization. Thus one policy test of national health insurance which can be made by the model is to vary these perceived costs.

The results of three trials are shown in Figure IV-3. In the first, the perceived physician service costs are reduced to 25 per cent and hospitalization

4. Lave and Lave, p. 262
5. Stevens and Stevens, p. 414. They cite the example of three Michigan doctors whose reimbursement claims totaled over $800,000.
cost to 10 per cent. In the third both costs are reduced to zero, while in the second the costs are increased from present levels to 75 per cent and 40 per cent respectively.

The model indicates a virtual explosion of demand when direct costs are lowered. Relative to the standard model run, total per capita cost increases by a factor greater than five; physician visits per person increase by 50 per cent, and hospital days per person more than triples. At this point, it should be noted that the specific numbers are unimportant. The debate should center on whether or not the U.S. health care structure should behave in this general way under a comprehensive national health care program, and if so what is the best resolution.

The experience to date under third party payments makes this expanding demand mode very plausible. Moreover, there is no evidence that the demand level is near saturation. As Lave has observed, "if we all had the best possible medical care and could avail ourselves of the most modern medical technology, we could easily devote one-third of our resources to medical services without feeling much healthier." 6

The model run with higher perceived costs shows greatly reduced levels of demand and total cost for

6. Lave and Lave, p. 265
health care. Although increasing the direct costs of care is probably not desirable and certainly unpalatable to politicians, the policy message of these tests is clear. That is, any program of national health insurance must include within it carefully designed mechanisms for regulating demand. In particular regulating the costs of individual services is insufficient. It is also necessary to meter the average amount of service rendered per person since the total demand also can be expected to increase with lower costs.

Finally, note that lowering the perceived cost of care in the first case increases the share of population enrolled in PPGs. This effect occurs in the model because the great demand for FFS service reduces perceived quality in that sector, and persons enroll in PPGs where the physician overload is less severe. However, when the perceived cost is set to zero, physicians in both sectors are extremely overloaded, and PPG subscribers leave in large numbers hoping to find improved physician accessibility by shopping in the FFS sector. Whether or not such an effect would in fact occur is perhaps debatable, but it does illustrate the PPG growth prospects in the event of national health care insurance may not be immediately obvious.
TABLE IV-3

EFFECTS OF ALTERATIONS OF PERCEIVED COSTS

<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Reduced Perceived Cost</th>
<th>Increased Perceived Cost</th>
<th>Zero Perceived Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care Cost Per Person ($)</td>
<td>284</td>
<td>377</td>
<td>2332</td>
<td>69</td>
<td>8705</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>58</td>
<td>113</td>
<td>703</td>
<td>20</td>
<td>2023</td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>11.7</td>
<td>4.9</td>
<td>3.6</td>
</tr>
<tr>
<td>No. of Physicians in U.S. ($x10^3)</td>
<td>348</td>
<td>667</td>
<td>800</td>
<td>490</td>
<td>1173</td>
</tr>
<tr>
<td>Physician Visits per Person/Year</td>
<td>4.62</td>
<td>6.77</td>
<td>9.31</td>
<td>2.80</td>
<td>16.6</td>
</tr>
<tr>
<td>Medical Students ($x10^3)</td>
<td>40</td>
<td>95</td>
<td>111</td>
<td>78</td>
<td>158</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.18</td>
<td>0.74</td>
<td>1.39</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.30</td>
<td>0.62</td>
<td>1.50</td>
</tr>
<tr>
<td>Hospital Beds in U.S. ($x10^3)</td>
<td>848</td>
<td>1018</td>
<td>3195</td>
<td>248</td>
<td>5972</td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.97</td>
<td>3.48</td>
<td>0.18</td>
<td>6.86</td>
</tr>
</tbody>
</table>

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VARYING HOSPITAL CONSTRUCTION RATES (Table IV-4)

In 1970, there were 4.2 short term hospital beds per thousand persons in the U.S. This supply level is in glaring contrast with the 1.6 beds per thousand subscribers of the Kaiser Plan. This difference is only partially accounted for by the younger age distribution of Kaiser subscribers and their utilization of non-plan hospitals for some services. However, there is still significant pressure to increase the supply of beds. The Major public hospitals in large cities are chronically overcrowded and new suburban developments demand convenient facilities. However, there is broad agreement that hospital beds stimulate their own use as discussed in Chapter II.

Two model policy runs were made to test the effect of increased and decreased hospital construction rates. In the standard model, new construction is governed by a desire to provide sufficient capacity to render care at current levels with an average 80 per cent bed occupancy ratio. An increased construction rate was produced by lowering the desired occupancy standard to 75 per cent while a reduced rate was produced by raising the desired occupancy standard to 85 per cent. The results are shown in Table IV-4. The increased rate yields a 2020 value of 5.3 beds per thousand persons while the constricted rate yields 2.3 beds per thousand.
### TABLE IV-4

**EFFECTS OF CHANGES IN HOSPITAL CONSTRUCTION RATES**

<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Increased Construction</th>
<th>Decreased Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care Cost Per Person ($)</td>
<td>284</td>
<td>377</td>
<td>591</td>
<td>293</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>58</td>
<td>113</td>
<td>178</td>
<td>88</td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>11.9</td>
<td>8.8</td>
</tr>
<tr>
<td>No. of Physicians in U.S. (x 10^3)</td>
<td>348</td>
<td>667</td>
<td>667</td>
<td>666</td>
</tr>
<tr>
<td>Physician Visits per Person/Year</td>
<td>4.67</td>
<td>6.77</td>
<td>6.78</td>
<td>6.76</td>
</tr>
<tr>
<td>Medical Students (x 10^3)</td>
<td>40</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.05</td>
<td>1.01</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.13</td>
<td>1.13</td>
</tr>
<tr>
<td>Hospital Beds in U.S. (x 10^3)</td>
<td>848</td>
<td>1018</td>
<td>1584</td>
<td>683</td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.97</td>
<td>1.50</td>
<td>0.66</td>
</tr>
</tbody>
</table>
persons (as contrasted with the standard model value of 3.38). Considering that the 1970 cost per bed day of care exceeded 80 dollars, the great effect of policy in this area on total health care cost is not surprising.

However, the prediction that PPG enrollment increases with rising hospital bed supplies may be a less intuitive response from the model. This occurs because a surfeit of beds in the FFS sector widens the cost advantage of PPGs thus stimulating enrollments.

These results clearly indicate that nowhere in our health care system is there greater potential of cost control than in the policy we follow (either by design or by default) in short-term hospital bed supply.

GENERAL CONSTRAINTS ON PREPAID GROUP PRACTICE GROWTH

Having discussed the impact of various policies on the overall health care system, we are ready to focus on those actions which prepaid groups may consider to promote their own expansion. These actions focus on the ability of the PPG to attract subscribers, to build facilities, and to attract physicians.

The most serious of these is the ability to attract new subscribers.⁷ There is a substantial chain of events

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⁷. This is not a universally shared view, and it is undoubtedly not true in all cases. However, it is a more commonly supported view in 1975 than it was 5 to 10 years ago.
which must occur before an individual accepts the PPG as his principal provider of health care. First, since almost all PPG subscribers are enrolled from employer or other groups, the PPG must first be accepted by the employer. It may typically take an employer one to two years to evaluate and select the PPG after the first contact is made. Then, the employees will be offered the PPG as one of a dual choice option together with a conventional health insurance option.

Then the individual can seriously begin to consider PPG enrollment. Many factors must converge in order for him to select the PPG. First, the deduction from his paycheck cannot be significantly greater than that resulting from the other choice. Also, he must not have a firm ideological attachment to the free physician choice or prestige aspect of FFS care. The PPG facilities must be conveniently located, not only to the place of work but also to his home. Finally, and often must important, his wife must concur in the decision. Thus it is not surprising that 20 per cent of an eligible subscriber group has been suggested as a saturation level for PPG growth.8

One way for PPGs to increase their penetration of eligible subscriber groups is to increase their marketing

efforts to enable more direct sales efforts to individuals. There are some difficulties with such an approach. One is that solo practice physicians are prohibited from advertising, and thus there is substantial resentment among physicians of active recruitment of subscribers.\(^9\) Another is that sales efforts are costly, and amortizing the cost in premiums impairs the PPG's competitive cost position. One estimate is that it costs about $100 for each new Subscriber.\(^10\)

To examine a possible upper bound to advertising efficacy, the model was modified to represent a 50 per cent increase in enrollment rates with no cost penalty and no increase in resignation rate. This was done both with and without the constraints on hospital construction rate and physician recruitment rate. The outcome is shown in Table IV-5. The indication is that an upper limit of total U.S. population accessible to PPGs under these circumstances is about 20 per cent.

One interesting effect which appears for the first time in this run is that physician visits per person increases as the PPG population percentage increases. The explanation is that as people leave the FFS sector, the FFS physicians stimulate an increased visit demand

9. For example, see "New Dilema for Doctors: HMO Advertising", Medical Economics, August 19, 1974
10. Marketing HMO Services, p. 68
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>18.9</td>
<td>19.1</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^7)</td>
<td>58</td>
<td>113</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Per Capita Cost for PPG Care ($)</td>
<td>110</td>
<td>160</td>
<td>157</td>
<td>158</td>
</tr>
<tr>
<td>Visits per PPG Subscriber/Year</td>
<td>4.21</td>
<td>5.21</td>
<td>5.34</td>
<td>5.30</td>
</tr>
<tr>
<td>Physicians in PPGs (x 10^3)</td>
<td>4.65</td>
<td>34.6</td>
<td>65.1</td>
<td>65.7</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>PPG Hospital Beds (x 10^3)</td>
<td>8</td>
<td>44.2</td>
<td>79.8</td>
<td>82.4</td>
</tr>
</tbody>
</table>
from the remaining population. The PPG is then forced to approximately match this increased level of service in order to remain competitive.

**VARYING THE MINIMUM VIABLE SUBSCRIBER ENROLLMENT** (Table IV-6)

In Chapter III, we discussed the limitation imposed on PPG growth by the need to achieve a reasonable subscriber population within a fairly short period of time. The population distribution of the U.S. together with reasonable PPG population penetration expectations effectively forecloses the PPG from serving most the population. Moreover, the governing table function in the standard model may not be severe enough since one interpretation of it is that when the PPGs achieve a total population percentage of 10 per cent, they would have captured 50 per cent of the population in all areas with population in excess of 250,000.

Thus, the model was run with a more conservative table function.\(^{11}\) As anticipated, the 2020 population percentage in PPGs has been reduced from the 10.2 per cent of the standard model to 6.8 per cent (See Table IV-6). Thus this factor is clearly an influential pressure point which is of essential importance to projecting PPG growth.

It also represents a potential opportunity for the

\(^{11}\) The Model change is FGPFT = 1.0/0.25/0.15/0/0/0/0
<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Model Run</th>
<th>Poorer Small Group Serv. CO</th>
<th>Improved Small Group Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>6.8</td>
<td>29.0</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>58</td>
<td>113</td>
<td>110</td>
<td>104</td>
</tr>
<tr>
<td>Per Capita Cost for PPG Care ($)</td>
<td>110</td>
<td>160</td>
<td>162</td>
<td>153</td>
</tr>
<tr>
<td>Visits per PPG Subscriber/Year</td>
<td>4.21</td>
<td>5.21</td>
<td>5.19</td>
<td>5.50</td>
</tr>
<tr>
<td>Physicians in PPGs (x10^3)</td>
<td>4.65</td>
<td>34.6</td>
<td>23.1</td>
<td>98.5</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.02</td>
<td>1.08</td>
</tr>
<tr>
<td>PPG Hospital Beds (x10^3)</td>
<td>8</td>
<td>44.2</td>
<td>29.7</td>
<td>123.4</td>
</tr>
</tbody>
</table>
PPG form to expand more readily if ways can be found effectively to serve smaller subscriber groups. A possible approach might include smaller, less specialized physician groups with specialized services available when absolutely necessary from an affiliated metropolitan PPG. Thus, an additional model run was made in which it was assumed that effectiveness in serving smaller groups could be enhanced. 12 Again, the effect on long-term enrollment is dramatic with the enrollment percentage reaching 29 per cent.

VARYING AGE DISTRIBUTION AMONG PPG SUBSCRIBERS (Table IV-7)

To some extent, the PPG can control the age distribution of its subscribers by its recruitment and advertising policies. It can focus its sales efforts on employers and thereby attract work force men and their families or it can solicit Medicare and Medicaid beneficiaries. Attracting the younger subscriber distribution has three important advantages. First, younger people require less health care, as we have seen in Chapter III. Second, the term of enrollment is potentially longer just from life expectancy considerations. Third, each worker enrolled typically adds his wife and children to the subscriber roll.

12. The model change is $FGPFT = 1/0.83/0.75/0.5/0.3/0.2/0$

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### TABLE IV-

**GROWTH OF PREPAID GROUP PRACTICES WITH VARYING ENROLLMENT PREFERENCES BY AGE GROUP**

<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Stronger Appeal to Young</th>
<th>Uniform Appeal by Age Group</th>
<th>Stronger Appeal to the Elderly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>15.0</td>
<td>10.1</td>
<td>8.9</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^6)</td>
<td>58</td>
<td>113</td>
<td>111</td>
<td>114</td>
<td>115</td>
</tr>
<tr>
<td>Per Capita Cost for PPG Care ($)</td>
<td>110</td>
<td>160</td>
<td>157</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Visits per PPG Subscriber/Year</td>
<td>4.21</td>
<td>5.21</td>
<td>5.26</td>
<td>5.21</td>
<td>5.20</td>
</tr>
<tr>
<td>Physicians in PPGs (x 10^3)</td>
<td>4.65</td>
<td>34.6</td>
<td>50.4</td>
<td>34.4</td>
<td>29.9</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.05</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>PPG Hospital Beds (x10^3)</td>
<td>8</td>
<td>44.4</td>
<td>64.3</td>
<td>44.0</td>
<td>38.7</td>
</tr>
</tbody>
</table>

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In spite of these clearcut advantages, three policy runs were made to test model behavior with varying PPG age distributions. These were a preferential recruitment of the younger (age 44 and below); a uniform recruitment across all age groups, and a preferential enrollment of the elderly. As expected, the first policy leads to highest PPG enrollments because the average term of enrollment before death is greater. However, the surprising result is that the average cost and level of service do not materially increase with the average age. The reason is that the PPG physicians uniformly lower the level of service across all age groups in order to avoid physician and hospital overload. 

**EFFECT OF THE HEALTH MAINTENANCE ORGANIZATION ACT ON PREPAID GROUP PRACTICE GROWTH**

The Health Maintenance Organization Act of 1973 was intended to stimulate the growth of group practices by providing up to $375,000,000 in federally guaranteed

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13. This effect comes about because the model provides that the average level of service in the PPG sector not fall too far below the average in the FFS sector. If the model were revised to insist on a comparable service by age bracket, then a more pronounced cost difference would appear in this run. However, it is possible that the current formulation is a better reflection of reality.
loans. Groups seeking to be designated as qualified HMOs must meet certain criteria. 1) The HMO must accept all prospective patients who apply during a specified annual enrollment period. 2) A comprehensive benefits package must be offered including treatment for mental illness, drug abuse, alcoholism and preventive dental care for children. 3) No HMO may accept more than 50 per cent of its subscribers from Medicare and Medicaid patients. 4) Premiums must be based on community ratings rather than experience ratings. The requirements are such that no group immediately qualified as an HMO, and there were less than 20 HMOs by the end of 1974. The law also provided that employers of 25 or more workers must give employees the option of enrollment in a qualified HMO if one is available.

However, the law does not necessarily modify the incentive structure which is inherent in the fee for service sector. That is, a physician member of an HMO may still bill the HMO on a fee for service basis, although he may suffer some reduction in fees if the group experience is poor. Moreover, participating physicians may devote up to 50 per cent of their time to non-HMO patients. Thus, the FFS-PPG dichotomy which exists in the model is largely unaffected by the HMO law.

14. Medical Economics, May 13, 1974; p. 39
However, PPGs have the option of becoming qualified HMOs if it is to their advantage. To measure the possible effects, the principal features of the HMO law were simulated in the PPG sector of the model. The 10 per cent constraints on construction rate and physician recruitment rate were removed, and the construction rate adjustment time was reduced from eight to six years. Thus, the federal funds enable the PPGs to expand as fast as they can recruit new subscribers. However, to qualify as an HMO, the comprehensiveness of the benefits increases. This is modeled as a 30 per cent increase in demand for physician services over a five year period. The PPG/HMO is required to allow open enrollments, and this is modeled by an increased rate of entry of elderly patients.

The outcome of the model run is shown in Table IV-8. For the degree of change implemented in the model, the lack of effect is notable. Cumulative enrollment in PPGs decreases from 10.2 per cent to 9.9 per cent, and changes in the other key system variables are similarly small. Thus the model suggests that the impact of the HMO law on health care delivery may be quite small.
TABLE IV -8

EFFECT OF 1973 HMO LAW ON PREPAID GROUP PRACTICE GROWTH

<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>HMO Law Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care Cost Per Person ($)</td>
<td>284</td>
<td>377</td>
<td>378</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>58</td>
<td>113</td>
<td>114</td>
</tr>
<tr>
<td>Percent Enrolled in PFGs</td>
<td>2.4</td>
<td>10.2</td>
<td>9.9</td>
</tr>
<tr>
<td>No. of Physicians in U.S. (x 10^3)</td>
<td>348</td>
<td>667</td>
<td>667</td>
</tr>
<tr>
<td>Physician Visits per Person/Year</td>
<td>4.62</td>
<td>6.77</td>
<td>6.77</td>
</tr>
<tr>
<td>Medical Students (x 10^3)</td>
<td>40</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.13</td>
</tr>
<tr>
<td>Hospital Beds in U.S. (x 10^3)</td>
<td>848</td>
<td>1018</td>
<td>1020</td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.97</td>
<td>0.97</td>
</tr>
</tbody>
</table>
CHAPTER V

POLICY SYNTHESIS AND MODEL CRITIQUE

Policy Synthesis

As we have seen in Chapter IV, a system dynamics model is a powerful tool for simulating alternative outcomes in response to postulated policies. This may be a sufficient contribution for the modeler, but in the final analysis, society will choose what course to follow, either by default or by conscious choice of policy makers. Conscious choice inevitably requires that value judgments be made as to what is "good" and what is not.

Even if the consequences of policy alternatives are understood, such value judgments are particularly difficult to reach in the field of health care. As we have seen, there are no applicable standards of need and issues of economic philosophy become entangled with equally volatile issues such as equal care for the poor and even life versus death.

However, based on the model's behavior and on the research which supports its definition, I will state a number of sample value judgments, simulate supporting policies, and exercise the model one additional time to measure the potential long-term results. My objective functions in so doing are first to favor a stabilized demand for health care, and second to promote the growth of prepaid group practices.

Value Judgment 1: The average level of health care
available per person in the United States is sufficient to support the maintenance of good health. Although such care should be available to all citizens, this should not be accomplished through policies leading to increases in average physician services or hospitalization. A significant decrease in per capita hospital care would not be detrimental to health.

Value Judgment 2: American medical schools are expanding too rapidly. Their rapid expansion, together with the high rate of entry of foreign trained physicians is serving to stimulate demand for health care service which is of questionable value to health.

Value Judgment 3: The perceived cost of health care, as impacted by third party payments, is too low. Moreover, much insurance is badly structured to favor the performance of expensive hospital procedures of questionable benefit. It should be restructured in such a way as to make the perceived cost of care nearly equal across almost all income levels.

Value Judgment 4: The expansion of prepaid group practices is in the best interest of the health care system because the basic structure of the PPG favors the delivery of health care service in an efficient and economical form rather than stimulating excess demand and expensive, but marginal, treatment.
Accordingly, the following design changes were made within the model: 1) The intrinsic growth rate of the medical schools was halved, by changing the response time from 30 to 60 years. 2) The desired ratio of physicians per capita was fixed at 0.001 rather than being allowed to drift upward with demand. 3) The perceived costs of physician visits and hospitalization net of insurance were increased by ten per cent. 4) The PPG advertising effectiveness factor was increased by 25 per cent, and the rate of enrollment of younger families was increased by 25 per cent while the new enrollment rate of persons 45 and over was reduced by 50 per cent.

The resulting model outcome is indicated in Table V-1 and Figure V-1. A comparison of the hypothetical year 2020 values of the modified system with the 1970 values shows that the total cost and physician utilization per capita are relatively unchanged. The cost per capita has decreased due to a reduction in hospitalization per year per person. The total number of physicians has grown only in proportion to the population. The medical schools display nearly a linear growth as opposed to the rapid expansion and decline indicated by the standard model run. The prepaid groups have achieved an 80 per cent greater growth than in the standard model.

Whether the reader agrees with the structure of the model, or whether he sympathizes with the value judgments
<table>
<thead>
<tr>
<th></th>
<th>1970 Values</th>
<th>2020 Standard Model Run</th>
<th>Synthesized System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care Cost Per Person ($)</td>
<td>284</td>
<td>377</td>
<td>220</td>
</tr>
<tr>
<td>Total U.S. Health Care Cost ($x10^9)</td>
<td>58</td>
<td>113</td>
<td>66</td>
</tr>
<tr>
<td>Percent Enrolled in PPGs</td>
<td>2.4</td>
<td>10.2</td>
<td>17.9</td>
</tr>
<tr>
<td>No. of Physicians in U.S. (x 10^3)</td>
<td>348</td>
<td>667</td>
<td>499</td>
</tr>
<tr>
<td>Physician Visits per Person/Year</td>
<td>4.62</td>
<td>6.77</td>
<td>4.74</td>
</tr>
<tr>
<td>Medical Students (x 10^3)</td>
<td>40</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>PPG Physician Load</td>
<td>1.00</td>
<td>1.03</td>
<td>1.01</td>
</tr>
<tr>
<td>FFS Physician Load</td>
<td>1.00</td>
<td>1.13</td>
<td>1.05</td>
</tr>
<tr>
<td>Hospital Beds in U.S. (x 10^3)</td>
<td>848</td>
<td>1018</td>
<td>738</td>
</tr>
<tr>
<td>Bed Days per Person per Year</td>
<td>1.13</td>
<td>0.97</td>
<td>0.68</td>
</tr>
</tbody>
</table>
### Table V-1

**SYNTHESIZED MODEL DYNAMIC BEHAVIOR**

- B - Total Hospital Beds
- C - Total Health Care Cost
- D - Doctors
- G - Population in Medical Students

<table>
<thead>
<tr>
<th>Year</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>200.1</td>
<td>400.1</td>
<td>600.1</td>
<td>800.1</td>
</tr>
<tr>
<td></td>
<td>.125</td>
<td>.25</td>
<td>.375</td>
<td>.5</td>
</tr>
<tr>
<td>1990</td>
<td>37.5</td>
<td>75.1</td>
<td>112.5</td>
<td>150.1</td>
</tr>
<tr>
<td></td>
<td>300.1</td>
<td>900.1</td>
<td>1200.1</td>
<td>150.1</td>
</tr>
<tr>
<td>2010</td>
<td>37.5</td>
<td>75.1</td>
<td>112.5</td>
<td>150.1</td>
</tr>
</tbody>
</table>

1970: - G - M - C - D - B
1990: - G - M - C - D - B
2010: - G - M - C - D - B
presented, or whether he finds the postulated outcome favorable is irrelevant. The model structure could perhaps be modified or expanded to represent a more perceptive view of the health care system. Policies could be simulated in support of other value judgments. If a more desirable outcome were defined, we could search for policies to achieve it.

However, the definition of a system dynamics model such as the one presented here forces us to clearly define the assumptions which underlie our understanding of how the system works. It exposes areas where our understanding is limited and it suggests areas where vital data are absent. It reveals possible behavior modes that would not normally be anticipated. It enables us to experiment with the system in an inexpensive and rapid way. And most particularly, it forces us to acknowledge the long term consequences of current policy decisions, and by design, to modify those consequences if we care to.

Model Critique

A master's thesis at M.I.T. is given the approximate weight of two courses, or about 40 per cent of the total program during the final semester of the program. This means that a thesis represents perhaps two man-months of effort, spread over four months of calendar time. This compressed time frame forces elimination of one of the key steps in the development of a policy model: the extensive debate and criticism by interested parties. I am certain that the model
presented here could benefit greatly from such criticism.

In addition, I consciously elected to make the time frame of the model begin in 1970, whereas I believe that a preferable date would have been 1960 or even 1950. This was done for two reasons: 1) Detailed parameters for both FFS and FPG sectors are available for 1970, whereas they are not for many years prior. 2) I did not want to have to expend a large amount of effort causing the model to emulate actual results over the first twenty years. However, this is a significant advantage for a model which hopes to inspire active public debate, and was the course followed by Forrester in *World Dynamics*.¹

A third major criticism I would make is that the PPG sector of the model is parameterized almost entirely from Kaiser-Permanente data. This is in part attributable to the excellent presentation of information in Somers' book on the Kaiser plan and partially because comparable information from other major PPG plans was not found.²

Perhaps the most common criticisms of system dynamics models are that variables are too highly aggregated, that important factors are omitted, and that the table functions represent behavior unsupported by data. In general, I

¹ Forrester, *World Dynamics*, p. 9
² Somers, *The Kaiser-Permanente Medical Care Program: A Symposium*
believe that such criticisms are not well-founded, especially when compared with other techniques which are available for analyzing complex system behavior. However, with more time there are other factors which I might have attempted to incorporate into the model.

One of these is the effect of foreign medical graduates (FMGs) on the U.S. health care system. If 40 per cent of our new licentiates continue to come from foreign countries, then their effect on the system cannot avoid being significant. An obvious modeling difficulty which would accompany the inclusion of FMGs in the model is that it might necessitate including the growth dynamics of worldwide medical schools, and this would be a very troublesome extension.

The model assumes that a constant 60 per cent of new physicians enter the FFS and PPG sectors while the rest enter research, administrative, or other endeavors. It might well be true that opportunities in such fields may saturate reasonably soon, and that more doctors will be forced into direct patient care. This is possibly a reasonable area of extension of the model.

The model maintains a strict dichotomy between the PPG and FFS sectors, and the effects in each sector of changing distributions of care among office visits, hospital outpatient clinics, and ambulatory care centers are not modeled.

In general, the behavior modes displayed by the model
are consistent with the results which might actually result from the various policies tested. There are at least three areas where improvements might be sought, however. First, the model shows a brief period of rapid growth and subsequent decline in visit demand per physician in the 1970 to 1980 time period. This may result from the failure to include foreign-trained doctors, and error in the initialization of the system, or it may even have captured some aspect of reality. Second, the model shows a continuous and almost linear decrease in per capita hospitalization over the fifty year period. This is a possible criticism of the model, but it follows from the fact that there is no estimate available of the minimum care which our population needs in support of good health. Finally, the model's response to zero perceived cost of care is probably too explosive. On the other hand, this should serve as a warning that continuing expansion of medical insurance coverage in present forms may only serve to aggravate our recent experience of expanded health care cost without accompanying gains in health.
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APPENDIX A

GLOSSARY OF MODEL MNEMONICS

The following pages give a listing of the mnemonics used in the model. They are listed in alphabetic order.
BFN  INITIAL VALUE OF BF
BFOR  BED OCCUPANCY RATE, FPS (DIMENSIONLESS)
BFT  BED LIFE, FPS (YEARS)
BG  BEDS, PPG SECTOR (BEDS)
BGAT  BED CONSTRUCTION ADJUSTMENT TIME, PPG (YEARS)
BGCR  BED CONSTRUCTION RATE, PPG (BEDS/YEAR)
BGCRP  POSITIVE BED CONSTRUCTION RATE, PPG (BEDS/YEAR)
BGCRC  INDICATIVE BED CONSTRUCTION RATE, PPG (BEDS PER YEAR)
BGDR  BED DEMOLITION RATE, PPG (BEDS/YEAR)
BGF  BED TRANSFER RATE, PPG TO FPS (BEDS/YE AR)
BGFP  PPG TO FPS BED UTILIZATION FACTOR (DIMENSIONLESS)
BGPFT  TABLE RELATING BGF TO PPG BED OCCUPANCY (DIMENSIONLESS)
BGI  INDICATED BEDS, PPG (BEDS)
BGN  INITIAL VALUE OF BG (BELS)
BGOR  BED OCCUPANCY RATIO, PPG (DIMENSIONLESS)
BGRMAX  MAXIMUM BED CONSTRUCTION RATE, PPG (BEDS PER YEAR)
BGT  BED LIFE, FPS (YEARS)
BPPD  BED PRICE PER DAY (DOLLARS)
BPPDN  INITIAL VALUE OF BPPD (DOLLARS)
BPM  BIRTHS PER WOMAN (DIMENSIONLESS)
BRCF  BED DEMAND FACTOR FROM COST, FPS (DIMENSIONLESS)
BRCFT  TABLE RELATING BRCF TO PERCEIVED BED COST, FPS (DIMENSIONLESS)
BRDFE  BED USAGE RATE, FPS, AGE 65 OR UP (BED DAYS/YEAR/YEAR)
BRDFM  BED USAGE RATE, FPS, AGE 45-64 (BED DAYS/YEAR/YEAR)
BRDFR  BED USAGE RATE, FPS, AGE 15-44 (BED DAYS/YEAR/YEAR)
BRDFY  BED USAGE RATE, FPS, AGE 0-14 (BED DAYS/YEAR/YEAR)
BRDGE  BED USAGE RATE, PPG, AGE 65 OR UP (BED DAYS/YEAR/YEAR)
BRDGM  BED USAGE RATE, PPG, AGE 45-64 (BED DAYS/YEAR/YEAR)
BRDGR  BED USAGE RATE, PPG, AGE 15-44 (BED DAYS/YEAR/YEAR)
BRDGY  BED USAGE RATE, PPG, AGE 0-14 (BED DAYS/YEAR/YEAR)
BRE  BIRTH RATE, FPS (PERSONS PER YEAR)
BRE  BIRTH RATE, PPG (PERSONS PER YEAR)
BRSF  BED DEMAND STIMULATED BY OCCUPANCY RATIO, FPS (DIMENSIONLESS)
BRSFT  TABLE RELATING BRSF TO BED OCCUPANCY RATIO (DIMENSIONLESS)
BRSPG  BED USAGE RATE FACTOR, PPG, FPS COMPETITION (DIMENSIONLESS)
BRSG  BED DEMAND FACTOR STIMULATED BY OCCUPANCY, PPG (DIMENSIONLESS)
BRSGT  TABLE RELATING BRSG TO PPG BED OCCUPANCY RATE (DIMENSIONLESS)
BRSPPF  BED DEMAND FACTOR STIMULATED BY PHYSICIANS, FPS (DIMENSIONLESS)
BRSPPT  TABLE RELATING BRSPPF TO FPS PHYSICIAN LOAD (DIMENSIONLESS)
BUFF  BED UTILIZATION, FPS (BED DAYS/PERSON/YEAR)
BUPG  BED UTILIZATION, PPG (BED DAYS/PERSON/YEAR)
CPP  YEARLY COST OF HEALTH CARE PER PERSON (DOLLARS/YEAR)
CPPP  YEARLY HEALTH CARE COST PER PERSON, FPS (DOLLARS/YEAR)
CPPG  YEARLY HEALTH CARE COST PER PERSON, PPG (DOLLARS/YEAR)
CR  COST RATIO (DIMENSIONLESS)
CTOT  TOTAL U.S. HEALTH CARE COST PER YEAR (DOLLARS)
DFE  DEATH RATE, FPS, AGE 65 AND UP (PERSONS PER YEAR)
DFM  DEATH RATE, FPS, AGE 45-64 (PERSONS PER YEAR)
DFP  DEATH RATE, FPS, AGE 15-44 (PERSONS PER YEAR)
DFY  DEATH RATE, FPS, AGE 0-14 (PERSONS PER YEAR)
DGE  DEATH RATE, PPG, AGE 65 AND UP (PERSONS PER YEAR)
DGM  DEATH RATE, PPG, AGE 45-64 (PERSONS PER YEAR)
DGP  DEATH RATE, PPG, AGE 15-44 (PERSONS PER YEAR)
DGY  DEATH RATE, PPG, AGE 0-14 (PERSONS PER YEAR)
DRPPF  POPULATION GROWTH RATIO, FPS, AGE 65 AND UP (DIMENSIONLESS)
DRPFM  POPULATION GROWTH RATIO, FPS, AGE 45-64 (DIMENSIONLESS)
DRPFR  POPULATION GROWTH RATIO, FPS, AGE 15-44 (DIMENSIONLESS)
DRPFY  POPULATION GROWTH RATIO, FPS, AGE 0-14 (DIMENSIONLESS)
DRPGE  POPULATION GROWTH RATIO, PPG, AGE 65 AND UP (DIMENSIONLESS)
DRPGM  POPULATION GROWTH RATIO, PPG, AGE 45-64 (DIMENSIONLESS)
DRPGR  POPULATION GROWTH RATIO, PPG, AGE 15-44 (DIMENSIONLESS)
DRPGY  POPULATION GROWTH RATIO, PPG, AGE 0-14 (DIMENSIONLESS)
EMS  PERSONS ENTERING MEDICAL SCHOOL (PERSONS PER YEAR)
FG  POPULATION TRANSFER RATE, FPS TO PPG (PERSONS PER YEAR)
FGAF  ADVERTISING TRANSFER RATE, FPS TO PPG (DIMENSIONLESS)
FGAFN  INITIAL VALUE OF FGAF (DIMENSIONLESS)
FGCF  COST TRANSFER RATE, FPS TO PPG (DIMENSIONLESS)
FGCPT  TABLE RELATING FGCF TO COST RATIO (DIMENSIONLESS)
FGE  POPULATION TRANSFER RATE, FPS TO PPG, AGE 65 AND UP (PERSONS/YEAR)
FGN  POPULATION TRANSFER RATE, FPS TO FPG, AGE 45-64 (PERSONS PER YEAR)
FGPF  POPULATION TRANSFER RATE, FPS TO PPG (DIMENSIONLESS)
FGPPT  TABLE RELATING FGPF TO PERCENT PPG ENROLLMENT (DIMENSIONLESS)
PPEN INITIAL VALUE OF PPE (PERSONS)
PPG POPULATION FRACTION IN PPG SECTOR (DIMENSIONLESS)
PPM POPULATION, FFS, AGE 45-64 (PERSONS)
PPMN INITIAL VALUE OF PPM (PERSONS)
PPPOXG PHYSICIAN RATIO QUALITY FACTOR, PPG (DIMENSIONLESS)
PPPQGT TABLE FUNCTION RELATING PHYSICIAN RATIO TO QUALITY (DIMENSIONLESS)
PPPQOF PHYSICIAN RATIO QUALITY FACTOR, FFS (DIMENSIONLESS)
PPPQFT TABLE RELATING PHYSICIAN RATIO TO QUALITY (DIMENSIONLESS)
PPR POPULATION, FFS, AGE 15-44 (PERSONS)
PPRN INITIAL VALUE OF PPR (PERSONS)
PPY POPULATION, FFS, AGE 0-14 (PERSONS)
PFYN INITIAL VALUE OF PPY (PERSONS)
PGE POPULATION, PPG, AGE 65 AND UP (PERSONS)
PGEN INITIAL VALUE OF PGE (PERSONS)
PGM POPULATION, PPG, AGE 45-64 (PERSONS)
PGMN INITIAL VALUE OF PGM (PERSONS)
PGR POPULATION, PPG, AGE 15-44 (PERSONS)
PGRF POPULATION GROWTH RATE, FFS (PERSONS PER YEAR)
PGRFE POPULATION GROWTH RATE, FFS, AGE 65 AND UP (PERSONS/YEAR)
PGRFM POPULATION GROWTH RATE, FFS, AGE 45-64 (PERSONS/YEAR)
PGRFR POPULATION GROWTH RATE, FFS, AGE 15-44 (PERSONS/YEAR)
PGRFY POPULATION GROWTH RATE, FFS, AGE 0-14 (PERSONS/YEAR)
PGRG POPULATION GROWTH RATE, PPG (PERSONS PER YEAR)
PGRGE POPULATION GROWTH RATE, PPG, AGE 65 AND UP (PERSONS/YEAR)
PGRGM POPULATION GROWTH RATE, PPG, AGE 45-64 (PERSONS/YEAR)
PGRGR POPULATION GROWTH RATE, PPG, AGE 15-44 (PERSONS/YEAR)
PGRGY POPULATION GROWTH RATE, PPG, AGE 0-14 (PERSONS/YEAR)
PGRN INITIAL VALUE OF PGR (PERSONS)
PGY POPULATION, PPG, AGE 0-14 (PERSONS)
PGRN INITIAL VALUE OF PGR (PERSONS)
PHA TOTAL US PHYSICIANS ACTIVE (PHYSICIANS)
PHAF PHYSICIANS ACTIVE, FFS (PHYSICIANS)
PHAFN INITIAL VALUE OF PHAF (PHYSICIANS)
PHAG PHYSICIANS ACTIVE, PPG (PHYSICIANS)
PHAGN INITIAL VALUE OF PHAG (PHYSICIANS)
PHBCF COST FACTOR, MODEL FACTORS TO TOTAL HEALTH CARE (DIMENSIONLESS)
PHCT  PHYSICIAN CAREER TIME (YEARS)
PHDRF  PHYSICIAN DEATHS AND RETIREMENTS, FPS (PHYSICIANS PER YEAR)
PHDRC  PHYSICIAN DEATHS AND RETIREMENTS, PPG (PHYSICIANS PER YEAR)
PHF  PHYSICIANS ENTERING FPS PRACTICE (PHYSICIANS PER YEAR)
PHEGMX  MAXIMUM RATE OF ENTRY OF PHYSICIANS INTO PPG SECTOR (PHYS/yr)
PHEGC  INDICATED RATE OF ENTRY OF PHYSICIANS INTO PPG SECTOR (PHYS/yr)
PHEG  PHYSICIANS ENTERING PPG PRACTICE (PHYSICIANS PER YEAR)
PHFG  PHYSICIAN TRANSFER RATE, FPS TO PPG (PHYSICIANS PER YEAR)
PHFL  PHYSICIAN LOAD IN FPS SECTOR (DIMENSIONLESS)
PHFP  PHYSICIAN FRACTIOIN IN FPS AND PPG SECTORS (DIMENSIONLESS)
PHGF  PHYSICIAN TRANSFER RATE, PPG TO FPS (PHYSICIANS PER YEAR)
PHGIA  PPG Physician Net Income Adjustment Time (YEARS)
PHGL  PHYSICIAN LOADING, PPG (DIMENSIONLESS)
PHI  PHYSICIANS INDICATED, TOTAL US (PHYSICIANS)
PHIF  PHYSICIANS INDICATED, FPS (PHYSICIANS)
PHIG  PHYSICIANS INDICATED, PPG (PHYSICIANS)
PHNIG  PHYSICIAN NET INCOME, FPS (DOLLARS/YEAR)
PHNIGN  INITIAL VALUE OF PHNIG (DOLLARS/YEAR/YEAR)
PHNIP  PHYSICIAN ANNUAL NET INCOME, FPS (DOLLARS PER YEAR)
PG  POPULATION, PREPAID GROUP SECTOR (PERSONS)
PPBF  POPULATION PROJECTION FOR BED CONSTRUCTION, FPS (PERSONS)
PPBG  POPULATION PROJECTION FOR BED CONSTRUCTION, PPG (PERSONS)
PPF  POPULATION PROJECTION FOR PHYSICIANS, FPS (PERSONS)
PPG  POPULATION PROJECTION, PPG SECTOR (PERSONS)
PPPDF  DESIRED PHYSICIANS PER PERSON, FPS (DIMENSIONLESS)
PPPDG  DESIRED PHYSICIANS PER PERSON, PPG (DIMENSIONLESS)
PPPN  INITIAL VALUE OF PHYSICIANS PER PERSON, FPS (DIMENSIONLESS)
PPPNG  INITIAL VALUE OF PHYSICIANS PER PERSON, PPG (DIMENSIONLESS)
PPT  POPULATION PROJECTION TIME (YEARS)
PRF  PHYSICIAN NET PRICE PER VISIT (DOLLARS)
PRG  EQUIVALENT PHYSICIAN NET INCOME PER VISIT (DOLLARS/VISIT)
PRN  INITIAL VALUE OF PRF (DOLLARS)
PRPF  PERCEIVED PHYSICIAN COST SHARE (DIMENSIONLESS)
PRPFD  INITIAL VALUE OF PRPF
PRRF  PRICE RATIO, FPS (DIMENSIONLESS)
VGE  PHYSICIAN VISITS, PPG, AGE 65 AND UP (VISITS PER YEAR)
VGEN  INITIAL VALUE OF VGE (VISITS PER YEAR)
VGFP  VISITS BY PPG ENROLLMENTS TO FFS PHYSICIANS (VISITS PER YEAR)
VGPFT  TABLE RELATING BGFPT TO PPG PHYSICIAN LOAD (DIMENSIONLESS)
VGM  PHYSICIAN VISITS, PPG, AGE 45-64 (VISITS PER YEAR)
VGN  INITIAL VALUE OF VGM (VISITS PER YEAR)
VGP  VISITS PER PHYSICIAN PER YEAR, PPG
VGPNN  INITIAL VALUE OF VGP (VISITS/YEAR)
VGR  PHYSICIAN VISITS PPG, AGE 15-44 (VISITS/YEAR)
VGRN  INITIAL VALUE OF VGR (VISITS PER YEAR)
VGY  PHYSICIAN VISITS, PPG, AGE 0-14 (VISITS PER YEAR)
VGYN  INITIAL VALUE OF VGY (VISITS/YEAR)
VPP  VISITS PER PERSON, TOTAL US POPULATION (VISITS PER PERSON PER YEAR)
VPPP  VISITS PER PERSON, FFS (VISITS PER PERSON PER YEAR)
VPPG  VISITS PER PERSON, PPG (VISITS/PERSON/YEAR)
VRCF  VISIT RATE COST FACTOR, FFS (DIMENSIONLESS)
VRCFT  TABLE RELATING VRCF TO PERCEIVED COST (DIMENSIONLESS)
VRF  VISIT RATE, FFS, AGE 65 AND UP (VISITS/YEAR/YEAR)
VRFM  VISIT RATE, FFS, AGE 45-64 (VISITS/YEAR/YEAR)
VRFR  VISIT RATE, PPS AGE 15-44 (VISITS/YEAR/YEAR)
VRFY  VISIT RATE, FFS, AGE 0-14 (VISITS/YEAR/YEAR)
VRGE  VISIT RATE, PPG, AGE 65 AND UP (VISITS/YEAR/YEAR)
VRGM  VISIT RATE, PPG, AGE 45-64 (VISITS/YEAR/YEAR)
VRGR  VISIT RATE, PPG, AGE 15-44 (VISITS/YEAR/YEAR)
VRGY  VISIT RATE, PPG, AGE 0-14 (VISITS/YEAR/YEAR)
 VRQF  VISIT RATE QUALITY FACTOR, FFS (DIMENSIONLESS)
VRQFT  TABLE RELATING VISIT RATE TO QUALITY (DIMENSIONLESS)
VRSF  PHYSICIAN STIMULATED VISIT RATE, FFS (DIMENSIONLESS)
VRSFG  VISIT DEMAND FACTOR, PPG, FFS SECTOR STANDARD (DIMENSIONLESS)
VRSFT  TABLE RELATING VRSF TO FFS PHYSICIAN LOAD (DIMENSIONLESS)
VRSG  PHYSICIAN STIMULATED DEMAND FACTOR, PPG (DIMENSIONLESS)
VRSGT  TABLE RELATING VRSG TO PPG PHYSICIAN LOADING (DIMENSIONLESS)
YRF  AGING RATE, FFS AGE 15 (PERSONS PER YEAR)
YRG  AGING RATE, PPG, AGE 15 (PERSONS PER YEAR)
APPENDIX B
MODEL LISTING

The following pages give a complete listing of the model described in Chapter III. The model dynamic behavior as shown in Figures III-21 and III-22 as well as the standard model values for the year 2020 were produced by the model as listed.
* PREPAID GROUP GROWTH DYNAMICS MODEL
NOTE $$\text{PCPULATION SECTOR}$$
NOTE ******
A  P.K=PF.K+PG.K
A  PF.K=PFY.K+PFP.K+PFM.K+EFF.K
A  PG.K=PGY.K+PGR.K+PGM.K+EGE.K
L  PFY.K=PFY.J+DT*PGRF.Y.J
A  PGFY.K=PFY.J+DFY.JK+DFY.JK
N  PFY=PFYN
C  PFYN=56.86
L  PFR.K=PFR.J+DT*PGRFR.J
A  FGRFR.K=YPP.JK+PGR.JK+GRF.JK-DFR.JK
N  PFR=PFRN
C  PFRN=82.46
L  PFM.K=PFM.J+DT*PGRFM.J
A  PGFRFM.K=PFM.JK+GRF.JK+GFM.JK-MEF.JK+DFM.JK
N  PFM=PFMN
C  PFMN=41.26
L  PFE.K=PFE.J+DT*PGRFE.J
A  PGRFE.K=MEF.JK+GFE.JK+GFE.JK-DFE.JK
N  PFE=PFEF
C  PFEF=19.66
L  PGY.K=PGY.J+DT*PGRGY.J
A  PGRGY.K=BGY.JK+GY.YJK+FGY.JK+SG.JK+GY.JK
N  PGY=PGYN
C  PGYN=2.06
L  PGR.K=PGR.J+DT*PGRGR.J
A  PGRGR.K=YBG.JK+GGR.JK+GGR.JK+GRM.JK-DGR.JK
N  PGR=PGRN
C  PGRN=1.796
L  PGM.K=PGM.J+DT*PGRGM.J
A  PGRGM.K=RMG.JK+GRM.JK+GRM.JK-GRM.JK
N  PGM=PGMN
C  PGMN=0.996
L  PGE.K=PGE.J+DT*PGRGE.J
A PGRGE.K=MEG.JK-GFE.JK+FGE.JK-DGE.JK
N FGE=PGN
C PGEN=9.215E6
R BRF.KL=((BPW)/30)*(PFR.K)*(0.51)
R BGR.KL=((BPR)/30)*(PGR.K)*(0.51)
C BPS=2.75
R YRF.KL=FFF.K/15
R YRG.KL=PGY.K/15
R RPM.KL=FFF.K/30
R RMR.KL=PGY.K/30
R MEF.KL=PFM.K/20
R MEG.KL=PGM.K/20
R DPY.KL=0.0016*PFY.K
R DGY.KL=0.0016*PGY.K
R DPR.KL=0.0019*PFR.K
R DGR.KL=0.0019*PGR.K
R DFM.KL=0.0111*PFM.K
R DGM.KL=0.0111*PGM.K
S DPE.KL=0.0586*PFM.K
R DGE.KL=0.0586*PGM.K
NOTE $$$$$$$$$
NOTE PHYSICIAN EDUCATION SECTOR
NCTE *******
L UMS.K=UMS.J+DT*(EUMS.JK-GUMS.JK)
N UMS=UMSN
C UMSN=40000
R EUMS.KL=(UMSA.K/URS)*((EHK.PHI.K)/PAT)
C PAT=32
R GUMS.KL=DELAY3(EUMS.JK, UET)
C UET=4
L UMSA.K=UMSA.J+DT*(UMS.J-UMSA.J)/UAT
N UMSA=UMSAN
C UMSN=3.6000
C UAT=4
L IAR.K=IAR.J+DT*(GUMS.JK-GTAR.JK)
N IAR=IARN
IA = N = 30000

GIAR.KL = IAR.K / IA T

IA T = 3

NOTE $$$$$$$$$

NOTE PHYSICIAN DISTRIBUTION SECTOR

NOTE $$$$$$$


N PHAF = PHAFN

C PHAFN = 204000


N PHAG = PHAGN

C PHAGN = 4650

A PHA.K = (PHAF.K + PHAG.K) / PFP

R PHEP.KL = PHEP*K*GIA R.JK - PHEG.JK

A PHEGC.K = PHEP*GIA R.JK*PEPG.K

A PHEGM.K = 0.1*PHAG.K

R PHEG.KL = MIN(PHEGM.K, PHEGC.K)

R PHEG.KL = PHAF.K / PHCT

R PHEG.KL = PHAG.K / PHCT

C PHCT = 35

R PHEP.KL = 0

R PHEG.KL = 0

A PEPG.K = (PHAG.K / (PHAF.K + PHAG.K)) *(PHIG.K / PHAG.K) *(PHAF.K / PHEF.K)

C PHEF = 0.6

A PPF.K = PPE.K + PPT*PGRF.K


C PPT = 10

A PHEF.K = PPF.K*PPPDP.K

A PPPDP.K = PPPFN*PPPQF.K

C PPPFN = 0.001

A PPPQF.K = TABHL (PPPOPT, QPF.K, 0.5, 1.5, 0.25)

T PPPOPT = 2.5/1.4/1.0/1.0/0.95

A PEG.K = PG.K + PPT*PGRG.K

A PGRG.K = FG.K + GF.K + BRG.JK - DGY.JK - DGR.JK - DGM.JK - DGF.JK

A FG.K = EGY.JK + FGR.JK + FGM.JK + FGE.JK

A GF.K = GFY.JK + GFR.JK + GPM.JK + GPE.JK

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A PHIG.K=PPG.K*PPPDG.K
A FPPDG.K=FPPIGN*PFPQG.K
C PPPGN=0.001
A FPPDG.K=TABHL(PFPQGT,QPG.K,0.5,1.5,0.25)
T PFPQGT=2.0/1.5/1.0/.8/.0.7
A PHIL.K=(PHIP.K+PHIG.K)/PHFP
NOTE $$$$$$ neural
NOTE Fee for Service Physician Demand Sector
NOTE *******
L VFY.K=VFY.J+DT*VRPY.JK
N VFYN=VFYN
C VFYN=210.1E6
L VFR.K=VFR.J+DT*VRPR.JK
N VFR=VFRN
C VFRN=379.0E6
L VFM.K=VFM.J+DT*VRPM.JK
N VFM=VFMN
C VFMN=214.2E6
L VFE.K=VFE.J+DT*VFFE.JK
N VFE=VFEN
C VFEN=123.5E6
A V.F.K=VFY.K+VFR.K+VFM.K+VFE.K+VGF.K
R VRPY.KL=VFY.K*(VDF.K+DREFY.K)
R VRPR.KL=VFR.K*(VDF.K+DREFR.K)
R VRPM.KL=VFM.K*(VDF.K+DREFM.K)
R VFFE.KL=VFE.K*(VDF.K+DREFE.K)
A DREFY.K=EFRP.K/PE.K
A DREPR.K=EPFPR.K/PE.K
A DREFM.K=EPFRM.K/PE.K
A DREPF.K=EPFRF.K/PE.K
A VDF.K=BCF.K+VRCF.K+VRSF.K
A VRFQ.K=TABHL(VRFQT,QPF.K,0,2,0.5)
T VRFQT=-0.5/-0.3/-0.1/-0.2
A VRCF.K=TABHL(VRCFT,PRPF.K,0,1,0.25)
T VRCFT=0.25/0.10/0/-0.25/-0.4
A VRSF.K=TABHL(VRSFT,PHFL.K,0,2,0.5)
VRSPT=0.2/0.15/0.1/0/0.2
VGP.K=VG.K*VGFP.K
VGFP.K=TABHL(VGFT,PHGL.K,0.2,0.5)
VGFT=0.03/0.03/0.05/0.1/0.3
VFP.K=VP.K/PHAP.K
PHFL.K=VFP.K/VFPPN
VFPPN=4550
QPF.K=QPF.J+DT*(QAF.J-QPF.J)/QTPF
QPFN=1
QTPF=2
QAF.K=QAFN/PHFL.K
QAFN=1
PRFP.K=PRFPN
PRFPN=0.5
NOTE $$$$$$$$$
NOTE PREPAID GROUP PHYSICIAN DEMAND SECTOR
NOTE ***********
VG.Y.K=VG.Y.J+DT*VG.Y.JK
VG.Y=VGYN
VGYN=7.03E6
VG.R=VG.R.J+DT*VG.R.JK
VG.R=VG.RN
VG.RN=7.82E6
VG.M=VG.M.J+DT*VG.M.JK
VG.M=VG.MN
VG.MN=4.89E6
VG.E=VG.E.J+DT*VG.E.JK
VG.E=VGEN
VG.E=VGEN
VG.E=1.29E6
VG.K=VG.Y.K+VG.R.K+VG.M.K+VG.E.K+VG.K
VF.G.K=0
VRGY.KL=VG.Y.K*VDG.K+DEG.Y.K
VRGR.KL=VG.R.K*VDG.K+DEG.R.K
VRGM.KL=VG.M.K*VDG.K+DEG.M.K
VRGE.KL=VG.E.K*VDG.K+DEG.E.K
A \[ VDG.K = VRS.G.K + VRS.P.G.K \]
A \[ DRPGY.K = PGRGY.K/PG.K \]
A \[ DRPGZ.K = PGRGR.K/PG.K \]
A \[ DRPGM.K = PGRGM.K/PG.K \]
A \[ DRPG.E.K = PGRGE.K/PG.K \]
A \[ VRS.G.K = TADBL(VRS.GT, PHGL.K, 0.2, 0.5) \]
A \[ VRS.GT = 0.4/0.25/-0.05/-0.1/-0.2 \]
A \[ VRS.P.G.K = (0.8*VPP.G.K - VPPG.K) / VPP.G.K \]
A \[ VPP.G.K = VG.K/PG.K \]
A \[ VFPF.K = (VP.K - VGP.K) / FP.K \]
A \[ VGP.P.K = VG.K/PHAG.K \]
A \[ PHGL.K = VGEP.K / VGPPN \]
C \[ VGPPN = 4516 \]
L \[ QPG.K = QPG.J + DT*(QAG.J - QEG.J) / QPTG \]
C \[ QPTG = 2 \]
A \[ QAG.K = QA.GN/PHGL.K \]
C \[ QA = 1 \]
N \[ QEG.QPGN \]
C \[ QEGN = 1 \]

NOTE $$$$$$$$$$$
NOTE HOSPITAL BED SUPPLY - FEE FOR SERVICE SECTOR
NCTE ****************
A \[ B.K = B.F.K + BG.K \]
L \[ B.F.K = B.F.J + DT*(BFCR.JK + BGF.JK - BFG.JK - BFDR.JK) \]
N \[ B.F = BFN \]
C \[ BFN = 840000 \]
R \[ BFCR.KL = MAX(BFCR.P.K, 0) \]
A \[ BFCR.P.K = BFDR.JK*(BFI.K - EF.K) / BFAT \]
C \[ BFAT = 6 \]
A \[ PPBF.K = PF.K + BFAT*PGR.F.K \]
A \[ BDPF.K = (BFOR.K*BF.K*365) / PP.K \]
A \[ BFI.K = (PPBF.K*BUFP.K) / (0.8*365) \]
R \[ BFG.KL = 0 \]
R \[ BFDR.KL = BF.K / BPT \]
C \[ BPT = 40 \]
NOTE $$$$$$$$$$$
NCPE HOSPITAL BED SUPPLY - FFEPAID GROUP PRACTICE SECTOR
NOTE $$$$$$$$$$
L BG.K=BG.J+DT*(BGCR.JK+BFG.JK-BGF.JK-BGDR.JK)
N EG=BGN
C BGN=8000
R BGCR.KL=MIN(BGCRC.K,BGRM.K)
A BGCRC.K=MAX(BGCRP.K,0)
A BGRM.K=0.1*BG.K
A BGCRP.K=BGDR.JK+(BGI.K-BG.K)/BGAT
C BGAT=8
A PPG.K=PG.K*BGAT*PGBG.K
A BUPG.K=(BGOR.K*BG.K*365)/PG.K
A BGI.K=(PPBG.K*BUPG.K)/(0.85*365)
R BGDR.KL=BG.K/BGT
C BGT=40
NOTE $$$$$$$$$$$
NOTE DEMAND FOR BEDS - FFE PCR SERVICE SECTOR
NOTE $$$$$$$$$$
L BDFY.K=BDFY.J+DT*BDFY.JK
N BDFY=BDFYN
C BDFYN=18.18E6
L BDFR.K=BDFR.J+DT*BDFR.JK
N BDFR=BDFRN
C BDFRN=71.68E6
L BDFM.K=BDFM.J+DT*BDFM.JK
N BDFM=BDFMN
C BDFMN=63.45E6
L BDFE.K=BDFE.J+DT*BDFE.JK
N BDFE=BDFEN
C BDFEN=75.65E6
A BDF.K=BDFY.K+BDFR.K+BDFM.K+BDFE.K+BDGF.K
A BDGF.K=BDG.K*BDGF.K
A BGPF.K=TABHL(BGFPT,BGOR.K,0.7,1,0.05)
T BGFPT=0.05/0.1/0.15/0.25/0.35/0.4/0.4
R BDFY.KL=BDFY.K*(BDDPF.K*CRFPY.K)
BDFR.K = BDFR.K* (BDFR.K*DRPPR.K)
BDFM.K = BDFM.K* (BDFM.K*DRPPM.K)
BDFE.K = BDFE.K* (BDFE.K*DRPPF.K)
BDF.K = BCP.K + BRSF.K + BRSPP.K
BCFT = 0.3/0/0.4/-0.6/-0.7/-0.75
BCFPN = 0.2
BRSF.K = TABHL (BRSFT, BFPK, 0.55, 1, 0.05)
BRSPK = 0.25/0.23/0.2/0.1/0.05/0/-0.05/-0.1/-0.2/-0.3
BRSPF.K = TABHL (BRSPFT, PHIL.K, 0.2, 0.5)
BRSPK = 0.3/0.2/0/-0.05/-0.2
BFPK = BDF.K / (BP.K*365)

NOTE: DEMAND FOR BEDS - PREPAID GROUP PATIENTS

L
BDGY.K = BDGY.J + DT*BRDG.JK
NL
BDGY = BDGYN
CL
BDGYN = 0.364E6
L
BDGR.K = BDGR.J + DT*BRDG.JK
NL
BDGR = BDGRN
CL
BDGRN = 0.840E6
L
BDGM.K = BDGM.J + DT*BRDG.M.JK
NL
BDGM = BDGMN
CL
BDGMN = 0.808E6
L
BDGE.K = BDGE.J + DT*BRDG.E.JK
NL
BDGE = BDGEN
CL
BDGEN = 0.463E6
R
BRDGY.KL = BDGY.K* (BDDG.K*DRPGY.K)
R
BRDGK.KL = BDGR.K* (BDDG.K*DRPGR.K)
R
ERDGK.KL = BDGM.K* (BDDG.K*DRPGM.K)
R
BRDG.E.KL = BDGE.K* (BDDG.K*DRPGE.K)
A
BDG.K = BDGY.K + BDGR.K + BDGM.K + BDGE.K + BDFG.K
A
BDFG.K = 0
A
BRDG.K = BRSG.K + BRSPF.K
A
BRSG.K = TABHL (BRSGT, BGRK, 0.7, 0.9, 0.05)
T  BRSGT=0.15/0.1/0/0.2/-0.35
A  BRFGK=(0.5*BDPPG.K-BDPPG.K)/BDPPG.K
A  BDPPG.K=BDG.K/PG.K
A  BDPPG.K=(BDP.K-BDGF.K)/FP.K
A  BDOR.K=BDG.K/(BG.K*365)
NOTE $$$$$$$$$$$
NOTE POPULATION TRANSFER BETWEEN SECTORS
NOTE $$$$$$$$$$
A  QRFG.K=QPG.K/QAF.K
A  QEGF.K=QFF.K/QAF.K
R  FGY.KL=GGRN*PGY.K*FGTF.K
R  FGR.KL=GGRN*PGR.K*FGTF.K
R  PGM.KL=GGRM*PGM.K*FGTF.K
R  FGE.KL=GGRE*PGE.K*FGTF.K
C  GGRN=0.2
C  GGRMN=0.2
C  GGNE=0
A  FGT.P.K=FGQF.K*FGCF.K*FGF.K*FGAF.K*FGPLF.K
A  FGA.F.K=FGAFN
C  FGAPN=1
A  FGQF.K=TABHL(FGQF.T,QRFG.K,0.5,2,0.5)
T  FGQFT=0.6/1.0/1.1/1.2
A  FGEF.K=TABHL(FGCFT,CR.K,0.0,0.2,0.0,0.1)
T  FGCFRT=0.8/0.9/1.0/1.0/1.0/1.1/1.1/1.1/1.2
A  PGF.K=PG.K/P.K
A  FGPF.K=TABHL(FGPFT,PGF.K,0.5,0.6,0.1)
T  FGPFRT=1/0.5/0.3/0.2/0.1/0.05/0
A  FGPLF.K=TABHL(FGPLFT,PHGL.K,1.1/1.5/0.1)
T  FGPLFRT=1.0/0.98/0.85/0.7/C.4/0
R  GFFY.KL=GARN*PGY.K*GFTF.K
R  GFRY.KL=GARN*PGR.K*GFTF.K
R  GFRM.KL=GARN*PGM.K*GFTF.K
R  GFER.KL=GARNE*PGE.K*GFTF.K
C  GARN=0
C  GARNE=0
A  GFTF.K=GFOF.K*GFCP.K*GFFF.K
A \[
GPQF.K = TABHL(GFQFT, QRGF.K, 0.5, 2.0, 0.5)
\]
T \[
GPQFT = 0.8 / 1.0 / 1.25 / 1.40
\]
A \[
GFCF.K = TABHL(GFCFT, CR.K, 0.2, 0.8, 0.1)
\]
T \[
GFCFT = 1.1 / 1.05 / 0.99 / 0.95 / 0.85 / 0.7 / 0.6
\]
A \[
GPPF.K = TABHL(GPPFT, PPG.K, 0.1, 0.5)
\]
T \[
GPPFT = 1 / 0.8 / 0.5
\]
NOTE \$\$\$\$\$\$\$
NOTE PRICE MECHANISMS
NCTE \$\$\$\$\$\$\$
A \[
PHNJF.K = PRF.K \times VF.K / PHAF.K
\]
A \[
PRF.K = PRN \times PPRF.K
\]
C \[
PRN = 9.13
\]
A \[
PRRFT = TABHL(PRRFT, PHFL.K, 0.2, 0.5)
\]
T \[
PRRFT = 0.5 / 0.7 / 1.0 / 1.4 / 2.0
\]
L \[
PHNIG.K = PHNIG.J + DT \times (PHNIF.J - PHNIG.J) / PHGIAT
\]
N \[
PHNIG = PHNIGN
\]
C \[
PHNIGN = 37500
\]
A \[
PRG.K = PHAG.K \times PHNIG.K / VG.K
\]
C \[
PHGIAT = 2
\]
A \[
BFPD.K = BPFDN \times BF.D.K / BDPN
\]
C \[
BPFDN = 229.6
\]
C \[
BFPD = 81
\]
A \[
CR.K = (CPPF.K - CPPG.K) / CPEF.K
\]
A \[
CPEF.K = (CPPG.K \times PG.K + CPPF.K \times PF.K) / PHBCF
\]
C \[
PHBCF = 0.62
\]
A \[
CPPG.K = (2 \times VG.K \times PP.G.K + BDG.K \times BPPD.K) / PG.K
\]
A \[
CPPF.K = (2 \times VF.K \times PRF.K + BDF.K \times BPPD.K) / PF.K
\]
NOTE \$\$\$\$\$\$\$
NOTE SUPPLEMENTARY EQUATIONS
NOTE \$\$\$\$\$\$\$
S \[
VF.P.K = (VF.K + VG.K) / P.K
\]
S \[
BDPP.K = (BDF.K + BDG.K) / P.K
\]
S \[
CPP.K = CTOT.K / P.K
\]
NOTE \$\$\$\$\$\$\$
NOTE CONTROL CARDS
NCTE \$\$\$\$\$\$\$
N  TIME=1970
SPEC  CT=0.2/LENGTH=50/PLTPEF=2/PRTPEP=5
PLOT  PHA=D(0,800000)/PFG=G(0,.5)/UMS=M(0,150000)/B=B(0,1200000)/
X  CTOT=C(0,150E9)
PLOT  CPP=C(0,350)/VPP=V(0,6)/PHGL=G(0,1.2)/PHPL=F(0,1.2)/BDPP=B(0,1.2)
PRINT  CPP/PHA/PFG/UMS/B
PRINT  VPP/BDFP/PHGL/PHPL/CTOT
PRINT  PHAG/QAG/BG/PBPG/BROR
PRINT  VPEG/VPEGF/BDPFG/CPPG/CR
RUN  FIRST RUN
QUIT