PREDICTION OF ACUTE CARE BED REQUIREMENTS FOR SCATTERED AREA POPULATIONS

by

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ABSTRACT

In supporting the projection of bed requirements for Newfoundland to 1986, an extensive literature review was conducted to identify small area population projection methods and bed prediction models. A bed prediction model was developed for this study. For each health region, projected morbidity for diagnostic (bed) clusters was calculated by: projecting the age-sex population; holding 1976 age-sex cluster morbidity patterns and length of stay constant; projecting the base and flow referral morbidity patterns of four health regions and finally the projected morbidity patterns were combined and translated into beds and adjusted for occupancy. The population projection method was the Short Ratio. The diagnostic clusters were medical-surgical, obstetrical, pediatrics and psychiatry. The prediction of beds utilizing this model was compared with a bed to population rate method. It was demonstrated that bed requirements do change in respect of age-sex population changes. The requirements are stated for each region. This study suggests that the model used for bed and population projections are useful planning tools in Newfoundland because of ease in use. The elemental problem of supplying a population data base for each hospital district by age and sex was solved and is expected to be extremely useful in years to come. The usefulness will come from an evaluation of these methods and their acceptance as first steps in the planning process.
DEDICATION

I feel that to pursue the writing of a thesis in the manner in which I have requires a complete dedication of time, thought and effort. This I have been able to do. I have also had the time to meet with and attend to the accompanying frustrations and pressures. The completion of this thesis is important to me because there is a very personal satisfaction which it has given and there is a keener sense of direction to my life.

It is from my wife, Connie, that this satisfaction and direction was given. It was given by accepting my continual absence from home, by accepting frustrations which surfaced at home and by continually sharing with and supporting me through the highs and lows. A thank-you, as appreciation, does not suffice because the majority of this thesis, the freedom to think and organize ideas, was encouraged and given to me. To state it more appropriately, I feel it was far easier for me to be writing than to be contending with family, home and thesis.
ACKNOWLEDGEMENTS

There were many who had an instrumental part in the completion of this thesis. I am sure they knew that the assistance which they had given to me was both important and appreciated. The value which I impart to each and every contribution goes far beyond the expression of a word. I shall remember each and every contribution warmly; it is the sincerest thanks that I can give.

To Mort M. Warner, Ph.D., University of British Columbia, I would like to give a very special thanks for both his "investment" in an unforgettable entre last year and the ensuing energy which he instilled to me. To Dave Bryant, Ph.D., Memorial University, I would like to give a personal thanks for his keen criticisms, understanding and sense of direction as I sought the completion of my thesis.

I give thanks to both the Deputy Minister, Dr. Lorne Klippert and Assistant Deputy Minister, Mr. Ambrose Hearn, executives of the Newfoundland Department of Health who have continually expressed their interest for and support in my endeavors.

I am certain that Mr. and Mrs. Arthur Rodd, Charlottetown, Prince Edward Island do not expect thanks. However, I would like to take this opportunity to thank them because they were important to the completion of this thesis.

I would also like to thank Statistics Canada officials, particularly Mr. L. Lefebre for his help. I would like to acknowl-
edge with appreciation the efforts of the Canadian Hospital Association's library staff who provided me with a timely and tailored reading package. Mr. George Courage, Director, and Mr. Hugh Riddler, demographer, with the Central Statistics Division, Newfoundland Government, provided me with census data and a great deal of advice. I would like to thank both. Finally, I must thank my own staff who contributed whatever resource they could to assist me in this study.
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CURRICULUM VITAE

Eoin O'Brien graduated from the University of Prince Edward Island in 1971 with a Bachelor of Business Administration degree. Between 1971 and 1973, Mr. O'Brien was employed as a teacher at St. Joseph's Elementary School in Windsor, Newfoundland. Between July 1973 and September 1974, after being accepted into the Government of Newfoundland Hospital Administrative Program, he completed a year's residency at the Central Newfoundland Hospital, Grand Falls, Newfoundland. In September 1974, Mr. O'Brien entered the Health Care and Epidemiology's program of Masters of Science (Health Services Planning) at the University of British Columbia. Following a two year program he was employed in the position of Hospital Consultant with the Newfoundland Department of Health. In January 1977, Mr. O'Brien assumed new responsibilities with his appointment as Director of Research and Statistics with the Newfoundland Department of Health.
CHAPTER I

INTRODUCTION

The Purpose and Nature of the Study

Between 1966 and the present, numerous large scale studies, related to Newfoundland's Health Care System, have had difficulties in defining populations by health statistical district and by age and sex. This information is currently not available to either the Department of Health or to researchers. This data is a necessity for health planning and research, and therefore, its inefficient organization in or absence from a health data system is a critical problem.

Over the years no formalized mechanism has been adopted to calculate the need for acute care hospital beds for the Province of Newfoundland. Instead, the Department of Health has relied upon intimate knowledge of the system, implicit methods and recommendations of bed needs contained in various independent studies. Thus, the Department has been hindered in its analysis of area-wide patterns and in its planning of resources for age and/or sex-specific groups in the province. During 1979, the Department of Health's responsibilities were expanded to include the operation of Nursing Homes. Future planning for the elderly age groups or chronic care patients will, of necessity, require an age and sex area-specific data file.
It is the design of this study to propose useful and practical methods to solve this problem and to provide a basis for future development. Therefore, it is the study's specific intent that an age-sex distribution by health statistical district and region be established and projected into the future; that a statement of acute care beds will be established by area and by clinical (bed) service; and that the changes in the age-sex structure of the province and health regions will be observed in respect of the prediction of acute care hospital beds.

Health Planning and Health Statistical Systems

A very simple definition of planning is: "The intelligent process that precedes decision making." This is a terse statement carrying many implicit meanings. Four pertinent and distinct themes found in a literature review relate to this process: rationality, uncertainty, precision and confusion.

Rationality. Rationality can be viewed from two perspectives. It is a characteristic of a planner who combines intelligence and data in selecting the proper allocation of resources. From the second perspective, it describes the same process in which the planner must choose according to predetermined constraints. The ability to reason is relative to the situation at hand, to the limitations imposed on choice, and to the state of knowledge which is to be reasoned.

Uncertainty. As planning involves forecasting and the decision to increase or decrease present activities, or to alter more appropriate activities, the highest degree of certainty must be
carried from the present to the future. Therefore, a thorough analysis of the present situation must rest upon the availability, timeliness, validity and reliability of the data which characterizes the situation at hand or the decision that must be taken.

**Precision.** Throughout the course of the review it was evident that there were a multitude of factors which determine health related utilization levels. To understand their intricate relationships, alternative techniques such as multivariate analyses have been applied. On the distribution side, planners are now desiring to be more observant of the various and differing health care needs of specific groups in the population. The emphasis at a government policy level is changing from a resource distribution which is focused upon the concept of bed to the realization that the character of the hospital is undergoing changes. The hospital is assuming more responsibility for alternative forms of care. At the planning level of government, the delivery system is not only getting more remote, it is getting more complex. To attend to these views, the quantity of data will increase but the need for precision will be of greater concern in the conduct of technical rationality.

**Confusion.** Jeffers et al. have drawn attention to the difficulty of defining and validating what utilization really means. Many writers use the terms need and demand interchangeably. Need is an "ought to be" or "medical" statement that is not restrained by economics. Medically defined need does not have to agree with consumer defined need. Neither necessarily equate with demand. Demand represents the actual usage of health resources which may fall short of or exceed the level of need. The difference between
demand and need defined by the consumer may be influenced in some degree by supply which relates to medically defined need. Often cited in the literature as a criticism of demand distribution models is the expression: "need minus demand produces an unseen part of the "iceberg." Being specific in view reduces the confusion of the observer; therefore, rationality is enhanced.

Data Requirements for Various Examples of Planning Approaches.

Four approaches to health planning described by Newhouse are the production function approach; its variant, the needs approach; the market signal approach; and a modified version of the market signal approach which is supported by a smaller accessible data base. Data for the production function and needs approaches focus upon the health status of the population. Data for the market and modified market approaches rely upon health status, population growth and insurance coverage. The modified market approach uses a higher concentration of demographic data which is available. The modified market approach is proposed as an alternative to more costly surveys and as a means to reduce the planner's dilemma in deciding what factors, and therefore, what data should be collected when data bases are becoming increasingly complex. The choice of any of these models is not only dependent upon the nature of the problem but also upon the existence of an adequate data base.

The common data bases required for each of the four approaches are health status (and utilization) and demographic. The health status data base describes both morbidity and mortality in the population. Alternatively, status is inferred from the utilization levels of health resources. The demographic data base provides information on "the size, territorial distribution and composition
of the population; the components of population change—fertility, mortality and migration; and with the characteristics of the population. 

MacStavic states that these two data bases form the "heart" of a health care statistical system and must be separate but interdependent data bases. Any system delivering a health care resource, must by purpose, influence directly or indirectly the health status (and utilization) of its service population. The "heart" of the system must be able to deliver appropriate data to the task of determining the effectiveness or efficiency of resource distribution on health status (and utilization). By subjecting this data to statistical analyses, mathematical projection and estimation, analyses such as basic utilization, community health statistics, future facility needs and basic resource can be conducted.

Demographic information as one of the data bases deserves additional attention because it implies much more than a collection of data and characteristics. It was observed in the review that planners are concerning themselves, more and more, with the specific distribution of resources to defined population groups. Planners often compare data between region or province (for example, the Statistics Canada data on Interprovincial Hospital Utilization and Morbidity). When comparing or in fact using or deriving data by populations, age and/or sex, it is essential that planners know the "source of demography and the accompanying methods of handling statistics derived from them." This also implies that planners must be familiar with the methods of deriving population data.

This discussion is leading to the conclusion that as a mentor for health planning, a very important construct is the continuing development of a data base which is as clear, precise and certain as
the planner or decision maker requires for an informed and intelligent decision. This conclusion is also presented in the Report of the Ontario Council of Health on Health Statistics which describes the needs and purposes to be served by a health statistical system. 14

1. The system should enable the identification of health problems, needs and wants of the population and should provide for the population's major health problems.

2. The system should provide the data needed for the sound planning of health services and programmes.

3. The system should provide the data needed for effective and efficient operations and administration of health services and programmes.

4. The system should provide the data for evaluation of health services and programmes.

5. The system should facilitate the conduct of epidemiological research particularly for the major lethal, disabling and productivity reducing diseases which afflict the population.

The quality of a health planning decision is dependent upon its preceding intelligent process. Predicting the future or altering present systems to present or future objectives therefore casts considerable importance on the processes of analysis and collection of data. The concept of a health statistical system, as presented in this discussion, is intended as a comparative base for the various points raised to support the significance of this study. Of equal importance in the discussion is the choice of the term "health statistical system."

Prior to 1978, the Statistics Division had been the responsibility of the Hospital Services Division of the Department. The function of the Statistics Division had been to capture and analyze hospital utilization and inpatient morbidity data. Recently there was an expansion of responsibilities which entailed: cleaning up data files; coordination, collection and dissemination of any type
of information requested by Department of Health officials or researchers in the field; and a planning function in research when data files and collection methods (under reorganization) are at the stage of producing timely and accurate data. In other words, the role which the Division is developing is being influenced by a more encompassing view of the delivery of health care.

Therefore, the points raised to support the significance of the study care not only statements of fact, they are philosophical statements of what ought to be, and as presented, would mean that the study is contributing a great deal to planning and research both inside and outside the Department of Health.

**Significance of the Study**

Together, the Hospital Services and the Cottage Hospital Divisions of the Department of Health are held accountable for 39 health statistical districts. Each health statistical district can be subdivided to hospital community or it can form part of a health region (4 in total). Each health statistical district has a hospital or an alternative facility which is funded or operated directly by the Department. Two major types of data are collected for the health statistical districts. For each hospital, utilization, personnel, and cost figures are collected from the Annual Return of Hospitals, and from a more general accounting from the monthly financial statements submitted by the hospitals. The second type of data is the Inpatient Hospital Morbidity File which can identify community, district hospital and region of patients, including transfers. Presently, these age-sex specific files are related to population by total populations at the district and regional levels (no age and
sex), and to an age and sex population at the provincial level.

There have been and continues to be too many instances in which Department of Health officials and researchers and/or epidemiologists, or other researchers outside the department have not been able to obtain the basic demographic data of age and sex for health statistical districts. The Brain Commission in 1966 described the demographic data in Newfoundland as "limited in scope and detail." In 1973 and 1974 the Health Planning and Development Committee published four reports covering 21 health statistical districts. It had this to say: "Because the census tracts do not coincide to this statistical district [referring to health statistical district] it is not possible to obtain a population breakdown by age, sex, marital status or family size." Unfortunately, this study group made no attempt at solving this problem. McKinsey and Company in 1978 were greeted with this problem in a commissioned study for the St. John's Hospital Advisory Council. This group did solve their problem and did provide an age-sex population and projections but this was done for three levels of care regions: primary, secondary and tertiary. There are 4 health regions and 39 health statistical districts which under normal conditions are not defined by levels of care for planning. Boundaries of these various planning divisions do not conform to present age-sex distributions of the population by census divisions.

The Department of Health has been supportive of obtaining an age-sex description of the population in each health statistical district. Resources are distributed to these districts either directly through programs within the various divisions of the Department or through the hospital, which is the focal point of the
district. To accommodate the measure of effectiveness and to define further distribution of resources to specific needs, aggregate population figures alone are not sufficient. A very real concern at the present time is the Department's desire to estimate the elderly population for each health district and region. This arises because of the new responsibility which has been assumed by the Department of Health for the operation of Nursing Homes.

Four studies by the Planning Division of the Department of Health point to the need for new estimates of district and/or region age-sex populations and bed requirements. Three of the studies relate to population projections. In only one does the projection go beyond 1976. "In Population 1971 and 1976, Newfoundland by Health Region and Health District" the total population was to have been projected to 1991. The projections are incomplete in that few districts are projected to 1991 or even beyond 1981. These Reports do not state their methodological approach. However, it is known that a variety of methods were used, one of which was the average yearly growth rate. The replication of these studies would be difficult because there is a large component of experience and judgement involved.

Finally, a study entitled "Hospital Beds in Newfoundland Per 1000 Population as Compared to Projected Hospital Beds in Newfoundland Per 1000 Projected Population" distributed beds to regions on the basis of current and total population. This study suffers the same problems as cited previously. The methodology, as confirmed by the Planning Division involved the use of population estimates from various studies and the intuition and experience of the writer of that report. The method of estimating beds was inconsistent; in
establishing bed rates, projected bed rates were modified according to future plans for expanding or constructing facilities, to the assimilation of areas and to "rules of thumb", all of which were not stated in the Report.

In the review of a health statistical system and in the light of the preceding discussion, the significance of having a more precise demographic base for the Statistics Division is linked with its future efforts and responsibilities in research. By focusing upon bed predictions and the concommittant changes in the age-sex population, it is anticipated that more attention will be given to future data requirements in the province. Little has been said with regard to the bed prediction itself. The predictions will be timely and will provide a basis for discussion in determining bed requirements. The methods which are to be designed for this study bear weight because they will allow inspection, criticism and improvement. In other words, the quality of data should be enhanced, and therefore the character of a health planning decision should be improved under the assumption of intelligence or rationality.

The Study Problem

This study's purpose is to establish standards for calculating and predicting the acute care bed requirements, taking into account the changes in the age-sex distribution of the population.

For Newfoundland, the requirements which have been identified are as follows:

1. Determine the bed service categories by:
   (1) current and projected years,
   (2) morbidity diagnostic codes.
2. Determine a valid and reliable projection period for population projections and bed estimations.

3. Determine the age-sex population for the current year (reference year) for each health statistical district and health region.

4. Project the age-sex population for each health statistical district and health region for the projection period.

5. Determine by bed service, the morbidity use by age, sex and region for the reference year.

6. Project bed service requirements by age and sex for each region.

7. Determine the changes in the age-sex distribution of the population in respect of the acute care bed requirements for Newfoundland.

Limitations

The limitations listed below have been established for the present study. Limitations, number: (1) and (6) should be noted as they are important to the analysis of results.

1. The population sorting and assignment of an age-sex population are to be carried out at the health statistical district levels. Population projections will involve aggregation of data to regional levels so that the accuracy of its input to morbidity projections for regions will be enhanced. Therefore population analysis will be confined to regional and provincial levels.

2. Morbidity incidence is restricted to 1976 Hospital Inpatient morbidity for 44 acute care hospitals in Newfoundland.

3. Newborns are being omitted from the study.

4. Beds are restricted to acute care beds: medical-surgical; obstetrical; psychiatric (acute care hospital) and pediatric classifications.

5. Four hospitals are being omitted from the study. The
beds in these facilities are considered long-term. The hospitals are: Waterford (Mental Health), Children's Rehabilitation, St. Patrick's and St. Luke's Nursing Homes.

6. Diagnostic bed service is a hospital inpatient morbidity classification which requires a specific type of bed to service or care for the cluster of diagnoses. In other words, a gynecological patient cannot as sometimes occurs, occupy an obstetrical bed by this study's definition.

7. The health statistical district is being used by this study because it is the current geographical area that is employed by the Department of Health. It is not within the scope of this study to discuss alternative divisions for use by the Department of Health.
Chapter I

Footnotes


13 Gerry Bernard Hill, pp. 1-49.


21 Personal communication with G. Gover, Acting Director of Planning, Department of Health, Newfoundland, August, 1979.
CHAPTER II

THE BROAD SPECTRUM OF FACTORS ASSOCIATED WITH

HEALTH RESOURCE UTILIZATION

Introduction: The Broad Spectrum of Factors

In the context of this literature review, there were numerous studies which examined the contributory factors which led to the expression of a demand for or the utilization of a health care resource. Whilst a representative catalogue of all these variables has the appearance of a shopping list, it is evident that a precise statement of determinants and relationships has not yet been found. Even though some of the studies have examined relatively few variables, their reviewers are very quick to point out that such an isolated view forms but one band of the spectrum.

A synoptic picture of these variables can be obtained by combining the studies of Pierce and MacStravic. Given below are headings and examples. The order in which these appear does not indicate their relative importance.

Demand and Utilization: Factors and Examples

Economic: The individual's cost of time, distance and transportation; the health system's cost of resources and priorities; the level of resources available.

Socio-psychological: The individual's behaviour in confronting the acuteness, delay, fear or preventability present in a situation.
Demographic: The population's growth, education level, income, cultural origins and age-sex structure.

Physical: A population's level of morbidity or mortality.

Organizational: The individual's or professional's accessibility to services under the consideration of availability and universality of resources and facilities, or degree of centralization or decentralization of the system.

Environmental: The absence of an adequate water and sewage disposal system or the pollutant effects of an industrial complex.

Political: The lobbying of a community for a hospital when the primary reason, although stated as health, is economic (jobs).

Technological: The level of medical expertise for the services required.

The previous listing was presented to emphasize that demand or utilization can be considered by a statement consisting of many variables. MacStravick suggests that in the future techniques such as multivariate analyses will become more commonplace. As an example of numbers and relationships, the studies by Harris and Brooks and Beenhaker provide a good starting point. Not only do these studies point to a growing list of variables, they also point to the selection of what variables through analysis, are considered to be the most important for a given situation. In this context, a study which selects but a few factors should be cognizant of possible relationships with other variables, and that the same is true of many factors; that is, the importance of variables in one situation is not necessarily the same in another situation. The selection of variables for study can cover a broad spectrum by logic alone, but the final selection of variables to be analyzed is dependent upon the situation, practicalities of time and effort, the techniques of analysis, and the appropriateness to the problem at hand.
Morbidity, Age-Sex

Although the level and structure of morbidity are believed to be important determinants of health resources utilization, morbidity data have often been overlooked in the planning of health resources.\(^5\) [underlining by the present writer].

This quotation from Navarro has a number of key concepts which require further explanation. The level and structure of morbidity are grounded in age, sex and health condition. Morbidity applies in two distinct settings. First, morbidity is an aggregate term which describes the health status of the population. Second, morbidity is a modified term which defines the numbers and types of conditions which are admitted to, or separated from, health care institutions. The quotation also implies that there are various levels or perspectives to morbidity. Some of these levels are: expressed actual or demand morbidity (prevalence, incidence); primary, secondary or tertiary morbidity (resource distribution and degree of sickness); and consumer or expert defined morbidity (factual or perceived levels that ought to exist). Although authors recognize morbidity and age-sex factors, frequently these factors take a back seat to other sets of variables. Donabedian made reference to this in a review of 225 studies by a number of researchers.\(^6\) In only one case was morbidity data used to derive a statement of resource requirement.

According to Doyle et al.\(^7\) "the most statistically significant variable affecting hospital bed days were age and sex." "Age was five times a better predictor than any other single variable." [Previous hospitalization, income, income groups, rural-urban
differences (accessibility as one), residence, sex differences, race and age were other variables considered.] One would anticipate a result such as this because resources are, in a large measure, being supplied to deal with morbidity which is a function of age and sex.

Examples of the relationship between age-sex and morbidity are drawn from Bright, Das and Das, and Umenyi. As age or survival increases, the individual's susceptibility to morbidity and to the chronic degenerative or debilitating conditions also increases. This requires a special type of care. Changes in birth, death and survival rates may within a generation cause significant shifts in the age-sex groups. Younger, and especially elderly groups, consume more resources in the acute care setting, ceterus paribus. Depending upon the age distribution and number of women in the child-bearing years, the need for obstetrical services may vary. However, women at risk for complicated pregnancies may differ in age patterns, and require a differing set of resources. Sex-age related conditions such as cancers of the prostrate or reproductive organs require separate types of beds. Cardiovascular disease and cancers of the stomach or upper respiratory organs are age-related. To cite more examples would be redundant for logic alone tells that changes in the age-sex distribution of the population will have a consequent effect upon utilization, at least in the volume of services, if all other factors are held constant. Therefore, one of the basic steps for the planning of health resources to morbidity levels is to know the age-sex distribution of the population.

Morbidity, Age-Sex and Geographical Distribution

A difference in morbidity patterns by age groups between rural and urban areas was demonstrated by Pfeiffer et al. who plotted
stomach cancer cases on a map of Newfoundland. The observed pattern which followed the coastline was also concentrated in a pocket on the east coast. Fodor's preliminary observations, on cardiovascular disease rates between two areas of Newfoundland indicate that one area has twice the rate of the other, and this finding is true for all age specific rates. A number of consultant reports on the more northern and less densely populated regions of the province record a greater proportion of morbidity conditions which are associated with environment, sanitation, nutrition and social disintegration when compared with the rest of the province. Whilst these studies support generalizations to geographical differences the authors also point to the important intervening variables such as cultural and eating habits.

The remoteness experienced by some communities often accompany such problems as weather, distance, accessibility and delay. These contribute to longer stays, higher costing services and more consumption of resources. The remoteness of physical separation from larger centers can sometimes lead to a lower profile when demands are expressed. Planners are often forced politically to recognize high visibility areas such as cities or larger communities. This is also a bias because these communities have more resources, higher levels of skills and education and more organizational ability. In this context the development and organization of resources is far easier. The natural outcome is that utilization rates are higher. This does not necessarily mean that there is a significant qualitative difference in the services provided to either the urban or rural patient.
Many small area variations in health resource utilization were described by Wennberg and Gottelsohn. Some examples were: hospital bed rates, discharge rates, occupancy, length of stay, diagnostic rates and proportion of elderly (over 65 years). An interesting comment which they make is that the physicians, which they observed, tend to concentrate in urban areas for more than economic reasons. Physicians are also cognizant of the age structure of a community and the type of medical practice which they desire. They suggest (as one reason) that physicians, in general, do not move to rural settings because there is a higher concentration of unproductive age groups. Many physicians do not like to care for the elderly because case variety and cure is limited. The outcome of this generalization is that supply of physicians is reduced; therefore, a corresponding reduction in utilization is experienced. When MacStravic discussed the factor of distance he cited Jarvis' Law: The utilization ratio is inversely related to distance. This law in conjunction with the previous discussion contends that different populations by area and structure require varied sets of health resources, at least to satisfy current utilization patterns.

To summarize both discussions of morbidity by age and sex and by geographic distribution, two points are presented as being appropriate to health planning in the Newfoundland setting. Sibole suggests that the growth of the population has created a very different type of effect. Growth in the population has far outstripped the growth of health care resources. Present resource levels often do not relate to newer populations and therefore may represent substandards, if and when resource utilization is intended for planning. The critical element of this view is the relationship
between present consumption and the present population which is consuming resources. Small area population information is considered by Wennberg and Gottlesohn as vital to sound health planning. In the quotation that follows note the implication that there is an absence of current population analysis relative to the resources distributed.

Health information about total population is a prerequisite for sound planning, decision making and planning in the health care field. Experience with a population based health data system in Vermont reveals that there are wide variations in resource input utilization of services and expenditures among neighbouring communities. Variations in utilization indicate that there is considerable uncertainty about the effectiveness of different levels of aggregate as well as specific kinds of services.  

The Newfoundland geography is comprised of many small area populations and as previously stated there are elements of data collection that require improving in the Newfoundland situation. Consequently a discussion of Newfoundland and its rural problems of health resource delivery and integration with larger systems will be presented under a separate heading in Chapter III and in Appendix A.

**Forecasting: Prediction, Projection and Estimation**

The term health planning, by definition, must include some element of forecasting, prediction, projection or estimation. To many planners these terms are used interchangeably to describe one phenomena, a quantitative state in the future. To the ardent demographer each of these terms is distinct and has its own specialized body of knowledge. Keyfitz uses prediction and forecast as equivalents which mean a future statement of what is to occur with a probability of its occurrence. Projection does not have a probability attached. Instead it is conditional: "If the birth rate
declines, what will happen?" If a probability is attached to a "what if" statement, the result is a restricted forecast. To carry the "what if" birth rate statement to a real situation, the probability of the decline would have to be stated. In the case of this thesis there is a population projection, a morbidity assumption and a prediction of bed requirements. The prediction arises because a real situation (current pattern) is expected at the future date.

Determining the future is distinct from forecasting the future. Determining the future involves identifying the factors which relate to health care utilization, and intervening by altering those factors which are amenable to adjustment. In other words, the real or current situation is being modified for the future utilization levels. Forecasting does not alter current factors. Instead, observed changes of factors are used to predict the impact that these changes will have on future utilization. Specifically, the content of a forecast must cover all aspects of the situation which is to be planned.

As Bergwall et al. describe content, the forecast must contain projections for the planning period and a thorough analysis of facts relating to the current situation. The forecast should appear as if in a table comparing 1979 on one side and 1989 on the other side. An encompassing forecast should consider the following components: political; social (demographic); economic; technological; and health: resources, status services; and health (environment). A short list of forecasting techniques is derived from MacStravic, Bergwall et al. and Navarro.

1. Present Centered (present will repeat)

2. Trend Extrapolation (past will repeat)
3. Trend Correlation (past link between two factors will repeat)
4. Multivariate Forecasting (past link in complex ways to one factor will repeat)
5. Consensus (future defined by experts)
6. Intuition (subjective judgement)
7. Statistical Models (numerous estimating equations predict future)
8. Analogy (plausible parallels drawn between future and prior event)

Forecasting methods can also be defined by their association with particular branches of knowledge. Of concern to this thesis are two methods, social forecasting (demographic and populations) and health planning. Each of these in turn will be discussed: social forecasting in terms of methods of projecting subnational populations; and health planning in terms of bed (resource) determination or prediction methods. Regardless of method, often the very basic step is a population projection. This is so because planners often must focus their attention upon activities which are related to the individual or groups within the population. The activity rate, such as morbidity by age, is dependent upon population. To determine future levels of morbidity by age, the growth of the population by age is taken into account. Bergwall et al. describe social forecasting—population projection, as the key independent variable of health planning.

Methods of Subnational Population Projections

There are various methods of projecting populations and these can be divided into two broad categories: national; and subnational (local, regional, area). The methods which are listed
below can be applied to either category. However, the methodologies available for local projections are more numerous and are more germane to the thesis:

1. Arithmetic or Geometric Extrapolation Methods
2. Ratio Method
3. Correlation Method (Econometric)
4. Component Method
5. Cohort Survival Method
6. Other Methods

Many of the articles dealing with population methods review very briefly those which apply to the determination of local area populations. The discussion which follows was drawn from Wolff, Siegel, Schmitt and Crosetti, Zitter and Shryock Jr., Spiegelman, Grauman, Bergwall et al., U.S. Bureau of the Census, and Gnanasekaran.

Mathematical Projection Models involve an assumption of past trends and a continuation of these trends as a constant into the future by a specific annual or average amount. Specifically, the arithmetic method projects an increase or decrease in annual or average amount whereas the geometric projects an average annual rate or percentage increase or decrease. Alternatively, these methods are known as trend curves. These methods are used less frequently because their ability to handle numerous assumptions is very limited. Yet they are often useful for short term projections or quick studies where time and cost are at a premium and rough estimations will suffice. Of the various types of trend curves to which data are fitted only the logistic curve is suggested as suitable for long term projections.
The Ratio Methods find their main application in projection problems which deal with geographical subdivisions. This method is employed in situations where areas are not defined by boundaries for which data is readily available and where independent projections of a larger reference area are available. The method involves calculating, from census data, the ratio of a smaller population area to its reference population area. The ratios may be applied to total population or to the age-sex specific population of both areas. The ratio which is calculated can be based upon a constant (one observation) or a trend period (multiple observations). This ratio is then applied to an independent population projection for the larger area.

Four distinct Ratio Methods are observed in the literature: Short, Long, Ratio Correlation and Ratio Cohort. The short calculation involves the bypass of hierarchical divisions in the population; that is, the community may be calculated against the larger reference area. In the long method the steps would follow a sequence, for example, community, district, region and county or province. The ratio correlation involves the correlation of the ratios of percent change or observed change between one area and its larger reference area between observation points. The ratio method has also been used to work backwards from a population projection towards its constituent parts. The disadvantage of this method is that it relies on past data as with mathematical methods. However, it can provide a projection, when trends are examined, that is not overtly optimistic. A distinct advantage is the method's flexibility in a given situation in that it can be modified without producing wide variance in the end product. This does not imply that the
flexibility extends to all situations.

The **Component Methods** are often used to project populations because they demonstrate a better understanding of the factors which comprise population growth and because they can present a finer picture. Methods can be combined so that a **component-cohort** design can be utilized to provide age projections which the simpler component methods cannot provide.

From numerous observations over time, total births, total deaths and net migration are projected and their values are substituted in an equation, such that the observed population plus projected births minus projected deaths, and plus or minus net migration yield the projected population for the time period desired. The **component-cohort method** involves the application of age-specific vital rates projections to the age-sex population which is to be projected. Researchers suggest this method even when the component method is the method of choice. The **cohort method** utilizes age-specific fertility and vital rates and carries forward the latest population by age to a specified date. Some of the component methods assume zero migration whereas other related methods treat migration as a distinct component.

The advantage of the component methods is that they are more analytical in their treatment of population change because they are projecting the major components of population change. The method also has greater flexibility in assumptions of future growth. Component methods are not suggested where there are a great many areas to project and when migration varies frequently between regions and/or over time. The accuracy of this method also depends upon the availability and precision of vital statistic rates for the smaller areas.
If this information is not available then assumptions of national or provincial rates may have to be applied. Significant shifts in these vital rates may also affect the projection results. However, these criticisms are also relevant to other types of projection methods in degrees. Writers also suggest the use of simpler alternative methods where there are a large number of small area projections. If the anticipated results of alternatives are approximately the same, time, cost and detail mitigate choice.

**Econometric Models** involve the projection of a population by comparing either the population to its components with other economic variables or indicators which are felt to be associated with population growth or change. For example, a correlation may be applied between migration and such economic variables as employment, unemployment, income or wage level, location of industry and economic prospects of areas. The assumption is that past relationships between variables will continue into the future. An example of this type of model is **holding capacity** which relates population change with the number of dwelling units, vacant dwelling units, vacant or excess land, household size and topography of the land. Econometric methods have the advantage of understanding the components of population with a higher degree of sensitivity. It is suggested that this method lies more appropriately, at the present time, in the domain of the true demographer. The sensitivity applied in this type of model could be demonstrated through consideration of the following example: When an industry in a local community closes down normally there is a temporary or permanent out migration of the productive population for work only or for work and permanent residence. The age structure of the community may also be seriously
affected in the sense of having a higher percentage of young (unproductive) and elderly population (unproductive) relative to newly defined population.

Other Methods are also identified in the literature from time to time. The analogy method examines the experience of an area which is deemed to be similar to the area under consideration. The past trends of the "other" determines average growth patterns which in turn are applied to the area under consideration. The apportionment method, although cited in many instances as distinct from the ratio method, appears in principle to be a variant of this method. The projected growth of a population (usually an independent calculation) is prorated among its constituent parts according to their relative growth. If a population decreases or remains stable in an area, the population in an area remains as a constant. Even very crude methods such as adding the natural increase of the population to the census has been used. A number of researchers have mentioned taking the average of several methods in producing projections. Although this might provide a more reliable projection, the averaging tends to minimize highs and lows which might be worthy of analysis. Finally, there is a method called the vital rates method which compares trends in birth rates, death rates for local areas and compares these with national or regional rates.

Citations from the 1950's, 1960's and 1970's confirm that there is as yet no single method which can be applied in all situations. The variety of methods has arisen because population parameters are often ill-defined, situations require a tailored method, and there are differences in the availability and quality of local area data. Siegel stated in the 1950's that "it is not possible to
forecast the population of small geographic areas accurately."  

Grauman, in the 1960's, addressed the search for a routine and flexible method of all situations as being "like the attempt to circle the square." Gnanasekaran, in the 1970's, suggested that the "need for research can hardly be over-emphasized" in the attempt at finding a superior method for projecting local area projections. What these authors conclude is that the contention that one method is superior to others does not hold water because each method, relative to givens of situation, time period or population size, can be considered as accurate as any other method. When establishing the appropriateness of method, accuracy, time, and cost considerations balance between the statements of choice and the marginal return of increased accuracy. In other words, the ease in method of simpler projections may far outweigh the more complicated measures when results approximate each other.

Accuracy of Subnational Population Projection

There are a number of writers who state without testing that the various projection methods are similar in their accuracy. There are also writers who suggest the use of one method over another. Two of the more encompassing tests and reports on accuracy are provided by White and Seigel both of which are cited by Gnanasekaran who states that more testing is required.

White concludes that no one method provides a clearly superior edge on accuracy. In various tests of the wide range of methods against various controls, the cohort-survival with migration, apportionment and the ratio II methods make consistently better projections considering average percentage of error and percentage
errors exceeding 10% for both the 10-year and 20-year projections. The ratio II method assumes that the percentage increase in population in an area is the same as that experienced by the national population. In 20-year projections, errors on the average, are twice that of 10-year projections. On average percent error in 10-year projections, these methods scored in the 5 to 6% range whereas the overall average was 7% in all 10-year projections.

Seigel concludes in his study that forecasts beyond 15 years are useless. With a forecast period of 10 years, the average error was 8.4% with more than 25% of these involving errors of 10% or more. The ratio method was scored at 5.7%, the cohort-survival was scored 5.9% and the simpler component method was scored at 10.3%. The average error for estimates of 5 years or less was 7.5% and for estimates between 5 and 10 years 9.5%. The findings of this study correspond with the findings presented by White. In terms of accuracy Seigel has this to say:

In view of the negative evidence so far regarding the superiority of the more elaborate over the more simpler methods of making small area forecasts, it should be recognized that no consistent demand can be properly made at this time for the use of more elaborate methods on the grounds of accuracy of results.

A basic set of principles which promote the accuracy of population projections or forecasts are drawn from Seigel, White, Gnanasekaran, and Grauman. The principles are as follows:

(a) Errors increase directly with the length of projection. Twenty-year projections on the average have twice as many errors as 10-year projections.

(b) Rate of errors decreases as population size increases.

(c) Rate of errors decreases as observed economic bases become more diversified.
(d) There is inherent danger in utilizing a constant rate of growth over consistently long periods because unique shifts in rates may be missed.

(e) Accuracy is dependent upon the quality of data: that is, the accuracy of census data, vital statistics data or rates of projections which are relied upon.

(f) Rate of errors tends to be larger in areas that experience wide fluctuations in migration.

(g) Where the population is considered to be stable in both past and present, less analytical models may be more appropriate.

(h) No one method of population projection is clearly superior. Therefore, the choice of method must rest with appropriateness of situation and of time and cost.

(i) The average forecast range is generally between 10 and 20 years.

(j) In evaluating accuracy, Seigel (1953), noted the following two practical difficulties which he stated appeared quite frequently.

i. "the inadequacy of the methodological statement given in a report or the numerous variations of a particular method which may be employed rendering difficult or impossible the important classification in terms of type of method."

ii. "the failure of the author to specify the actual base date of forecasts rendering difficult or impossible the important allowance for the length of the forecast period."

Note. Errors are defined as the quantity of errors and as a percentage difference between projected and actual population figures.

The Temporal Reliability and Relationship Between Forecasting and Health Planning

As stated previously, both a projection and prediction are involved in arriving at a statement of required beds. Previously it was noted that population was the key independent variable in health planning. It follows that the prediction period for health planning must necessarily follow the guidelines established which enhance the
reliability of population projections. Most writers agree that forecasts and projections should fall between five and fifteen years. Projections beyond this point reduce accuracy considerably. However, planners and forecasters are sometimes asked to make projections of twenty years or more. In these cases there has to be an explicit assumption that the future state is limited. Particularly in these cases, a range of high, medium and low are given. Based upon the assumptions of reliability, the decision maker chooses his projection.

From the review of bed forecasting formulas most health planners did not commit themselves to a period greater than fifteen years. Invariably, the period of choice is between five and ten years. Although reasons are not often given for forecast length, there are implied assumptions which conform to theory and practice. In the explicit state, a number of plausible arguments can be offered for a five to ten-year projection or forecast (short term), which in the opinion of the writer, is a more appropriate planning cycle than a period over fifteen years (long term). In this context, a medium expectation of reliability would be anticipated for the ten to fifteen-year cycles.

A long term plan can mean the dedication of current resources to a future course of action which is highly uncertain. Alternatively, it may also call for a future level and availability of resources which may also be uncertain. A long term plan allows enough time for unexpected shifts in the factors which determine demand in the future. Examples might include the age-sex distribution, economic stability, migration, level of education or income. How does one predict technological advances particularly in a field
where advances are very rapid? There is a heavy cost implication at two points for long range plans if there is a major deviation from the plan. There is the cost of alteration and new plans (and resources which might not be used further), and there is the cost of modifying systems or resources introduced in phases of the original plan so that they conform to the new plan. Long range planning also presupposes a political stability and the non-arbitrary intervention of priorities and philosophical underpinnings. A very decided advantage to long range planning is that there is a specific goal on the horizon. The path into the future with short term plans may be very haphazard or incremental in nature. In other words, the part may not relate to the whole. Long range planning, therefore, offers a higher probability of a functioning and coordinated system.

With the propensity of health care systems to maintain what they have in resources and programs, there is an ever increasing focus upon cost and accountability, for example, zero base budgeting is being promoted for all areas of government. The intent of zero base budgeting is that programs must have their purpose and operating level justified each year. In the same vein, a short term projection forces a more frequent appraisal. The path may be tentative or incremental in nature, but relative to the distribution of very costly resources this approach would tend to minimize error. A ten-year projection (and to fifteen years) allows age cohorts to move to different utilization and morbidity levels. Five years may be enough time to experience dramatic changes in medical and related technologies. To this extent short term plans would be more responsive.
To summarize, the main reason that a short forecasting term should be used is that accuracy is substantially increased, ceretus parabus in comparison to long range forecasting. Inaccuracies may produce services and resources which are both costly and unsatisfactory to the public and government.

Summary

Initially it had been stated that the factors associated with utilization formed a broad spectrum. These can be derived scientifically or logically but selection of factors for analysis is unique to a situation, even though there may be general applicability. This is so because need or demand are "soft," that is, there is a heavy reliance upon standards many of which have a qualitative base.

For any health statistical system to function properly in relation with a health planning function, demographic, morbidity and utilization data must be available and interdependent. One vital element of forecasting future levels of resources is the necessity for a thorough analysis of the present situation. Current resources must, therefore, be related to the current population consuming these resources.

The technique of forecasting whether it is population, utilization rates or level of resources to be consumed takes its design and method from the problem of focus. Of importance is that the choice of approach has to be credible; it has to lay its assumptions before the decision maker for examination, validation and application. It is through this process that research and practice are blended.
Chapter II

Footnotes


10 Das and Das, pp. 262-281.


13 Personal communication with Dr. J. C. Fador, Epidemiologist, Community Medicine, Memorial University, St. John's, Newfoundland, 15 August 1979.

15. Robin E. MacStravick, pp. 73-135.


17. Wennberg and Gittelsohn, pp. 1102-1108.


22. Bergwall, Reeves and Woodside, pp. 61-76.


24. Bergwall, Reeves and Woodside, pp. 61-76.

25. Ibid.


34 Bergwall, Reeves and Woodside, pp. 61-76.


37 Ibid.

38 Siequel, pp. 72-87.

39 V. Grauman, pp. 554-565.

40 Gnanasekaran, pp. 1-8.


42 Siegel, pp. 72-87.

43 Gnanasekaran, pp. 108.

44 Siegel, pp. 72-87.

45 White, pp. 480-498.

46 Gnanasekaran, pp. 1-8.

47 Grauman, pp. 554-565.
Prior to discussing the various categories of bed planning models a number of comments are in order. In the literature many of the bed planning, prediction or determination models are not exclusive to their own branch of planning. The word 'bed' can be replaced by the generic term, "resource." The type of bed planning model, therefore, describes a general approach to the distribution of resources either in the present or in the future. Just as there is no one routine or superior method for projecting small area populations, there is yet no one routine or superior model for determining or planning beds in the future. The choice of a bed planning model belongs to both the situation and to the decision maker. The model is as accurate as its assumptions and use by a decision maker who understands its limitations and who has the necessary skills and data to apply the model.

There have been many methods developed to determine current and future bed requirements. These vary from the very simple bed to population ratio method to the more complex methods, which attempt to acknowledge and incorporate the many factors which may be associated with the utilization of a bed. Similarly, planning perspectives have undergone a gradual shift from the aggregate population
base to the more specific and localized needs expressed in the population. Regardless of the perspective and model, four criticisms are common to both. First, most models deal only with demand, and therefore, overlook the influence of supply. Second, demand is often treated as representative of the population's morbidity. Third, demand frequently is comprised of few components. Fourth, direct morbidity data is seldom utilized for calculations. These criticisms could be handled in one formula but it would be a monumental task in time, energy and money. More important, planners and decision makers operate under constraints. The strategic constraint in a modelling design and application is that what is relevant in one situation at one point in time may not be relevant in another situation or time. What is appropriate for the researcher may not be practical for the administrator.

To continue the present discussion of bed planning models a six-part classification schema was developed from the observations of Donabedian, Navarro and MacStravick. The types of bed planning models are:

I) Utilization

II) Multiple Factor

III) Distributional Analysis

IV) Non-Formal or Consensus

V) Standards

VI) Multiple Methodology

Utilization

This method entails the use of a bed related utilization rate such as admissions, separations or patient days expressed as a use rate per thousand population. The resultant rate is then mani-
pulated by standards through the use of simple mathematics. The use rate may be past, current or predicted. The entire formula's calculation can be used to analyze the deficiencies of the current situation or to provide a statement of expected resources. Below are typical formulas:

1) \[
\frac{\text{Rate} \times \text{Standard}}{365 \times \text{Standard}} = \text{Total Required Beds}
\]

Admissions per Thousand Current Population (projected) \times \frac{\text{Population} \times \text{Average Length of Stay}}{365 \text{ days} \times \text{Occupancy Rate}} = \text{Total Required Beds}

2) \[
\text{Beds per Thousand Current Population} \times \text{Projected Population} = \text{Total Required Beds}
\]

The rates method is the most frequently encountered. It exists in various forms such as: the bed to death or birth ratio which assumes a constant relationship between the event and bed; and the critical number of beds (in two forms) which is computed by multiplying average daily census by average lengths of stay and dividing by 365 days. Alternatively, average daily census just equals the required beds. To these calculations an arbitrary adjustment is made to incorporate peak periods or to include the waiting list. The same type of arbitrary adjustment is made in the Hill-Burton Formula of the United States. The average daily census, however, is first adjusted by an occupancy standard.

The criticisms of this model are numerous and are worth discussing because they are also germane to the other models. A bed rate formula assumes that it is the size of the population which determines the beds and is, therefore, a trend correlation similar to the bed death ratio formulas. Bed rates imply that all the beds are available to the population and that the beds and related
services are the same and can meet all the population's differing morbidity patterns. The critical number has factors which are not independent and demand constitutes a greater number of factors. Using current utilization protects the status quo and amplifies any defects which are in the system. Of the standards used in the formula, Shonick's reaction is tempered with questions: What is the proper occupancy rate? average length of stay? or bed rate? Roemer suggests that supply influences demand. Beside these criticisms are advantages of speed, of ease, and of flexibility in adjusting standards to produce a range of values. Donabedian states that these methods can be used accurately in the hands of a skillful administrator or decision maker.

The changing perspective of many planners from the aggregate to the specific needs of populations has led many to refine methods. These refinements are being added to simple formulas which continue to survive because no superior method as yet has been found. The refinements discussed below are interesting because they demonstrate tailoring to a situation.

Umenyi (1977) displays a number of refinements: adjusting the length of stay to provide a range of bed requirements; and using a simple formula in conjunction with a thorough analysis of nine variables in estimating maternal and newborn bed requirements. MacStravic employs a simple model with four criteria of availability and choice of hospital, unit, and bed. Laine and Wilson and Caldwell calculate beds by region using rates per catchment population and patient flow. Laine and Wilson further refine by utilizing group standards and calculating beds by service. Dufour combines average daily census, population projections and utilization patterns
by clinical service and by age-sex categories.\(^{23}\) Karniewicz applies a normal distribution to coronary incidence by hospital to check the reasonableness of the incidence which is then inserted into a simple formula.\(^{24}\)

**Multiple Factor Analysis**

This method, as described by Feldstein, is a "relation between current demand and population and economic characteristics. Beds are then built to satisfy future demand predicted by the forecast equation of values of population characteristics, again, to allow the capacity for random fluctuation."\(^{25}\) The use of multiple regression is characteristic of this method. Brooks and Beenhaker\(^{26}\) give a very good idea of the complexity of relationships and factors in a hospital setting. They predict demand for 17 services using 3-4 variables for each service. They had initially selected 117 variables for examination. Doyle et al.\(^{27}\) use regression to estimate the probability of hospitalization which is then applied to the population and average length of stay by age to yield hospital bed days, a factor for the convention formula. *Simulation* has also been experimented with and *queuing theory* has been adapted for solutions to both critical number of beds and waiting list.\(^{28}\)

Regression, simulation, and queuing theory seem to be largely confined to local settings such as hospitals or clinical settings. Two requirements of this model are that the user must have a large available and specific data set and must have an intimate knowledge of systems structures and relationships of the hospital or service which he is observing. These requirements make the task of application to a number of regions or large areas more difficult. The advantage of the regression is a greater deal of understanding and
accuracy to the prediction of demand but as mentioned previously it is relative to the situation at hand. However, regression techniques deal only with demand and the possibility of omitting a key variable increases the significance of errors.

**Distribution Analysis**

This model assumes that there is a pattern to the presentation of patients for admission and that the pattern can be described by a distribution curve. In simple terms, the critical number of beds is adjusted which insures that the beds will be over-filled on one to five days out of a hundred. The adjustment is a multiple of the standard deviation and the insurance is a probability that the beds determined will not be exceeded (patients turned away) given the pattern of admissions each day. The method normally used is the poisson distribution, a skewed form of the binomial distribution which requires consistent observations that are random and independent in nature. The key advantage of this method is that the number of beds can be calculated from one type of information: the mean average daily census.

Typically, the poisson technique is applied to service beds which do not have electives or contain a lower percentage of electives, steady or long term care, medical/surgical care and obstetrical care. However, Lichterman and Gulinson have applied the technique to each of the bed services in a hospital on the assumption that the errors are not significant.

As the average daily census increases the difference between total beds and mean number of beds is smaller than it would be for a smaller hospital or service. Normile and Ziel propose services which are flexible; that is, the beds can be increased or decreased.
to suit the average daily census. This has an effect on occupancy while maintaining a high service or protection level. Shonick suggests the increasing of daily census by aggregating service catchment area. However, this not only produces efficiency but it reduces accessibility. Two articles, by Weckworth and Blumberg, provide very practical applications of the poisson formula.

Refinements to this method include: application with criteria of distance, occupancy and service level; incorporation with the concept of distinct patient facility (patient and facility are exclusive to each other under normal conditions); and application to the critical number of beds so that an allowance is made for bed turnover interval which results from inefficiencies or maintenance activities. Shonick utilizes a refined distribution called CENSA which he believes is more representative than poisson. Clearly, writers feel that the poisson technique should not be used unless its statistical assumptions fit the situation. The more important refinement of this model is that it forces a perspective to a level of service for the population with efficiency as a function of service. Simpler methods use occupancy adjustment which assumes efficiency and an ability to meet service levels. However, the articles cited demonstrate that this is not necessarily so and that service levels are very often exceeded.

Non-Formal and Consensus

Non-formal methods are those which do not apply conventional or mathematical models. In many cases they will also lack formality. Donabedian describes a consensus model called the delphi technique. This technique is a formal process which involves an original listing of variables which is passed to a group for consensus. Through a
process of repetition and refinement, a final list of variables is prepared which has the consensus of all members. Some studies have stated that in the development of their model, standards such as bed rates and occupancy from other study areas were examined. Presumably, this established a consensus for the parameters of the model or for the standards which were to be employed. Similarly, a meeting of planners or administrators in which a bed rate is decided through observation and argument constitutes a non-formal mechanism. The chief disadvantage of this distributive method is that it is highly subjective even though experts are used. However, the results which are applied may be valid as has been stated previously.

**Standards**

This method necessarily overlaps with previous models because the basic formulae involve the choice of an occupancy, a length of stay or a bed related use rate standard. This standard can be derived by analogy, from past utilization or current utilization and by assumption based on experience. The standards model is set apart from others by the overall force which a standard impacts on the model. In Nova Scotia a bed ratio of 4.5 acute care beds per thousand population is used. The method to distribute beds is a calculation involving locality, number of separations, percent of total municipal separations, current year population served and population estimates. The model assumes distribution to regional or area needs yet the distribution is confined by the standard of 4.5 beds which implies that area needs do not differ from the standard.  

The model used by Laine and Wilson not only points to a refined use of standards but also to the problems inherent in any
standard. In this model a bed ratio standard is chosen for each region (defined by a catchment population). Each hospital in a region is grouped by rated bed size. An acceptable occupancy standard is established by group performance. Within hospital, by diagnostic category, a standard length of stay is established. As is pointed out in the study, calculation would have been far easier and more precise if professionals could decide on acceptable standards of length of stay. Shonick has already been cited for the comment, 'What is proper? or appropriate?'

Specific reference is made to productivity and performance models and to an ideal resource model. Productivity is expressed as total utilization (current or expected) over the total capacity, per resource unit. If the standard is not related to local production units, resource distribution may be very unsatisfactory. Performance can be subdivided into: the distribution of exact quantities of resources to meet the desired standard; or the best possible mix of resources is determined by a value within the range of values established for a standard. The ideal resource unit such as a renal dialysis unit determines its own utilization and population identification is the last step. Service potential is predetermined. This model can also work in reverse order.

Multiple Methodology

In the course of the present discussion a number of writers resorted to different means in solving their problem. For example, given a pediatric and obstetric unit, pediatric beds could be calculated by a conventional method and obstetric beds could be calculated through the poisson technique. The results would then be combined
for total bed needs. Umenyi used both convention and correlation. Slutsky used regression, poisson and queing theory. Brooks and Beenhaker used multiple regression with a conventional model. The key advantage of these types of studies is tied more to the flexibility in approaching bed distribution problems, not to mention the possibility of comparing various methods within the study.

Summary of Methods

Figure 3-1 presents in outline form many of the key components which characterize the models previously discussed. As presented, the components follow a predetermined order. However, this does not necessarily imply that each is in the correct order nor that all the factors have been considered. Instead, it is presented for the purpose of illustrating the various methods which could be utilized in determining beds. With discretion, and as illustrated on the outline, a line can be drawn between components to describe a particular model.

The presentation of the various types of bed planning models brings together a number of observations relevant to both the design and application of these models. In the more localized setting, the variety was greater and these testify to the versatility of techniques to problem solving. Some models involved multiple techniques while others sought prediction through the analysis of a large number of variables. Even with the simpler methods more refinements were being added to compliment the shifting emphasis from planning for an aggregate population to planning for a local population. Yet the focus of these models is a formula common to all (average daily census equals required beds). The differences in approaches arise
Outline of key factors for bed requirement models:

Fig. III-1

- Problem focus
- General orientation: data base
- Demands or need factors
- Analysis of data base
- Central orientation
- Distribution of beds focus
- Problem focus

Higher predictability

- Age, sex, patient level
- Ethnic level
- Specific hospital
- Local service
- Aggregate population

- Bed issues
- Resource constraints
- Projected demand
- Assumed need
- Bed requirement model
- Analysis of need factors
- Central orientation
- Distribution of beds focus
- Problem focus

Lower predictability
from the many intricate relationships between variables associated with utilization, the designer and the many qualitative judgements often required in health planning.

Each type of model, therefore, has its own assumptions and each in its own way contributes to a better understanding of what is or is not relevant to distributing resources. As variables are acknowledged and selected, the limitations of a bed planning model become known. The model's application is therefore enhanced. As has been stated on numerous occasions, there is as yet no one model which is superior to another. The practicality and results of a bed planning model are dependent upon assumptions, situation, data availability quality, etc., which are the very reasons cited in population models. Therefore, the design of a bed planning model is left to the ingenuity and reason of the planner, under assumptions that can be validated by decision makers who are associated with or know the problem.

**Description of Three Bed Planning Models at Higher Policy Making Levels**

The following three examples of bed planning models are presented in detail to illustrate both the approach and methods which are being used at the government or regional level. These models also demonstrate current thinking and the shifting of emphasis to deal with localized needs, from a higher policy level than the hospital. These approaches would be appropriate in the Newfoundland setting in the sense that the data is available or could be made available for use in these approaches.
Variation in bed distribution was noted among areas in the province. These variations were compared with bed distribution policies in other provinces. On the basis of observed deficiencies in the province, the Department of Health decided to implement a method of equitable distribution; therefore, planning guidelines were established for both the interim or short run and for the long range periods. The basic distribution variable was bed allocation per capita. Refinements of distribution included: age distribution, inflow of out-of-province residents and inter-regional inflow and outflow of New Brunswick residents. At the heart of the model is the calculation of the net population which is adjusted for its age structure relative to the provincial age structure. In both the short term and long term model, the ratio of 5.5 beds per 1000 is held as a policy objective.

Short-term Model

By region, the following bed calculations are incorporated to step 5.

1. Beds for actual census population.
2. Beds due to inflow from out of province.
3. Beds due to inflow from other regions.
4. Beds due to outflow to other regions
5. Total beds to serve net population \((1 + 2 + 3) - 4\)

These beds are then distributed: acute, 75%; extended care, 15%; rehabilitation, 5%; and psychiatry, 5%. These figures also represent policy statements as to what services should be available in a region. The model excludes tertiary service, daycare, renal
dialysis, hemodialysis, labour, holding, hostel, detoxification, recovery room, D.V.A. and D.N.D. beds which are considered separately.

The total beds calculated are compared with what actually exists and the difference becomes a target for action.

The long range model is a modification of the short-term. Both inflow and outflow between regions is eliminated from the calculation. The implied assumption is that the region will have the service or alternative for which the migrant was seeking.

*Division of Hospital and Medical Facilities Public Health Services Model*[^49]

Donabedian drew attention to the Public Health Services model because of its various refinements, even though conventional methods were used. His interest rested upon its specific data requirements: age-sex composition of the population; utilization by age and sex; a projected use rate by age and sex; and a demand estimate, comprised of the preceding variables, which is calculated by service category. The bed requirements are adjusted by a desired occupancy level which is particular to the characteristics of the service. Bed requirements for all hospitals are the summation of aggregate service requirements. The services considered in short-term hospitals are Obstetrics, Pediatrics, Medical and Surgical. Long-term facility beds are calculated using the same methodology. To summarize the methodology for a given number of hospitals, the procedure is: by service, the patient day ratio by age and sex is projected on a future age-sex population; all age groups within the service are summed to get a grand total patient day figure, and these total days are then divided by 365 and multiplied by a desired occupancy factor. A priori, there are chronic or extended care
(long stay patients) who occupy short-term beds. These have not been addressed in the model even though there is a separate calculation for long-term patients (over 65 years). The medical surgical days are calculated on the entire age structure and obstetrics and pediatrics are subtracted out. The following extract is taken from the text of Donabedian.

### Obstetrical bed use, short-term hospital

**D.** Projected number of females aged 15-44 in thousands (from a previous projection)

**E.** Deliveries per 1000 in females aged 15-44 per year (current or projected rates)

**F.** Length of stay, in days, per delivery (current or projected values)

**G.** Projected patient days of obstetrical care per year 

\[(D \times E \times F)\]

**H.** Projected average daily census for obstetrical care

\[
\frac{(D \times E \times F)}{365}
\]

**L.** Projected beds for obstetrical care at 75% occupancy

\[L \div .75\]

---

**Hospital Bed Requirements: An Occupancy Factor Determination Approach 1975**

The Occupancy Factor Determination model proposed by the authors was applied to the City of Chicago Health Service Area and Suburban Health Service Area. The key concepts employed are poisson distribution, distinct patient facility (D.P.F.), protection level, out of service beds (due to maintenance, remodelling, etc.), protected occupancy (the average daily census divided by the number of beds required for a D.P.F., which represents maximum occupancy). A distinct patient facility represents a service which, under normal
conditions, cannot be occupied by other than the type of patient for which it was designed to serve.

The model which is used to determine bed requirements is given below (from text pp. 6-8).

1. Determine the average daily census by D.P.F. Current utilization (or desired or projected?).

2. Set a protection level for each D.P.F. (Arbitrary choice).

3. Select theoretical probability distribution for each type of D.P.F. (This study used poisson for all D.P.F.'s).

4. Calculate the net required beds for each D.P.F.

5. Add average out of service beds to net required beds for each D.P.F. and sum these to get gross required beds for each set of D.P.F.'s.

6. Divide the sum of the average daily census for all D.P.F.'s in the set by the sum of the gross required beds to determine the appropriate average occupancy for each set of D.P.F.'s.

Returning to original formula in Step #1,

\[
\frac{\text{Average daily census}}{\text{Occupancy factor (Step } \#6)} = \text{required beds, and}
\]

\[
\frac{\text{Projected patient days in year } X}{\text{Occupancy factor (Step } \#6)} \div 365 = \text{beds required in year } X
\]

Beds required in year X are calculated for each D.P.F. category in each hospital and for all hospitals studied. The D.P.F. (bed) categories are: medical/surgical, obstetrics, pediatrics, psychiatric and other. The required beds which are determined may be analyzed within county boundaries by the size of hospital or D.P.F. Similarly, the components of the calculation of beds (average daily census and occupancy factor) can be given in these types of analyses.
Summary

The hospital bed continues to occupy a strategic position in health care planning. It is to the hospital that a great portion of our health costs are directed because of the curative role which they play. Theoretically, the hospital is the most efficient place where a "package" of services and resources can be distributed to the population. This "package" is given inertia when a patient occupies a bed or when the bed is expected to be filled. Goldman and Knappenberger\textsuperscript{51} respond to their own question of allocating beds: "The principle advantage of bed allocation is the potential efficiency to be derived by grouping patients with similar health problems in the same physical area convenient to facilities and the services they require. Patient grouping allows specialization which is particularly good for the specialist." In utilizing one concept for resource distribution such as beds, rightly or wrongly, the task of comprehending the multitude of various interacting parts and resource requirements is reduced to manageable proportions.

However, Ferrer suggests that less time be devoted to focusing upon determination of future levels of resources. Perhaps we should, instead, concentrate on using the available resources in the most effective manner or mix to deal with the problems presented by patients.\textsuperscript{52}

It is evident from the review that various methods and modifications to bed planning formulae have been developed as flexible tools for problem solving. No one method is demonstrably superior based on results; however, models which show refinements such as age-sex utilization rates and clinical service rates are models which display more appreciation for the factors which impact
upon demand: a priori, these models are superior. It is also obvious that some methods are experimental and still must be proven. Regardless of the method used, it is at best a guideline for the planner or decision maker. Walsh and Bicknell\textsuperscript{53} appropriately conclude in their model: "following the determination of beds other relevant issues are considered and further adjustments are made."

Altruistically, the health planner is faced with the task of deciding what level of resources will produce an acceptable standard for both the local and entire population, given that some of his decision factors are subjective in nature. Part of this delicate task relies upon the capabilities of both the model and its user.

\textbf{Planning Studies in Newfoundland Related to Resource Distribution}

Pierce,\textsuperscript{54} in 1967, had this to say about the province's method of calculating bed requirements:

\begin{quote}
In planning for new facilities the Department considers each situation on an individual basis. Although there is no formula or standard such as age-sex breakdowns, occupancy levels, travel distance, past patterns of hospitalization and other factors are taken into consideration.
\end{quote}

Pierce's comment relates to the Department of Health as a planning entity with methods developed within a planning function. Methods can be found in numerous studies commissioned by the Department. Further, an examination of statistics and events leads to a conclusion that there is an implicit model for calculating beds in Newfoundland. Beds set up per thousand population in the province for the years 1960, 1970 and 1976 were 7.9, 7.9 and 7.6, respectively. From 1976 to the present the budget for the Department has undergone tightening. In this same period, other provinces exper-
ienced this constraint and also questioned the appropriateness of existing bed levels. The outcome was a general reduction of beds per thousand population. Newfoundland and other provinces have reduced their bed levels. By March 31, 1978, a rate of 6.4 approved and staffed was the experience for both short term and long term beds. Yet, Pierce's original observation remains, in part, to be true. There is no formalized model within the department.

Pierce made reference to the Brain Commission Report of 1969. The Brain Commission used an analogy method with other provinces and the Canadian average to establish a bed rate of 8.0 beds per thousand population. At that time money was plentiful; therefore, expert opinion and statements of what ought to be could be entertained.

A similar analogy method was adopted in Outline of Mental Health Services, 1973. The psychiatric bed rate in Nova Scotia of .4 short term and .6 long term was multiplied by a projected population for each region in the province. In this determination of rate, both the census and occupancy of each region was surveyed. Dr. Rowe, in a presentation to a Geriatric Symposium in 1975, used both ratio and analogy to show the geriatric needs of the Newfoundland population. The proportion of types of geriatric beds expressed as a percentage of total beds in an English County was applied to the estimated beds in Newfoundland.

Between 1973 and 1974 the Health Planning and Development Committee published a general overview and three reports which dealt with 21 health statistical districts in Newfoundland. A great deal of discussion in these reports fell upon the determination of bed requirements. Liberties had to be taken in interpreting the
methodology as there was no statement of procedure. Numerous sub-methodologies were employed. Extended care and psychiatric care beds were projected as a standard ratio to the population. Aggregate beds were projected in the same fashion but there were assumptions of both time and distance. Beds in use were surveyed to determine the number of beds which could be assigned to a level of care (e.g., acute, convalescent). These bed calculations (factors) were combined with a central methodology to provide a final estimate of beds. At the core of the calculation are two bed estimations: surgical and non-surgical. In very simple terms, the calculation involves the multiplication of cases, length of stay and occupancy factor.

A study, developed by the Department of Health Planning Division, deals exclusively with the current bed to population technique of distribution. The bed ratio is applied to projected population (aggregate) by health statistical district. In a number of cases the bed determination is adjusted in the future according to future expectations of health delivery and according to rates established in previous studies. Beds are estimated for 1981, and on paper it is the furthest projection available. As 1981 is close at hand, a new set of projections is in order. This study is more important for its underlying work on population projections, the methodology of which has been validated by the Government's Statistical Division. As there was no population figure for the health statistical district or for hospital services area, communities and health statistical districts had to be cross-referenced to census division data. This task was done manually. Consequently, a partial solution to the problem of defining the age-sex distribution of
these health statistical districts had been accomplished.

During 1978, McKinsey and Company conducted a study for the St. John's Hospitals Council. As of July 31, 1979, the final report had not yet been released. The following comments are from working papers. In the "Determining Need/Resource Balances" of Phase I of the project, the key elements for determining health needs were: population projections; morbidity and utilization patterns; the anticipation of changes in methods of care; the measure of needs met by facilities outside St. John's; and forecasting the net demand on St. John's.

This project went beyond previous health care related studies in Newfoundland in its attempt to define and project the age-sex population of three areas. These areas were defined by levels of care (primary, secondary and tertiary) and therefore did not coincide with census divisions. To circumvent this problem, the age-sex composition of the subregions was calculated through the use of a ratio method on census projections. The cross-referencing and population figures for health statistical districts was obtained from the study "Newfoundland and Labrador Population, Part II, 1966/1971." The age-sex projections were at the care level boundaries only.

Also interesting was the method of deriving and forecasting bed requirements. For the St. John's area a utilization rate (patient days per 1000) was calculated for each age and sex through a process of grouping patient days into four services (the computer program was developed by the Newfoundland Department of Health). The grouping was performed on the Canadian 188 Diagnostic Listing. The age-sex morbidity service rates were multiplied by the age-sex
population figures to produce a service need. The average daily census of the hospital was taken into account and subjected to the rationale of the Poisson distribution to determine maximum realistic occupancy rates. The final estimation of bed requirements was calculated by dividing the service specific patient days by 365 and by the maximum occupancy rate.

A clearly defined methodology for estimating bed requirements does not appear to exist at the government level. However, there is an implicit model which utilizes a standard rate. This standard rate appears to be a product of administrative judgement, comparison with rates established by other governments, recommendations from previous studies, dollar constraints, the summation of individualized (hospital) bed requirements and an experiential feeling for the needs of areas. In the opinion of the writer the continuation of this method is fostered by the relative smallness of the system. This smallness has traditionally led to closer contact between administrators and department of health officials. As a result, officials have a practical feel for the needs in areas. Yet there is the question of a stable bed rate over the past two decades. Plausible explanations do exist and these are attended to in the discussion to follow.

Problems Associated with the Distribution of Health Care Resources to Rural Areas in Newfoundland

At least 60% of the Newfoundland population resides in communities classified as rural by size, travel time or distance. The 340,000 rural residents do have problems in attaining a level of health care which has the quality, accessibility and availability of
resources found in the urban delivery system. In many respects, the problems which are experienced in rural areas are the same as those experienced by their larger more organized counterparts. Their difference which is felt is one in degrees.

The problems which arise in trying to deal with rural health care delivery are well attended to in the literature. The philosophical approach which surfaces is that the rural system must be thought of as unique; yet it must be integrated with a much larger urban system which is willing to deploy resources to solve rural system problems without jeopardizing the rights and needs of the rural population. This type of approach requires a continuing flexible and innovative management and planning style.

The problems associated with rural health care delivery are given below in a combined and generalized form. These are not meant to be inclusive; instead they form the bases of discussion in Appendix A.

Appendix A presents a more detailed discussion of these listed traits and also describes relevant examples applicable to the rural setting in Newfoundland.

1. Recruitment
2. Educational maintenance
3. Environment (public health, social, geography, etc.)
4. Population structure
5. Leadership and organizational activities
6. Imposition of other system standards
7. Economic base of community
8. Attitudes towards cooperation
9. Economic dependence on delivery system
10. Methods of financing
11. Misuse of professional time
Chapter III

Footnotes


8. Ibid.


15. Shonick, pp. 118-137.


MacStravic, *Determining Health Needs*, pp. 73-75.


Cardwell, pp. 107-111, 181.


Feldstein, pp. 369-381.


Ibid.

McLain, pp. 378-393.


Shonick, pp. 118-137.

Weckworth, pp. 52-54.

Blumberg, pp. 75-79, 80-81.

40 Shonick, pp. 118-137.

41 Donabedian, pp. 532-639.

42 Meeting of Planning and Research Directors, Atlantic Provinces Departments of Health, Halifax, 24 November 1978.

43 Donabedian, pp. 532-639.


45 Navarro, pp. 573-581.

46 Umenyi, pp. 1-74.


48 Brooks and Beenhakker, pp. 47-50.


50 Donabedian, pp. 532-639.


53 Ferrer, pp. 186-197.


57 Mental Health Services Division, *Outline of Mental Health Services in Newfoundland*, Newfoundland Department on Health, 1973.


66. Ibid.


70. Black, pp. 91-95.
CHAPTER IV

METHODOLOGY

Research Strategy

There were a number of very influential factors which contributed to the design of both the study and its component methods. The timing and need for a new set of bed estimates was appropriate because the only estimates available to the Department of Health were for a period ending in 1981. The method that was used by the Planning Division was a bed to population ratio projected into the future. Both opinion of the writer and of authors reviewed in the literature, predisposed the writer to attempt a design of a bed prediction model that was more analytical in defining local needs.

Through involvement with various studies during 1978 and 1979, in the capacity of supplying data to requests by planners and researchers, it became increasingly apparent that one very vital data file was missing for planning and research. This file was the age-sex population structure for the health statistical districts. This view was not only supported by epidemiologists and researchers but the Department of Health was very interested in obtaining age-sex data for these population units. Beyond this, the Department needed the age-sex data quickly because it was in the midst of planning for the operation of Nursing Home facilities in the province.
The underlying premise was therefore to construct a design which rested upon assumptions of what ought to be; it had to incorporate statements of accuracy or ranges among standards so that the reader or decision maker could adjust results or methods to deal with the problem at hand.

During 1978, McKinsey and Company conducted a study of needs for the St. John's Hospitals Advisory Council. A number of computer programs were developed by the Department of Health to collect data for their requests. As the present study evolved, it became evident that one of the programs could be utilized very effectively if a few modifications were made to it. In addition, the parameter of an age-sex population solution for the health statistical districts could be easily incorporated into this program to predict future bed requirements. In this sense, the design of the study unfolded naturally and was also the important consequence of need. The methodology (being more analytical) was considered to be an enhancement over the previous bed to population method. This opinion could not be left unchallenged.

Common and vital to each method was population growth. The bed to population method considered only aggregate population whereas the present study considered the growth of the population as comprised of age and sex movements. The design of both the methodology and the study, therefore, had to focus upon comparison of methods by showing if there were any effects of the age-sex structure movement upon the allocation of total acute care beds or acute care bed types. In so doing, the problem of providing current and projected age-sex populations to the health districts was also satisfied.
Research Setting

The study was conducted between July and December of 1979 in the Province of Newfoundland and Labrador. The focus of the study was upon health statistical district for population projections and upon health regions in the calculation of hospital acute care beds. Neither hospitals nor health districts were surveyed directly for data. Instead of the majority of the data was retrieved (or generated) from Department of Health data files.

Data Sources

In some cases it was very difficult to locate methods or materials. Consequently it is important that some of the data sources be explicitly stated so that future studies will have an easier time in data collection.

Universal Transverse Mercator (U.T.M.). This is the technical name of a system of coding health statistical districts and communities. There is an internal program available from Statistics Canada, CANSIM Better Use Development Division, Ottawa which cross-references with the census code file. Cross-reference codes can also be obtained from the Department of Health Planning Division prior to and following the major census division and subsequent changes in 1966 through the reports entitled: "Newfoundland and Labrador Populations: 1961, 1966, 1971, 1976 Health Statistical Districts" and "Newfoundland and Labrador Populations: 1961 and 1966 Health Statistical Districts."\(^1\)

Census Data Tapes. Both Central Statistics Division, Executive Council, Government of Newfoundland and the Geography Department
of Memorial University have 1976 and 1971 census tapes.

Hospital Inpatient Morbidity. Data is coded and stored on tape by the Statistics Division of the Department of Health. Two coding schemes are employed: the International Classification of Diseases, Eighth Edition, and a collapsed version, the Canadian 188 Diagnostic Listing (C-188).

Population Figures. Both census and projections are available from Statistics Canada publications or from the census tapes mentioned previously.

Length of Stay and Inpatient Morbidity Rates. Both types of data are available from Statistics Canada Publications and from the PAS Professional Activity Study, Commission on Professional and Hospital Activities publications on length of stay. The Statistics Division also produces the C-188 by length of stay and separation for age and sex.

Methods of Collecting Data

Sorting of Codes

As a major effort had been made at cross-referencing census divisions and subdivisions to the health statistical district, it was decided to utilize this work for the benefit of the present study. From the cross-reference which was available, each census community was transposed by age and sex to its appropriate health district. Each community's population was compared to the population figures provided in the original sort.

As this transposition was being conducted, the inclusion of
each community and enumeration area was checked against a Newfoundland map of Health Statistical Districts. This procedure was carried out for 1971 and 1976. Transposition error was expected. Normally this error reaches approximately 5%. The error rate which was employed for this study was that the summation of hospital district totals would not exceed the thousandth of a percent error when compared with the Census for Newfoundland. This criteria was met and was intended as a reliability measure for future researchers. In discussions with demographers the criteria established was very acceptable.

Population Projection Method

The final choice of method was the short form of the Ratio Method with a refinement which is suggested in the literature review. The ratio refinement was an observed change in the local age-sex specific population between two periods over an observed change in the provincial age-sex specific population between two periods. This ratio allows not only absolute change but it also allows an age-sex group's percentage of the total population to increase or decrease. The choice in using this refinement was, therefore, the reason for rejecting other ratio methods. The short form describes a method of calculating local populations against a national total instead of calculating through a hierarchy of levels.

The Cohort-Survival Method was considered as an alternative. However, the degree of detail required for the local level combined with an absence of current and available age-sex specific (and by local area) vital statistics, survival rates (the inverse of mortality), and fertility or migration rates pointed to the choice of
another model. The users of the cohort-survival method gave it a medium range of projection when compared to other methods. In other words, its accuracy in the short run would not be substantially better than that produced by other methods. However, in the long run this model would be expected to achieve better results than simpler methods such as arithmetic, geometric and ratio. A priori, on analytical grounds this model with good assumptions should produce superior results. These comments were confirmed in the literature review and in discussions with demographers within the Government and at Memorial University. In describing the problems to be overcome, such as the sorting of two codes and the lack of available specific data, the ratio method was considered a logical choice. A short term projection was chosen because it increased the accuracy of the projection.

The ratio method through the use of an independent and available set of provincial age-sex population projections considered the factors required of the cohort model in one figure. However, the difference is that the cohort model allows various choices in any one of the factors even though the estimate may be the same. Using the projection from Statistics Canada limits choice. Projection number 4 from Statistics Canada was used to project the health statistical districts. The components of the projection expressed as rates per 1000 populations for the projection period of 1976-1986 are:

- births - a downward shift from 19.6 to 18.7
- deaths - a slight upward shift from 6.2 to 6.3
- net migration - a decline from 4.2 to 3.5
- natural increase - a decline from 13.4 to 12.4
- total increase - a decline from 9.2 to 8.9
Concerns about the effects of migration were brought forward in the literature review. The original plan to consult knowledgeable municipal planners or hospital administrators in the various health statistical districts was rejected. It was felt by demographers that local estimates of migration would be biased. Choosing the ratio method and the projection figures from Census Canada meant that migration was already being considered in the population. The point that should be considered regardless of the approach taken is that small population projections do suffer from inaccuracies which arise in part from the sometimes unpredictability of a population's migration. Irregardless of the estimated accuracy of the population projections within this present study, the reader should be aware of potential inaccuracies.

A very key consideration with the projections is that Statistics Canada employs random rounding. All numbers end in 0 or 5. Any number can be exact or plus or minus 5; therefore, the range of values for any number is 10. Similarly, the projections were expected to show greater deviations from census values or wider fluctuations in the amount of error when smaller populated health districts were projected. By the very geographical nature of the province and varied population densities error rates were expected to differ. To give the observer an estimate of error that might be contained within the study's population projections, the ratio method was tested on a historical data set between 1966 and 1971. This 5 year base was projected to 1976 and then compared against the actual census figures for 1976. The methodology for estimating error is discussed under a separate title in Chapter V.

The following formula was used to calculate the age-sex
population projection for each health district. This formula was derived from the sense given to definitions in the literature review. As implied, a definitive formula was not found.

Step I. Age-Sex specific projection within a health statistical district.

\[ \text{Phas}_{t+n} = \frac{\text{Phas}_t - \text{Phas}_{t-n}}{\text{PNas}_t - \text{PNas}_{t-n}} \times [\text{PNas}_{t+n} - \text{PNas}_t + MA] + \text{Phas}_t \]

where \( \text{Phas}_{t+n} \) = age-sex specific population of the health statistical district for future year;

\( \text{Phas}_t \) = age-sex specific population of the health statistical district for base year;

\( \text{Phas}_{t-n} \) = age-sex specific population of the health statistical district for past year;

\( \text{PNas}_t \) = age-sex specific population of the Newfoundland projection for base year;

\( \text{PNas}_{t-n} \) = age-sex specific population of the Newfoundland projection for past year;

\( \text{PNas}_{t+n} \) = age-sex specific population of the Newfoundland projection for future year;

\( MA \) = migration adjustment if necessary

\( n \) = number of years from base year

\( t \) = base year

\( as \) = age-sex interval

Step II. This formula was repeated for each age-sex interval to structure the population in each health statistical district.

Step III. Totals were calculated for age interval (male and female) and for each sex (all age intervals) and a total population in each health statistical district was presented.

Step IV. Steps I, II and III were repeated for the second and final year of the projection period.

Step V. For each projection year, the age sex intervals were summed for all health statistical district within a health region.
Hospital Inpatient Morbidity Computer Program

This program was developed to retrieve the number of separations and total days stay by age and sex groups. The separations were clustered in groups of diagnoses which have been coded to the Canadian Diagnostic Listing (C-188), a collapsed version of the Eighth Edition of the International Classification of Diseases.

The program was modified to subtract out all patients under 15 years of age except those in an obstetrical diagnostic category. Further modifications were employed to express the clustered separations (age and sex) in age-sex specific rates per 100,000 population and clustered total days stay (age and sex) in age-sex specific lengths of stay.

The diagnostic clusters and the diagnostic code numbers are given below:

- **Pediatrics (15 years)**
  - C-188 List: 1-135; 146-188.
- **General Medical and Surgical**
  - C-188 List: 1-51; 60-135; 146-188.
- **Obstetrics**
  - C-188 List: 136-145.
- **Psychiatry**
  - C-188 List: 52-59

By utilizing the computer program an important assumption was made. The diagnostic cluster not only represented morbidity categories, it also implied an equivalent resource unit. This contrasts with a bed rate to population calculation which assumes a specific type of resource for the entire population. In other words, this study defines a need and then presumes a certain type of resource is needed. A second assumption arises and is similar to Blumberg's Distinctive Patient Facility. For the diagnostic clusters there is only one type of resource which can be used. If all the diagnostic coding was correct, a more precise statement of
needs to service is expected.

The data's quality was judged to be valid and reliable, albeit a biased view. This view stems from the writer's knowledge of the 1976 morbidity file, its preparation edit and final acceptance by Statistics Canada. There were no queries from Statistics Canada and the staff responsible for its preparation were satisfied that the file was internally consistent with past experience. This file has been in production for two years and has been accepted by researchers. Even if Newfoundland's data departs from the National experience departure may be one of circumstances and standards. The question that finally surfaces is whether these standards, which are judgemental, are right or wrong. Use and acceptance of the file does not necessarily mean that it is reliable and/or valid. Instead a degree of credence can be lent to the file.

The data was calculated for institutions which deliver acute care. Four hospitals were excluded from the study because they are dealing with long term care: Waterford (Mental Health), St. Patrick's and St. Luke's Nursing Homes, and the Children's Rehabilitation Centre. Therefore, the total number of hospitals was 44. The data (diagnosis) was sorted by residence or origin. A sub-methodology was established to account for referral patterns between regions or health statistical districts.

The referral program sorted each patient by the health region of origin and region in which the patient was treated. The patient's diagnostic cluster, age-sex and total stay were identified within each region of treatment and summarized to the four referral regions.

The morbidity data by origin was converted to a rate in the population and applied to population projections for the areas of
concern. Both bed service patterns and referral patterns were combined in each of the projection years to provide a realistic statement of bed needs for a given region. If this procedure had not been carried out, the referral pattern would have been erroneously related to population in which treatment occurred. The more logical approach was to base the pattern upon shifting populations; populations from which the patients originated.

Both programs were run on the 1976 Hospital Inpatient data file.

Manual Tabulation of Bed Categories

To compare the bed to population method with the study's prediction of beds which led to a statement of the age effect upon beds, the Annual Returns of Hospitals for 1976 were consulted for the 44 hospitals. Each of the hospitals was assigned to a health statistical district and to a health region. Beds in this study are defined as "staffed," that is, a bed which is actually available for patient accommodation and for which staff is available whether or not actually occupied. This bed would be comparable to the bed services which are fully utilized, the bed categories are:

Medical and Surgical Undistributed
Psychiatric
Obstetric
Pediatrics

Method of Analysis

Bed Prediction Formula

The literature review pointed to a variety of methods which could be used to predict beds. Three particular examples were
described in detail because they represented methods used currently and were also methods designed to meet local or specific needs developed at a higher administrative and policy level than the hospital. These methods did not influence the present study's design but do confirm the approach which evolved from the interaction of the problems.

The study's bed prediction model is in fact a statement with many standards. Morbidity rates by age and sex are assumed to be realistic and are held constant through the prediction period. Similarly, length of stay was held constant. The occupancy factor for each bed service was decided upon by a combination of use rates, standards in the literature review and opinion. More important is that each assumption relates to a region; therefore, provincial standards are the summation of these. The standards that are utilized are unique to this study and are not meant to be interpreted as policy statements for the province. Instead the study and design, as previously stated, was intended to provide a base for making decisions.

The bed prediction formula calculated the required beds for each age and sex by diagnostic cluster and region. Note that populations by age and sex were calculated at the health district level and summed to the regional level. The bed prediction required two major steps: one step related to all bed service requirements; the other related to making adjustments to account for referral patterns between regions and the understatement of demand (which is presented through the use of separations).

The bed prediction formula which was utilized to calculate age-sex beds for each diagnostic service is given below:
BSR as = Bed Service Requirement, age-Sex Specific

DSR as = a ratio of separations by age and sex over the corresponding age-sex population which has been adjusted upwards to reflect the admission rate

PP as = Projected Population; Age-Sex Specific

DSR as = Diagnostic Hospital Morbidity Rate; Age-Sex Specific

ALSD as = Average Length of Stay, Diagnostic Age and Sex Specific

BD = Bed at 100% Occupancy; therefore, 365 Days

O obr = Stated Occupancy Level for Bed Service

This calculation was repeated for the three census years in the projection term 1976, 1981 and 1986 for each region.

To accommodate the referral patterns, patients treated in each region (4) were subdivided by their point of origin (4 regions). This subdivision was carried out for each bed service. A total days stay rate was established for each bed service within a region by point of origin. This rate was applied to the projected population appropriate for the year and region of origin. Through the formula given below the final product was a statement of referral beds which was then added to or subtracted from a given region to reflect the logical movement of patients. This calculation was not necessary to demonstrate the change in bed requirement in respect of age-sex population changes, but it was consistent with the logic of bed estimation for regions. A bed service was then calculated by the following calculation:
where \( BSR_{as} \) = Bed Service Requirement, Age-Sex Specific

\[ BSR_{as} = \frac{TDS_{bas}}{365 \times O_{obsr}} \]

\( TDS_{bas} \) = Total Days Stay by Bed Service; Age-Sex Specific

\( O_{bsr} \) = Occupancy Level for Bed Service

The identified bed was then subtracted from the region of origin and added to the region of referral in the corresponding categorization. This calculation was not necessary to determine the changes in the age sex population in respect of bed requirements.

The understatement of demand (separations) was corrected by using regression analysis. Eighty-eight (covers 2 years) observations of separations and admissions were regressed to estimate the coefficient of \( X \) (separations).

**Estimation of Error Associated with the Ratio Population Projection Technique**

There were two reasons in support of testing the ratio method. First, very few articles, in recent times, examine and report on the method’s accuracy. Second, the method has not been used on health statistical districts prior to this study. Consequently, there is a need to give the decision maker some idea of accuracy so that he/she might adjust the final figures which are presented. The methodology for estimating the error associated with the use of the ratio projection technique is discussed separately in Chapter V so that the methodology can be clearly separated from the methods which lead to the prediction of beds. This separation will also focus attention to the evaluation of a population ratio projection technique, which is a subject that many researchers feel should be attended to when making projections in this day and age.
The findings and discussion of results will follow in Chapters V, VI and VII. Chapter V will present the methodology and analyze the estimated error associated with the use of the Ratio Projection Method and indicate the degree of error that can be expected in the projections of various sized population bases. Chapter VI will analyze both the present and future age and sex related populations of each region and for the province as a total. Chapter VII will analyze the bed service requirements for each region and the province relative to the changing population structure. Chapter VII will highlight the major limitations of the model and the highlights from each of Chapters V and VI. The relevance of the study to future planning in Newfoundland (Rural) will be discussed. Finally, future applications of the study will be examined.
Chapter IV

Footnotes


2 Ibid.

3 Personal communication with Mark Shrimpton, St. John's City Council, September, 1979.

4 Personal communications with demographers Dr. A. Alderdice, Memorial University; and Mr. George Courage and Mr. Hugh Riddler, Central Statistics Division, Newfoundland Government, September 1979.


6 Ibid.

7 Alderdice and Courage, personal communications.

CHAPTER V

ESTIMATION OF ERROR ASSOCIATED WITH THE USE OF THE RATIO METHOD

Introduction

It was noted previously in the literature review that more attention should be given to the estimation of error contained in population projection. This error can be calculated in a number of ways. The more direct and precise method is to compare the projected populations to their forthcoming actual census values. This tactic requires a waiting period and necessitates the selection of projection years which are census designates. Given reasonable assumptions, this population projection will stand until it is evaluated at some future period. An alternative approach is to apply the projection's methodology on a data set from the past, and project a population to a census year in the past. Estimating the error by following this latter approach has very distinct advantages. It provides the researcher with a practical feel for both the data and methodology. The estimate of error, in turn, would provide the user with an opportunity to accept, reject or modify the population projections which are being observed. The researcher would also enjoy the vantage point of being able to modify the projection approach based upon his own practical observations. Finally, this approach allows for a more rigorous evaluation of the method. If
it is combined with projection years which correspond to census years, the methodology can be evaluated before and after, and the preliminary estimation of the error itself can be evaluated for validity and reliability.

Assumptions

The ratio method was reviewed in detail in the literature review. The acceptable level of error which was established was an absolute mean of 10% or less for a projection of 10 years or less. A priori, a shorter projection period should give the expectation that the absolute mean error would decrease. The error is calculated by dividing the difference between the values of a projection year and its corresponding census year, by the value of the census year. The ratio is then converted to percent. In cases reported in the literature where the data conforms to suggested guidelines, the population bases were very large; that is, they were in the millions. In addition, these cases often projected total populations. These two conditions tend to decrease the error rate. Therefore, and in direct comparison with this study's projection of very small populations by age and sex intervals, a higher error rate may need to be accepted. Notwithstanding this opinion, the acceptability of the upper limits of the absolute mean error is totally dependent upon the use to which the population projection is being applied in the planning function.

The acceptable level of error should also be reviewed in relation to the property of single estimator of population to produce extreme values. If these extremes are expected then it becomes obvious that some form of prudent manipulation is required. Conse-
quentely, the overall estimate of error would be lower. Alternatively, it infers that the majority of errors encountered are very acceptable. In other words, the decision to accept or reject the projections should not fall solely upon a strict guideline of 10%. However, this guideline of 10% represents the experienced opinion of researchers and should carry considerable weight.

The population data from which the error was calculated was adjusted as little as possible. Mathematical signs were followed with the exception of four observations which had to be adjusted. In each case the magnitude and direction of change were the influencing factors. Two cases had negative populations. These were adjusted to a state of no change. When compared with census values the resultant error was reduced to zero. In the remaining two cases the direction of change was both illogical and large. These two errors were reduced from approximately 100% to 12.5%. The choice of following mathematical signs (versus logic) rested upon the opinion it would provide a clearer path for replication. It would also provide a potential user with a data set which would not have to be decoded. The use of logic may enhance the projections but it also suggests a state of imprecision.

The data provided by Census Canada has some error built into it. Through the process of random rounding, all numbers are rounded either upwards or downwards to 5 or 0. This error is negligible with very large populations but it is clearly visible in small population bases. A rounding error of 4 on a base of 100 or 50 yields an error of between 4% and 8%. In some situations a total population might be 30 yet the intervals may add to 15 or 45. On occasion when the ratio method is used, there are zero growth rates in these intervals when it is evident that such is not the case.
Method

An alternative strategy was developed to test errors associated with the ratio population projection method. Between 1966 and 1971 numerous census subdivisions underwent boundary changes. The task of providing equivalent units for comparison would be complex and difficult, particularly in trying to organize to the health statistical district area. While subdivisions changed, the census division remained stable during this period. Each census division was comprised of 22 age-sex intervals. Thus, for Newfoundland, there are 10 census divisions and a total of 220 age-sex intervals. The chosen and alternative strategy was to view each of these age-sex intervals as a district population base. In so choosing, and in the context of Newfoundland's smaller populated communities, the ratio method can be viewed as operating in a situation which is expected to give extremes of high variance and higher absolute mean errors.

The error was calculated for these 220 age-sex intervals. One hundred and ninety-three of these intervals had a population base under 3000. To provide a more precise estimate of error, that is, for larger population bases, the 220 intervals were compressed to 3 age intervals (sex combined). For this compressed set the estimate of error was calculated. Further in this attempt to provide a picture of error in larger populations, error was calculated for the total population only (both sexes) in each census division.

The estimate of error was also calculated in two ways. First, it was derived from sampling. Second, it was derived by considering the entire data set. The reason that the entire data set was presented was because it was not costly in time to do so and
because it was anticipated that a large sample would be required. The large sample was expected for the populations under 3000 because the variance was anticipated to be large and in the remaining intervals over 3000 there was very little effort required to use the total number of values.

The total sample was 94 and consisted of: 83 from the 0-2,999 stratum; 5 from the 3,000-9,999 stratum and 6 from the 10,000 and over stratum. The methods used to determine the sample size are given in Appendix B.

The basic scheme for the stratification of population and presentation of error is:

<table>
<thead>
<tr>
<th>Stratum</th>
<th>In certain situations the stratum are combined to</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2,999</td>
<td>3,000 - 9,999</td>
</tr>
<tr>
<td>10,000 - 24,999</td>
<td>25,000 - 49,000</td>
</tr>
<tr>
<td>50,000 - 74,999</td>
<td>75,000 +</td>
</tr>
<tr>
<td>10,000 +</td>
<td></td>
</tr>
<tr>
<td>25,000 +</td>
<td></td>
</tr>
<tr>
<td>50,000 +</td>
<td></td>
</tr>
<tr>
<td>75,000 +</td>
<td></td>
</tr>
</tbody>
</table>

It has been stated that the ratio method is expected to produce extreme errors. This being the case, there should be higher than normal distribution of errors at both tails of the distribution. As part of the methodology the estimation of error presented in the sampling was transformed using the Arcsin percent. The Arcsin percent transformation should pull the extreme values towards the mean; that is, it should normalize the data. In other words, the real question which is to be proposed is whether transformation assists in the analysis of this type of data.

Although obvious, the absolute mean error is far more important in determining the character of the error. The mean with signs considered is not an appropriate figure to examine because positive
values tend to cancel out negative values. Therefore the mean will approach the value of zero.

The estimation of error is presented through the following statistics: the absolute mean error, the standard error (SE) of the mean, the confidence limits and the number of errors under or equal to 10%.

As noted previously in the methodology there was a suggestion that the random rounding process was biased. To test this observation, 594 observations were restructured to a 3x2 contingency table and subjected to a Chi Square analysis. See Appendix C.

Finally to test error in relation to population size two statistical procedures were performed. The count of errors of 10% or under were compared with population size in a contingency table. The expected conclusion was that there would be a relationship such that the count of errors under or equal to 10% increased as population size increased. To examine the relationship between the size of error and population size, errors were plotted according to population stratum to first determine the array of points. Aggression or correlation was expected to be carried out.

Results

Table V-1 gives various presentations of the estimates of error associated with the use of the ratio projection technique. The variety of tables stems from both stratification and organization of the age-sex intervals. Table V-1A describes the estimate of error based upon sampling. From a sample of 94, the mean absolute error was 12.0% ± 1.6 (SE). As the population size increases, the mean absolute error is reduced from 13.0% to 5.2%. Thus it would
Table V-1

Estimation of Errors Associated With The Ratio Method\(^a\)

A. Age Sex Intervals (based on sampling)

| Stratum      | N  | |M|  | S.E. | No. Errors ≤ 10% |
|--------------|----|----|----|------|------------------|
| 0 - 2,999    | 83 | 13.0% | 1.8 | 51   |
| 3,000 - 9,000|  5 | 6.32  | 2.6 |   3  |
| 10,000 +     |  6 | 5.2   | 2.1 |   5  |
| Total        | 94 | 12.0% | 1.60| 59   |

B. Three Age Intervals\(^b\) (for 10 census divisions)

| Stratum           | N  | |M|  | S.E. | No. Errors ≤ 10% |
|-------------------|----|----|----|------|------------------|
| 0 - 2,999         |  9 | 9.7% | 2.9 |   6  |
| 3,000 - 9,999     |  2 | 10.8 | 6.3 |   1  |
| 10,000 - 24,999   | 15 | 7.0  | 2.0 |  12  |
| 25,000 - 49,999   |  3 | 4.7  | 1.4 |   3  |
| 50,000 - 74,999   |  1 | 4.6  | -   |   1  |
| Total             | 30 | 7.4  | 1.4 |  23  |

C. Total Populations (for census divisions)

| Stratum           | N  | |M|  | S.E. | No. Errors ≤ 10% |
|-------------------|----|----|----|------|------------------|
| 25,000 - 49,999   |  8 | 5.1% | 1.1 |   8  |
| 50,000 - 74,999   |  1 | 3.4  | -   |   1  |
| 75,000 +          |  1 | 2.3  | -   |   1  |
| Total             | 10 | 4.6  | 1.0 |  10  |

D. Age-Sex Intervals (by census division)

| Stratum       | N  | |M|  | S.E. | No. Errors ≤ 10% |
|---------------|----|----|----|------|------------------|
| 0 - 2,999     | 193| 13.2% | 1.3 | 123  |
| 3,000 - 9,999 |  14| 5.5   | 1.4 |  10  |
| 10,000 +      |  13| 6.5   | 1.8 |   11 |
| Total         | 220| 12.3% | 1.2 | 144  |

\(^a\)Ratio method was used to project a 1976 population from a 1966-1971 base (22 age-sex intervals times 10 census divisions). Projected values compared with corresponding census values for 1976 gives error expressed as a percent of the 1976 census value.

\(^b\)Compressed age intervals: 0-14, 15-64, 65+; 3 intervals per division.
appear, superficially, that a relationship existed between the size of the population and the size of the error. Indirectly this is also suggested by the proportional count of errors in each stratum under or equal to 10%. However, the only reliable figures expressed are those from the 0-2999 population stratum because there is a sufficiently large number of observations.

The sample results in Table V-1A compare reasonably well to the total data set estimated in Table V-1D. Two hundred and twenty observations yielded a mean absolute error of 12.3% ± 1.2. The rate of errors under or equal to 10% was .65 (144/220). This is similar to a rate of .63 established in the sample. Tables V-1A and 1B also suggest a relationship between population size and either error size or proportion of errors under or equal to 10%. While the number of observations decreases with population size, the standard deviations indicate that the spread of values around the mean decreases as the population size increases.

This decreased spread of data is reiterated in Tables V-1B and 1C. In Table V-1B, the age-sex intervals were compressed to three intervals before projection. The error estimated for 30 intervals was a mean absolute error of 7.4% ± 1.4. The rate of errors under or equal to 10% was .76 (23/40). For each stratum over 10,000 population, there was a far greater proportion of errors under or equal to 10% than in the preceding strata. Table V-1C, for the total population, gives the same picture. There was higher precision. However, the number of observations is very low. The mean absolute error of the total population is 4.6% ± 1.0 and all errors were under or equal to 10%. If aggregation of the data is performed prior to projection, the precision of the projection should be generally enhanced.
While it is both relevant and interesting to be comparing errors for small or large populations, the real and practical estimates for evaluation fall upon the 0-2999 stratum. This stratum characterizes much of the Newfoundland population. Therefore, the estimates of variance and the consideration of extremes for this stratum should weigh heavily upon the decision to accept, reject or modify the population projections. This designated importance should mean that this strata should be analyzed independently.

Based upon a sample (Table V-1A), the absolute mean of the 0-2999 stratum was 13.0% ± 1.8. The number of errors equal to or under 10% was 51, for a rate of .54. Within the estimates of the total data set (Table V-1D), the mean for this stratum was 13.2% ± 1.3. In examining this stratum within the total data set two stratagems were followed. First, two census divisions (44 observations) which are considered economically unstable and disadvantaged were subtracted from the 193,0-2999 population observations. The absolute mean declined from 13.2% to 10.5% and there was a subsequent reduction in the variance. By eliminating questionable data, 77.2% of the data fell within the 10% guideline.

If as has been suggested, extreme values are modified individually, a far better estimate of the usefulness of the projections is obtained. For a rule of thumb the 10% guideline could be doubled to 20%. If these extremes are subtracted from the 103 observations of the 0-2999 stratum (Table V-1D), the absolute mean error drops from 13.2% ± 1.3 to 6.4% ± .41. Eighty-one percent of the data is considered to be contributing to the acceptable guideline of 10% (see Appendix D). When the modified extremes are incorporated into the data the obvious outcome is a probable and full set of observa-
tions which meet the acceptable criterion. The main observation in these two exercises, as expected, is that the extremes do influence the estimation of error for the entire data set. Despite this influence of extreme values, the ratio method is appropriate for 80% of the age-sex intervals in the lower population classes. Although the ratio method has been evaluated on larger population bases, it can be applied, with due caution, to lower population bases.

Table V-2

<table>
<thead>
<tr>
<th>Arcsin $\sqrt{\text{Percent Transformation of Error Estimates}}$</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated with the Ratio Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on Sample)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Transformed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{S.E.}$ before retransformation for stratum are 1.4, 3.1, 2.8 and 1.25 respectively</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| $\text{S.E.}$ before retransformation for stratum are $18.4\%$, $7.0\%$, $6.8\%$ and $17.7\%$ respectively |

Table V-2 compares original interpretation and transformation of the sample estimates of error. The original sample has an absolute mean error of $12.0\% \pm 1.6$. The 99% confidence limits are $8\%$ (lower) and $16.1\%$ (upper). The transformed sample has an absolute mean error of
17.7° ± 1.25. Upon retransformation of Arcsin \( \sqrt{\text{percent values}} \) the confidence limits become 5.6% and 13.7% while the mean error is 9.2% ± 1.25. The transformation of the data presents a very optimistic picture; that is, it presents a lower estimate of the error. However, in terms of the transformation normalizing the data, it suggests that the body of the projections will tend to fall under or hedge around the 10% guidelines because transformation minimizes the influences of extremes on the mean. The view as presented by transformation parallels to some extent the manipulation of the original data set in which the errors greater than 20% were eliminated from the 0-2999 stratum.

The transformation of the error estimates for the two larger population strata does not enhance the analysis. The retransformed absolute means are 1.5% and 1.4%. The 99% confidence limits are far narrower than for the non transformed estimates. The retransformed means are too low and not representative of the errors displayed in these strata. For example, if a weighted average (elimination of 2 high and 2 low values) was considered, the estimated absolute mean of the 3,000-9,000 and the 10,000+ strata would be 4.8% and 3.1%, respectively, a decrease from 5.5% and 6.5%.

The preceding paragraphs showed that the use of the ratio projection method leads to a wide range of errors and to extreme values. Transformation pulls in the extremes toward the mean and therefore tends to hide them from the observer. Statements presented without transformation are more practical and useful. It is important to be aware of extreme values so that demographic adjustments can be made. Transformation, therefore, has low diagnostic abilities when anomalies occur.
The tables which have been presented appear to demonstrate two relationships with population size. First, the proportion of errors $\leq 10\%$ increases as population size increases. Second, the size of the error tends to get smaller as the population size increases.

To test the relationship between population size and proportion of errors above and below 10\% a contingency table, Table V-3, was constructed as follows:

Table V-3

<table>
<thead>
<tr>
<th>Error Size</th>
<th>0-2,999</th>
<th>3,000-9,999</th>
<th>10,000 +</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 10%$</td>
<td>123 (64%)</td>
<td>10 (71%)</td>
<td>11 (85%)</td>
<td>144</td>
</tr>
<tr>
<td>$&gt; 10%$</td>
<td>70 (36%)</td>
<td>4 (29%)</td>
<td>2 (15%)</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>193</td>
<td>14</td>
<td>13</td>
<td>220</td>
</tr>
</tbody>
</table>

$X^2 = 2.6; \quad X^2 = 9.2 < P \cdot (.01)$

The relationship that the proportion of errors under or equal to 10\% would increase as population size increased was not supported by Chi Square analysis ($P (X^2 = 2.6) > 0.25$). To compensate for low cell frequency the data was collapsed to a 2x2 contingency table. Again, the relationship was not supported.

To test the second relationship between the size of error and population size, the errors were plotted against the population strata to first determine the array of points. The graph of points is presented in Appendix E. The relationship between size of error and population size was not suggested by the array. The form of the data is horizontal with high variation at low population levels and
low variation at high population levels.

Yet, conclusions can be reached. It appears that as the population size increases the range of values to the errors decreases. There is also the appearance of a random dispersion to the errors in each stratum. This implies that it is the demographic characteristic of the population which is producing the variation in error and extreme values. More importantly, this finding suggests, that for each area being projected by the ratio method, that a demographic and complementary data file should be developed and used to support necessary adjustments to extreme values. With demographic adjustments to extreme values, the ratio method not only produces an acceptable level of errors ≤ 10% (.80) the method does not appear to influence the error. In the context of a province characterized by communities with very low populations, and in situations where demographic data is lacking, the ratio projection method can be utilized. The ratio method can, with due caution, give projections which have an acceptable level of precision for planning.
Chapter V

Footnotes


4 Freese, pp. 28-36.
CHAPTER VI

CHANGES IN BED REQUIREMENTS IN RESPECT OF POPULATION CHANGES

Introduction

The purpose of this study was originally intended to be both practical and experimental. Various subgoals which were identified are each as important in their own right as the end product. This study is the first major use of inpatient morbidity files in recent years. The primary activity related to these files has been the collection of data. It is only through practical use of the files that the appropriate types of data for planning can be determined. As was stated previously, in support of a health planning data base, this study has generated a very important population base which can be refined in the years ahead. As useful planning tools the Department of Health has two which it can evaluate: the Ratio Population Projection Method and the Bed Prediction Model.

Yet the key point to be demonstrated in the findings is a statement that bed requirements should be derived in a more analytical way. This study's method is expected to assign beds to service and regions in a more appropriate manner. A priori, there is the expectation that this method will be promoted for use in the province. In so stating in the probable and future tense there is an implication that even the present method may not in fact be promoted from
findings.

Methods

The method of projecting the population and predicting bed requirements has been detailed in Chapter IV entitled Methodology. The bed prediction model briefly involved projecting inpatient morbidity by age and sex within four distinct bed clusters: Pediatrics, Medical and Surgical, Psychiatric, and Obstetrics. The morbidity figures involved the 1976 admissions and length of stay which were held constant in each diagnostic category through the entire projection period. The total beds for each diagnostic cluster in each region was a summation of bed requirements for each age-sex interval. The total for all beds within a region was therefore both a sum of age and sex requirements and diagnostic clusters.

The Ratio Population Projection Method was not modified for the projections. Instead, all the hospital districts were combined to their respective regions to increase the population base for each age-sex interval. This step was taken for two reasons: to increase the accuracy of the population projection and therefore the prediction of beds; and to correspond with the level of analysis which was to be applied to the beds. The morbidity data was also collected and collated to the regional level only.

In the prediction of the beds, a number of adjustments to the derived figures were put into effect so that a more realistic requirement for each region was defined. For each region two sets of bed predictions were provided: The first calculation involved expressing the total morbidity and therefore bed requirements as a function of a region's population. Referrals (into and out of the
region) and out of province patients were therefore not related to the regions or provinces from which they originated. The second calculation allowed for projected changes in outflow of patients based upon changes in the region's population. Changes in the inflow of patients were related to changes in the population of regions from which patients came. These two approaches yield the same provincial totals but the regional totals vary considerably because of the changing flows. Both of these calculations are presented in table format. As a function of the work-up to arrive at these calculations, a summation of beds related to age and sex is provided.

To examine the changes in the beds relative to changes in the population, the predicted beds are presented by age-sex categories and also by diagnostic cluster showing percent change in the age-sex interval and the percent change in beds for the same age-sex interval. The beds are also presented in a sex breakdown to provide an indication of the type of separation or segregation for patient privacy. Finally, to demonstrate whether this entire method yields substantially different results from a bed to population ratio prediction method, the present study's estimates are compared with it, in addition to a redefined bed to population ratio approach.

The methodology for the bed predictions was followed precisely and checked for accuracy at numerous stages. Yet the final tallies in the projection years are different for the "with" and "without" referral predictions. The differences or error in any one year does not exceed 0.6%. The methodology and calculations were repeatedly checked. However, the error could not be reduced below 0.6%. Rounding errors should be minimal because decimals rounded to
tenths were carried all the way through the calculations. More probable, the error is a result of the many manual tabulations performed which involved both rounding and transcription. To reiterate, the figures and calculations were repeatedly checked. The error which does not exceed 0.6% should not hinder the application of either data or methods to planning purposes. The error does not distort the intent of this thesis which is to develop and utilize population projection and bed prediction techniques and data for health regions and districts (considered to be smaller populated areas).

**Population Results**

Appendix F presents the population in the four regions for the years 1976, 1981, and 1986. The populations are shown by age interval for each sex and for the total population. Table VI-1 (which is a summary of the more important observations from Appendix F) shows that there are remarkable similarities between regions. Six population groups form the nucleus of the discussion.

All regions show a decline in the pediatric 0-14 age groups. This is the continuation of a pattern which is a direct result of a declining birth rate. While the birth rate has steadily declined, the present projections assume that this will continue until at least 1986. However data is not yet available on births for recent years but figures released in 1976 show a decline which is very marginal. It may well be that the birth rate is beginning to level off. If this is the case, the projections over the next 5-10 years may have to be adjusted upwards. In doing the population projections, the pediatric 0-14 age intervals tended to show a great deal of
### Table VI-1

**Summary Analysis of Population Projections, 1976 vs. 1986:**

#### Population As Per Cent Of Total, 1976 and 1986

<table>
<thead>
<tr>
<th></th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 T.</td>
<td>38.3-32.8</td>
<td>35.5-28.7</td>
<td>35.6-28.1</td>
<td>31.4-24.5</td>
</tr>
<tr>
<td>15-64 T.</td>
<td>59.1-62.5</td>
<td>58.1-61.7</td>
<td>59.7-65.1</td>
<td>60.9-66.9</td>
</tr>
<tr>
<td>65+ T.</td>
<td>Stable</td>
<td>6.4- 8.8</td>
<td>5.3- 6.7</td>
<td>7.6- 9.3</td>
</tr>
<tr>
<td>25-44 M.</td>
<td>Stable</td>
<td>25-34 a.g.: 13.7-16.4</td>
<td>20-44 a.g.: 16.7-19.9</td>
<td>12.1-16.5</td>
</tr>
<tr>
<td>45-64 T.</td>
<td>10.5- 9.9</td>
<td>Stable</td>
<td>Stable</td>
<td>16.4-15.4</td>
</tr>
<tr>
<td>25-44 F.</td>
<td>20-44 a.g.: 11.3-14.0</td>
<td>20-44 a.g.:</td>
<td>Stable</td>
<td>11.9-15.3</td>
</tr>
<tr>
<td></td>
<td>38.1-45.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 T.</td>
<td>(237)</td>
<td>(5844)</td>
<td>(5243)</td>
<td>(13019)</td>
</tr>
<tr>
<td>15-64 T.</td>
<td>7261</td>
<td>9974</td>
<td>10735</td>
<td>35797</td>
</tr>
<tr>
<td>65+ T.</td>
<td>341</td>
<td>3001</td>
<td>1877</td>
<td>7351</td>
</tr>
<tr>
<td>25-44 M.</td>
<td>Stable</td>
<td>25-34 a.g.: 4772</td>
<td>20-44 a.g.: 4774</td>
<td>31003</td>
</tr>
<tr>
<td>45-64 T.</td>
<td>593</td>
<td>Stable</td>
<td>Stable</td>
<td>(1561)</td>
</tr>
<tr>
<td>25-44 F.</td>
<td>20-54 a.g.: 4567</td>
<td>Stable</td>
<td></td>
<td>14094</td>
</tr>
<tr>
<td></td>
<td>4890</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. When two numbers appear in each column, the first figure is for 1976 and the second figure is for 1986.
2. a.g. = age group.
3. ( ) = decline.
4. T = Total, M = Male, F = Female.
fluctuation in the amount of change. The decline of the pediatric base as with the status of other age intervals is related to the movement of a single variable, the Newfoundland population.

The Northern Region will have 32.8% the greatest percentage of pediatric 0-14 year olds relative to its own population. In absolute numbers, it had a very slight decline. The high impact regions are the Eastern with 13,019, the Central with 5,243 and the Western with 5,844. The Eastern Region's percentage of pediatric 0-14 is considerably lower than the remainder of the Province. By the end of the projection, 1986, the Northern Region is expected to have the greatest percentage of children 0-14 (32.8%) in comparison to the Eastern Region which should have the lowest (24.5%). In actual people the opposite picture is true, the Northern declined 237, whereas the Eastern declined 13,019.

The 15-64 age groups increased in all regions. Both the Western and Eastern Regions increased from 59.2% to 65.1% and from 60.9% to 66.9% respectively. Consistent gains are shown in three regions in the neighbourhood of 7-10,000, whereas the Eastern had a change of 35,797. This increase arises because of the 25-44 age group which is growing and shifting this growth to higher age levels. Between 2.6% and 3.4% increases were experienced in all regions except the Northern. These slight gains suggested increased cohort survival in early age groups.

It is interesting to observe the increase in the older population (65+ years). In the Northern, there is a very slight increase in the 65+ age group (2.9-3.0%) whereas the other regions display a much larger increase. Central Newfoundland demonstrates an increase of 3,801 twice that of the Western. However, Eastern is far greater
with an increase of 7,351 showing more emphatic signs of an aging population. It would seem from the population projections that the Geriatric base may not in fact be increasing between 1986 and 2000. The 45-64 age groups are either predicted as being relatively stable or declining. This does not mean that the geriatric base is not increasing for there is a "bulge," the 25-44 year age group, which is creeping upwards. With newer technologies in medicine, even if numbers were smaller, proportionately more may reach the 65+ age group through cohort survival.

The increased cohort survival is also suggested in the Pediatric base (0-14) and contributes to the bulge in the 25-44 age group. This survival in the early stages of life was a distinctive problem in Newfoundland in the past. Since 1966 Newfoundland's infant mortality rate declined from 28.1 to 14.6 in 1976. With this shifting decline an emphasis had been attached to both child and maternal care through both Public Health Medical and Nursing Programs. Yet the "bulge" and the gradual increase in the population to older levels appears to be also a product of unknown factors such as migration. Although a migration component was built into the projections by assuming the Statistics Canada projections it cannot be determined in these projections what the quantity is. The latest figures on migration for Newfoundland are from 1965 to 1970. Even to estimate net gains in the population and to classify a residual difference between periods is difficult because the figures on births and deaths are not presently organized to the health district and regional levels.

A very distinctive finding that arises from this aging population is the increase in the number of women in the higher risk
child bearing years. The assumption of increases in high risk pregnancies is made in the absence of age specific fertility rates which are not available for Newfoundland (the present method of computing beds does assign deliveries by age of the mother). Most notably 3 of the 4 regions show a stable or declining 15-24 female age group. However the 25-44 age group in the Central, Western and Eastern regions show percentage increases from 11.3% to 14.0%; 20.2% to 25.1%; and 11.9% to 15.3%, respectively. Translated to women, this means a combined count of 24,589 ascending to higher risk groups by 1986. Two areas of concern are presented in the Northern and Central Regions. In the Northern Region the 20-54 age group increases its count by 4,890. Nearly half of this increase is expected in the 35-44 age group. In the Western Region the 35-54 age group increases by almost 4,000 women.

To summarize on the findings for all regions: the pediatric 0-14 age groups is declining; the 15-64 age group is increasing, showing a strong increase in both the male and female 25-44 ages and a slight decline in the 45-64 age groups; and the 65+ population is showing a moderate increase. In deference to stating a moderate increase in 65+ ages, figures in the department show that between 20% and 30% of the patient days in hospitals are utilized by this group who in comparison to all others have the smallest percentage of people in the hospital. The consequences of a slight or moderate increase therefore becomes more significant. Of equal concern is the growth in the number of women ascending to higher child bearing risk groups. This particular group as well as others suggest that even though bed estimates incorporate these changes, further analysis will be required to allow for the types and level of care which is
to accompany both patient and bed.

**Bed Prediction Results**

Tables VI-2 and VI-3 show the bed predictions for each of the four health regions for the periods 1976, 1981 and 1986. Table VI-2 does not adjust the bed level within each region so that the referrals which are incorporated into regional figures are the product of changes in populations in the other regions. On the other hand, Table VI-3 does this, and it can be seen that the bed totals (within each diagnostic cluster and for all clusters) change in relation to Table VI-2. The analysis excludes out of province residents who are hospitalized in Newfoundland.

Table VI-2 summarizes the changing bed requirements of both the province and its four health regions. Figures taken from the tables are rounded upwards to the nearest bed for ease and clarity in presentation. Consequently, there may be rounding errors. At the provincial level 504 beds will be needed by 1986 over the figures established by this method for 1976. This figure is comprised of: Medical and Surgical, 434; Obstetrics, 60; Psychiatry, 59; and the only decrease of 48 in Pediatric beds. Respectively, the percentage contribution of each bed service would be: 86.1%, 11.8%, 11.6% and -9.4%. The major input into the increase in beds as expected was Medical and Surgical which extend a service component to a wide range of age groups. By region, the expected Medical and Surgical increases are in beds: Northern, 37; Western, 62; Central, 106; and Eastern, 293. The regional Obstetrical contributions to the total were: Northern, 7; Western, 12; Central, 10; and Eastern, 60. The Psychiatric increase comprised: the Northern, 3; the Western, 6; the
<table>
<thead>
<tr>
<th></th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
<th>Newfoundland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical/Surgical</td>
<td>145.1</td>
<td>164.4</td>
<td>181.2</td>
<td>239.3</td>
<td>269.1</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>35.6</td>
<td>42.6</td>
<td>42.2</td>
<td>52.4</td>
<td>59.5</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>12.6</td>
<td>14.0</td>
<td>14.8</td>
<td>24.9</td>
<td>27.4</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>64.0</td>
<td>63.9</td>
<td>64.3</td>
<td>71.4</td>
<td>62.6</td>
</tr>
<tr>
<td>Total</td>
<td>257.3</td>
<td>284.9</td>
<td>302.5</td>
<td>388.0</td>
<td>418.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
<th>Newfoundland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical/Surgical</td>
<td>125.7</td>
<td>142.3</td>
<td>155.8</td>
<td>213.6</td>
<td>241.5</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>33.6</td>
<td>40.1</td>
<td>39.9</td>
<td>50.5</td>
<td>57.7</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>10.6</td>
<td>13.7</td>
<td>12.5</td>
<td>23.8</td>
<td>26.0</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>50.4</td>
<td>51.8</td>
<td>50.7</td>
<td>51.5</td>
<td>45.4</td>
</tr>
<tr>
<td>Total</td>
<td>220.3</td>
<td>247.9</td>
<td>258.9</td>
<td>339.4</td>
<td>370.6</td>
</tr>
</tbody>
</table>

Table VI-2

Table VI-3
Central, 9; and the Eastern, 32. As anticipated the Pediatric population decreased and therefore, beds declined in each region: Northern, -1; Western, -9; Central, -14; and Eastern, -26.

Table VI-3 demonstrates the effects of adjusting the referral pattern of patients so the number of patients going into or coming from a region is a function of both the morbidity and changing population in the region of origin. When these adjusting figures are added to the base bed need in a region a slightly different pattern emerges. In comparison to Table VI-2 each region shows a reduction in bed needs for the year 1976 with the exception of the Eastern Region. This is expected because St. John's in the Eastern Region provides the tertiary levels of care for the province. The majority of referral adjustments require Medical/Surgical beds. In terms of bed requirements the referral adjustments reduced the total bed needs in the following regions for 1986: Northern, 303 to 259; Western, 460 to 408; and Central, 637 to 507. These reductions are seen as contributory to the increase in bed requirements for the Eastern Region from 1713 to 1921.

As an overall summary of these two tables, three of the regions will experience small adjustments to all bed service classes with the exception of the Eastern Region. As stated previously, the Eastern Region has a major function of providing tertiary level services. Coupled with a far larger population base, greater bed requirements are expected. When these findings are related to Table VI-7 which compares three methods of deriving bed needs, a very interesting observation occurs. The present bed levels in the Northern, Western and Central regions can more than adequately meet the redefined needs for 1986. Just the opposite is projected for
the Eastern Region. Current bed levels do not appear to be adequate for the 1986 level of morbidity, the need being in the order of approximately 300 beds. Two hundred and fifty-three of these fall in the Medical and Surgical category. A more elaborate discussion of these latter observations will be entertained in the discussion of Table VI-7.

Table VI-3 interprets bed needs in each region during the projection period by age and sex. The predicted population decline in the pediatric 0-14 age group is evidenced in a decline in the pediatric bed requirements in all regions. Provincialy the decline is 49 beds, 34 of which occur in the Eastern Region. The decline averages between 3% and 5%. The 15-64 age group naturally shows more requirements for beds because it is comprised of a larger population base and because a large portion of morbidity emanates from obstetrical diagnoses. This particular base, however, does not show strong changes. In fact, the Central Region between 1976 and 1986 shows a decline in its percentage of beds (49.7% to 46.5%) although the number of beds increased from 202 to 236. The Western Region shows the greatest increase in percent from 67.9% to 72.9%. Again in numbers, the Eastern Region is expected to increase by approximately 192 beds and yet there is only a marginal increase in these beds as a percent of total beds.

The 65 and over age group provides a distinct departure from the population projection findings, and therefore, the expectations for two regions. Both the Northern Region and the Western Region are expected to have a lesser percentage of beds being occupied by patients 65 and over, 12.0% to 11.6% and 16.8% to 15.8%, respectively. The Eastern Region is expected to increase from 24.5%
to 27.8% for a total of 137 beds. What is interesting is the 65 and over population for the Central Region which is about 2.5 times less than that of the Eastern area. Yet between 1976 and 1986, the 65 and over beds are expected to increase in the Central by 75 beds and will constitute 41.2% of all beds whereas the Eastern Region will have 27.8% of its beds occupied by the 65 and over patient.

Following is a summary of the anticipated beds assigned to the three age groups in 1986. The percentages are shown in the order of 0-14, 15-64, and 65 and over age groups. Northern - 19.6, 68.8, and 11.6; Western - 11.2, 72.9, and 15.8; Central - 12.2, 46.5, and 41.2; and Eastern, 14.4, 57.7, and 27.8.

Table VI-4 also separates each region's beds by sex. This will give an idea of the amount of segregation of beds required for privacy. Female beds are expected to increase more than males. At the provincial level the female gain is 1% of all beds. By region for 1986 the following sex percentages, in the order of male and female are: Northern, 39.4 and 60.6; Western, 39.4 and 60.5; Central, 35.1 and 64.9; and Eastern, 44.2 and 55.8.

Tables VI-5, VI-6 and VI-7 demonstrate a very distinctive sensitivity between population change and bed service needs. It appears from Table VI-6 that by region, changes in the male population have a greater effect upon corresponding changes in the bed service requirements. Provincially, both sexes have the same effect on beds. For the most part the increased sensitivity of the males is the result of the 25-45 age group because its major influence in the bed changes arises from its participation in Medical/Surgical beds. Population figures for the 45-65 ages are expected to decline slightly. The other component to this sensitivity is the geriatric
## Table VI-4

**Newfoundland and Regional Age-Sex Bed Requirements:**


<table>
<thead>
<tr>
<th></th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
<th>Newfoundland</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>17.4</td>
<td>17.1</td>
<td>17.2</td>
<td>21.8</td>
<td>18.9</td>
</tr>
<tr>
<td>5-9</td>
<td>6.8</td>
<td>6.9</td>
<td>7.0</td>
<td>5.2</td>
<td>4.3</td>
</tr>
<tr>
<td>10-14</td>
<td>4.6</td>
<td>4.8</td>
<td>4.9</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>15-19</td>
<td>5.5</td>
<td>8.1</td>
<td>4.7</td>
<td>4.5</td>
<td>6.2</td>
</tr>
<tr>
<td>20-24</td>
<td>4.5</td>
<td>5.0</td>
<td>6.0</td>
<td>6.7</td>
<td>8.2</td>
</tr>
<tr>
<td>25-34</td>
<td>11.2</td>
<td>12.7</td>
<td>14.1</td>
<td>9.9</td>
<td>11.0</td>
</tr>
<tr>
<td>35-44</td>
<td>8.8</td>
<td>10.1</td>
<td>12.6</td>
<td>13.5</td>
<td>14.7</td>
</tr>
<tr>
<td>55-64</td>
<td>10.1</td>
<td>10.0</td>
<td>10.0</td>
<td>15.8</td>
<td>15.9</td>
</tr>
<tr>
<td>65-69</td>
<td>5.3</td>
<td>6.3</td>
<td>6.6</td>
<td>9.7</td>
<td>11.3</td>
</tr>
<tr>
<td>70+</td>
<td>15.3</td>
<td>13.2</td>
<td>10.3</td>
<td>31.4</td>
<td>36.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>98.7</td>
<td>103.7</td>
<td>102.0</td>
<td>141.4</td>
<td>149.6</td>
</tr>
</tbody>
</table>

| **Females** |          |         |         |         |              |
| 0-4      | 11.5     | 13.3    | 11.3    | 12.9    | 11.8         |
| 5-9      | 5.6      | 5.9     | 6.1     | 3.7     | 2.9          |
| 10-14    | 4.3      | 5.8     | 4.2     | 4.5     | 6.2          |
| 15-19    | 14.5     | 17.3    | 10.3    | 10.5    | 19.1         |
| 20-24    | 19.3     | 22.9    | 23.9    | 26.9    | 30.8         |
| 25-34    | 21.9     | 25.9    | 29.7    | 36.2    | 42.6         |
| 35-44    | 11.7     | 16.4    | 24.5    | 19.1    | 23.4         |
| 45-54    | 10.1     | 11.0    | 12.6    | 21.3    | 23.4         |
| 55-64    | 8.9      | 9.8     | 10.4    | 19.8    | 21.2         |
| 65-69    | 3.2      | 2.9     | 2.8     | 8.4     | 9.8          |
| 70+      | 10.6     | 15.0    | 21.1    | 26.7    | 31.5         |
| **Total** | 121.6    | 144.2   | 156.9   | 198.0   | 221.0        |
| **Total Sex** | 220.3    | 247.9   | 258.9   | 339.4   | 370.6        |
Table VI-5
Population Change Compared with Bed Services Changes
Newfoundland and Regions 1976-86

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>17.3</td>
<td>17.8</td>
</tr>
<tr>
<td>Western</td>
<td>7.7</td>
<td>18.5</td>
</tr>
<tr>
<td>Central</td>
<td>6.4</td>
<td>21.1</td>
</tr>
<tr>
<td>Eastern</td>
<td>10.4</td>
<td>19.3</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>9.7</td>
<td>19.4</td>
</tr>
</tbody>
</table>

Table VI-6
Sex Population Changes Compared with Bed Service Changes\(^a\)
1976-1986

<table>
<thead>
<tr>
<th>Region</th>
<th>Pop. % Change Male</th>
<th>B.S.C. Male</th>
<th>Pop. % Change Female</th>
<th>B.S.C. Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>11.0</td>
<td>3.9</td>
<td>20.1</td>
<td>28.9</td>
</tr>
<tr>
<td>Western</td>
<td>3.7</td>
<td>11.9</td>
<td>13.3</td>
<td>23.3</td>
</tr>
<tr>
<td>Central</td>
<td>3.9</td>
<td>14.2</td>
<td>9.2</td>
<td>26.0</td>
</tr>
<tr>
<td>Eastern</td>
<td>11.3</td>
<td>20.6</td>
<td>9.7</td>
<td>18.2</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>8.3</td>
<td>16.5</td>
<td>11.1</td>
<td>21.7</td>
</tr>
</tbody>
</table>

\(^a\)B.S.C. = Bed Service Change
### Table VI-7

Population Changes Compared With Bed Service Changes

Newfoundland, 1976-1986

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Northern</th>
<th>Western</th>
<th>Central</th>
<th>Eastern</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P%</td>
<td>B%</td>
<td>P%</td>
<td>B%</td>
<td>P%</td>
</tr>
<tr>
<td>0-4</td>
<td>0.5</td>
<td>0.5</td>
<td>7.6</td>
<td>8.2</td>
<td>11.0</td>
</tr>
<tr>
<td>5-9</td>
<td>4.1</td>
<td>4.4</td>
<td>28.2</td>
<td>27.1</td>
<td>16.1</td>
</tr>
<tr>
<td>10-14</td>
<td>0.0</td>
<td>1.8</td>
<td>9.1</td>
<td>6.6</td>
<td>13.1</td>
</tr>
<tr>
<td>15-19</td>
<td>24.2</td>
<td>26.0</td>
<td>4.5</td>
<td>3.8</td>
<td>7.4</td>
</tr>
<tr>
<td>20-24</td>
<td>30.9</td>
<td>26.1</td>
<td>22.0</td>
<td>19.7</td>
<td>21.2</td>
</tr>
<tr>
<td>25-34</td>
<td>30.4</td>
<td>32.3</td>
<td>31.2</td>
<td>32.9</td>
<td>28.3</td>
</tr>
<tr>
<td>35-44</td>
<td>70.9</td>
<td>77.6</td>
<td>43.3</td>
<td>47.5</td>
<td>23.2</td>
</tr>
<tr>
<td>45-54</td>
<td>13.2</td>
<td>15.1</td>
<td>14.0</td>
<td>15.8</td>
<td>8.3</td>
</tr>
<tr>
<td>55-64</td>
<td>7.7</td>
<td>7.1</td>
<td>8.4</td>
<td>8.6</td>
<td>6.2</td>
</tr>
<tr>
<td>65-69</td>
<td>8.5</td>
<td>8.3</td>
<td>25.2</td>
<td>24.6</td>
<td>21.9</td>
</tr>
<tr>
<td>70+</td>
<td>32.8</td>
<td>21.3</td>
<td>42.3</td>
<td>42.0</td>
<td>64.1</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Underlined figure indicates negative change
2. Change is expressed as percent change on 1976 population
population where small changes in the number of patients have a correspondingly larger impact upon bed requirement. Both the Central and Eastern areas display this characteristic.

Table VI-5 compares total population change with bed service changes between 1976 and 1986. A similar sensitivity as described in Table VI-5 is found. Both tables suggest correlated figures such that a 1% population change translates into a 2% bed change. What is odd is the provincial relationship of population to bed change at exactly 1:2. On further examination in Table VI-7 this suggested relationship in fact becomes even more dramatic. By age and sex, invariably, there is a 1 to 1 relationship so that a 1% change in the population yields a 1% change in bed requirements. This holds for the direction of the change. Statistical procedures are not necessary because the strength of the relationship is self evident in the figures. Certainly there was expected to be a sensitivity between changes in the population and bed service requirements using this study's methodology. However, such a striking relationship was not anticipated for all age groups.

Table VI-8 compares 3 techniques at predicting the total bed requirements for each region. The Bed Service Requirement with Referral is the method employed by this study. Population changes affect the level and type of morbidity which in turn translates into beds. The Bed to Population Ratio Method expresses the beds in Newfoundland (staffed and in operation) over the population, a rate which is then multiplied by a projected population. Finally, the Bed Service to Population Rate is, in fact, a bed to population ratio technique. The major departure is that the initial statement of beds in the formula is established by sorting morbidity and
### Table VI-8
Comparison of the Bed to Population Ratio, Bed Service to Population and Bed Service Requirement With Adjustment for Referral

<table>
<thead>
<tr>
<th>REGION</th>
<th>1976</th>
<th>1981</th>
<th>1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>220.1</td>
<td>396.0</td>
<td>220.3</td>
</tr>
<tr>
<td>Western</td>
<td>339.4</td>
<td>426.0</td>
<td>339.4</td>
</tr>
<tr>
<td>Central</td>
<td>405.5</td>
<td>628.0</td>
<td>405.5</td>
</tr>
<tr>
<td>Eastern</td>
<td>1624.4</td>
<td>1494.0</td>
<td>1624.4</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>2589.6</td>
<td>2944.0</td>
<td>2589.6</td>
</tr>
</tbody>
</table>

B.S.R.R. = Bed service requirement with referral, the study's method.
B.P.R. = Bed to population ratio method.
B.S.P. = Bed service requirement with referral, 1976, expressed as a ratio to the population.
translating it into bed needs. However, morbidity and population
are not allowed to interact in the projections.

The bed to population technique gives a current or 1976
estimate of 2944 beds and assumes the occupancy rate of approximately
67%. The bed service requirement as the chosen alternative has an
assumption of higher occupancies. The Newfoundland occupancy using
these requirements is a pooled average of 83.7%. This figure is
primarily influenced by the Eastern Region which had been arbitrarily
established at 85%.

The bed to population method predicts a higher number of
beds for each region with the exception of the Eastern Region.
Provincially, this method gave a higher prediction than the other
methods. Note that there is an understatement of beds for the
Eastern area. One of the reasons for this is that the occupancy
level for many of the 1494 beds far exceeds the 85% occupancy level.
Consequently more morbidity is handled with less beds. The bed
service requirements are established at an 85% occupancy level. As
a second reason, the morbidity file forms the basis of the beds, not
what the hospitals state they have in beds (according to the Annual
Returns) which may or may not reflect actual needs. For 1986 the
bed to population prediction of beds for the province and regions
are: Newfoundland, 3237; Northern, 465; Western, 459; Central, 672;
and Eastern, 1641. An anomaly appears between the Northern and
Western Regions. The Western area has twice the population yet has
less beds than the Northern area. The number of beds in the Northern
area are influenced by isolation, weather, travel and lower occupancy
rates. Considering these factors, and what is actually needed based
on morbidity evidence, the bed to population technique tends to
perpetuate inadequacies in the system if such exist.

The bed service requirement with referral to population prediction is more conservative in estimating the provincial requirements. In relation to the bed to population technique there is a net difference of 397 beds. This approach also produced a lower bed estimate in each of the regions. Although it does not interact with morbidity it does assume that there should be proper sort of beds through morbidity at a given level of efficiency for the rate or base year.

This study proposes the bed service requirement with referral technique as the method which yields the best results for planning and also stands by the arbitrary choice of occupancy rates as desirable levels of efficiency. This forces consideration of alternative courses of action to provide health care to the Newfoundland population.

If the present level of beds as a ratio to the population in each region continues (historically there is no reason to believe that it will substantially change), it is possible to estimate the consequences of utilizing the bed service requirement method. The 1986 provincial prediction provided by this study is 3092 beds as compared to the ratio method prediction of 3237, a difference of approximately 144 beds occurs. Reliability is also confirmed by the practical calculation of percentage occupancy in various hospitals. A great many hospitals in Newfoundland fall into the smaller variety and have extremely low occupancy rates ranging from 12% to 50%. As was discussed in the literature review (Appendix A) there are reasons for this. The excess both present and future is not necessarily a product of inefficiencies but a product of changing roles and
shifting styles to deal with patients. Unfortunately the wrong statistic is measuring this changing activity.

This latter point and the key observations regarding bed predictions will be discussed as with the population observation in the final chapter. The discussion will relate the findings to the practicalities of the Newfoundland scene and to the planning role for the health care scene.
CHAPTER VII

SUMMARY AND DISCUSSION

Introduction

The present study has done more than it intended. The original objectives of this study were to provide a prediction of bed needs in the future and to provide both a sort and projection of population by age and sex for health regions and districts. The more advantageous result was a focus in planning philosophy; that is, a focus and statement regarding the types of data which are required for the future and the types of activities which must accompany these data requirements. This will be evident in the discussion to follow: summary of findings; advantages and disadvantages of methodologies; practical implications of the findings and future plans.

Summary of Error Estimation Associated With The Ratio Method

The accepted guideline for the amount of error in the population projection under or equal to ten years was established at the 10% level in the literature review. The Ratio Method was used to project an historical set of census values in Newfoundland. The result was compared to the actual values in the census year which was the year of projection. The projection period was five years.
Errors were recorded to stratified population bases.

The ratio population projection technique, a single estimator of the population, did produce extreme errors as expected. It was also judged acceptable as a planning tool because it produced an acceptable proportion of error under or equal to 10% for a five year projection. Acceptance was based upon: the character of the Newfoundland population; the opinion that extreme values would necessarily have to be prudently adjusted; and finally, that the majority of errors (81%) are under or equal to 10% when the extremes are identified (19%).

Sampling of the errors indicated that the absolute mean with standard error was 12% ± 1.2. The 0-2999 stratum which characterizes much of the Newfoundland population had an absolute mean of 13.0% ± 1.8. Comparatively, the total data set of errors had an absolute mean of 12.3% ± 1.2 and the 0-2999 stratum had an absolute mean of 13.2% ± 1.3. The proportion of errors under or equal to 10% in the sample was .63 whereas it was .65 in the total data set.

The 0-2999 stratum contributed heavily towards the means expressed in the preceding paragraphs. This stratum also typifies the small and scattered nature of the Newfoundland population. Therefore it was analyzed independently particularly for extreme values. Two census divisions which were felt to be unpredictable both demographically and economically were removed from the 193 errors in this stratum. The proportion of errors under or equal to 10% increased from .65 to .77. Alternatively, errors greater or equal to 20% were subtracted from the 193 observations. Eighty-one percent of the errors fell under or equal to 10%. The absolute mean dropped from 13.2% ± 1.2 to 5.1% ± .4. If, as has been suggested,
extremes must necessarily be adjusted then the original estimate of
the mean of 13.2% ± 1.2 should decline below the 10% guideline.
Similarly the proportion of errors falling under or equal to 10%
should be improved, over the 81% level.

The inference of an acceptable estimator of population is
also supported when the sampled errors are transformed by the Arc­
Sin √percent transformation. The Arcsin √ percent transformation
pulled extreme values from both ends of the distribution towards the
mean. The retransformed mean was 9.2% compared with the non trans­
formed mean of 12 (S.E. before transformations was 1.25). Consid­
ering both types of extremes the majority of the data hedges around
the 10% guideline. However, the transformation was considered to be
impractical for error analysis because it minimized the influence of
extreme values on the mean. These very extremes would be a point of
focus because they must be identified and dealt with by the demo­
grapher.

No relationship between population size and either the
proportion of errors under or equal to 10% of the size of error
could be established. The plotting of the errors did not suggest
either a linear or non linear relationship. Superficially, all the
tables suggest that the absolute mean error and size of error
decreases while the proportion of errors under or equal to 10%
increases as population size increases. The plotting of the errors
indirectly supports this relationship. As the population size
increases the range tightens and shifts downward. The subtlety of
these relationships arises because Newfoundland populations are in
thousands whereas studies in the literature offer this relationship
from populations in the millions. What is also interesting is that
the errors appear to be randomly located within each strata and range. More importantly this implies that the ratio projection method is not influencing the error. Instead it is the nature of the population being projected which is producing the fluctuations. This strengthens the argument for complementary data files for each area being projected so that extreme values can be modified.

The ratio projection method is considered to be an acceptable planning tool because the majority of the errors fall under the 10% guideline. The precision of this method is increased by aggregating population bases prior to projection, by shortening the projection period and by judiciously adjusting extreme values. Therefore, the method is considered appropriate for areas characterized by small scattered population bases and lack of key demographic data. It is also acceptable because it does not influence the absolute values of data being projected. The acceptance of this method, however, does not mean that the prospective projections will be accurate although this state can be inferred. The final test of accuracy of the ratio method will come in its first comparison with actual census values.

**Summary of Population Projections**

The ratio method was employed to produce the projections. To enhance the accuracy of the projections, and therefore the estimate of beds, the age sex populations of health statistical districts were aggregated to their respective regional level prior to projection.

In each of the 4 health regions, the pediatric 0-14 year population groups declined between 1976 and 1986. The Northern Region had the highest percentage of 0-14 year olds with 32.8%,
whereas the Eastern Region had the lowest at 24.5%, but the greatest number in decline, 13,019. The 15-64 year age groups increased in all regions between 7,000 and 10,000 people, while the Eastern increased by 35,797. Much of this change is taken up by a "bulge" in the 25-44 age group. Slight declines are seen in the 45-64 age groups. Within the female 25-44 age group, there was a total increase of 24,589. Each of the regions demonstrated an increase in the number of women. In the absence of fertility data and under the assumption of one birth rate, the number of high risk pregnancies is expected to increase. In the 65+ age group, a slight increase is observed. However, the Eastern Region is expecting an additional 7,851 to this group. A dramatic increase is seen in the Central Region. It is anticipated, however, that there may in fact be a slight decrease in this population after 1986 because of the declining 45-64 age group followed by an increase around the year 2000. The Eastern Region shows an aging population which is expected to grow in the future.

Summary of Bed Predictions

The projected population was interfaced with morbidity to give a prediction of bed needs. A separate prediction of beds was derived by allowing for proportional changes in the referral patterns into and out of regions. At the provincial level the bed requirement is 3093 beds. The bed requirements allowing for referrals and excluding out of province for each region in 1986 are: Northern, 259; Western, 408; Central, 637; and Eastern, 1921. These estimates are based on occupancy levels of: Northern, 65%; Western, 75%; Central, 75%; and Eastern, 85%. The present bed levels in the Northern,
Table VII-1

Summary of the 1986 Total Bed Requirements for the Four Health Regions in Newfoundland

<table>
<thead>
<tr>
<th>Region</th>
<th>Requirements (Beds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>259</td>
</tr>
<tr>
<td>Western</td>
<td>408</td>
</tr>
<tr>
<td>Central</td>
<td>637</td>
</tr>
<tr>
<td>Eastern</td>
<td>1921</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>3093</td>
</tr>
</tbody>
</table>

Figures rounded upwards to nearest bed. Total will not agree with regional figures.

Western and Central Regions can adequately meet the redefined bed needs as presented by this study. The Eastern Region's present bed level does not appear to be adequate. Approximately 300 beds will be needed by 1986, 250 of which will be medical and surgical.

By bed service the province is expected to show a decline of 48 pediatric beds and an increase in medical-surgical beds, obstetrical beds and psychiatry beds of 434, 60 and 59 beds respectively. In each case the Eastern Region contributes more beds to the figure because it has a far larger population base than the other 3 regions. Excluding the Eastern Region, the largest contributions to bed type are: Medical-Surgical - Central, 106; Obstetrical - Western, 12; Psychiatric - Central, 9.

By age groups, the pediatric 0-14 group is expected to decline by 48 beds provincially. The 15-64 age group, on the other hand, is anticipated to increase by 328 beds. This increase falls across all regions, most notably the Western and Eastern Regions. Both the Central Region, with its dramatic increase, and the Eastern Region account for the moderate increase in beds for the 65+ age
group. Provincially, the requirement will be 225 beds. By sex, the split in beds is expected to favor females which shows a provincial increase from 55.8% to 56.8% by 1986. With the exception of the Eastern Region, all regions should have between 60% to 65% of their beds designated female.

In comparison with existing levels of beds, the bed predictions for three regions in 1986 show that there will still be an excess of 206 beds. If present levels are projected there would be a greater excess, to the tune of 421 beds. The Eastern Region on the other hand is expected to require additional beds. This study's prediction is 1921. The bed to population ratio is 1641 and the current level is 1494.

The interfacing of age and sex and morbidity did show that bed requirements would differ from a prediction in which these variables had not been used. An "odd" degree of sensitivity between population change and bed change was observed; odd in the sense that invariably, and in the same direction, a one percent change in population was accompanied by a one percent change in bed service requirements. The change in bed service is a product of population and morbidity by age sex classifications.

Advantages and Disadvantages of the Ratio Projection Method

Advantages and disadvantages were outlined in the literature review. However, those which are discussed are those which have the benefit of hindsight. The ratio method does produce consistent results although extreme calculations were observed. This consistency is very positive in view of the lack of current data which is available in the province for making any type of projections. Fer-
tility rates are absent, the latest migration figures are for the period 1965-1970, and the births and deaths are not organized by health statistical district. The use of the ratio method provided for more current information to be used. The method itself is flexible in the sense that established rates can be modified without going through elaborate procedures. Similarly, extreme values can be immediately selected by employing a decision rule and can be modified on the basis of complementary demographic data and judgement. The ratio method is simple and easy to follow even when an ungainly set of figures requires manipulation. This simplicity provides ease in calculation and programming for computer.

On the negative side, the method is not sensitive to recent changes when a past period is, for example, 5 years. It assumes the continuation of a growth or decline rate at the same rate. Consequently recent growth rates which are levelling or reversing direction will be forced against logic. In addition, growth rates are expected to continue to infinity whereas declining rates are expected to reach a point where adjustments to zero values must be made (negative populations). In these terms, the method is inflexible.

The ratio method can produce two results. On the one hand there is a mathematical calculation which follows signs; on the other, there is a logical process. In some cases, logic dictates a declining population yet mathematical signs dictate a growth.

The use of this method is a choice for a single estimator or population. Extreme values are therefore expected. In some situations it is more than obvious that the ratio method does not perform well. This generally occurs in a very small population which has undergone a significant change relative to a minor national change.
If in the future the national population changes significantly, the projection for the local area would yield an extreme error.

Although this study judged the ratio method as being purposeful for the Newfoundland setting, small populations, certainly populations under 3000, produce more errors over 10% and a wider range to the errors than larger populations. In the context of age sex intervals, this problem is magnified because there are many intervals under 1000 population.

The Advantages and Disadvantages of the Bed Prediction Model

The bed prediction model utilized in this study, a priori, is better than the bed to population model. Yet it is difficult, if not impossible, to determine if the model produces good results. Only the application of its results would allow this conclusion. Certainly there would appear to be a built-in bias to give a conservative estimate because it deals with a demand situation (the actual inpatient morbidity experienced by the population).

The real advantage of this model is found both in its ease and flexibility of application within the planning function of the Department. Indeed the program was derived from a morbidity profile which was not intended as a bed statement. It is true that the translation of such is turned into statements regarding beds. What has happened in this study is that there is a simple and logical assumption, and its converse that morbidity classifications are also bed classifications. It was relatively easy to summarize morbidity and beds to the 4 health regions using this study's bed prediction model. With the very same program and switching a subroutine to select origin of patient, the type of referral could also be estab-
lished. At this point in time not all of the calculations have been programmed. However, it is being planned and will also be used for purposes other than bed estimates.

With a simple modification of percent occupancy at the regional level, a planner, given constraints of time and costs, can balance figures to derive the best combination of benefits, economy and efficiency. However this too can be a disadvantage because the arbitrarily chosen occupancy level may not be a product of needs or demands but instead might be a bias not necessarily appropriate. Whatever statement this model produces may, in fact, be impossible to achieve politically, particularly if it is addressing predictions on the conservative side.

The bed prediction model, as it stands, is advantageous in that its principles dictate the establishment of a provincial bed policy which is a summation of policy statements from the various areas. In other words, the provincial prediction is not forced upon either the population or regional planners. However, because there is ease in the use of this model and because it is part of an existing data system at the provincial level, the model has the disadvantage of requiring very little input from regional planners. Consequently any statement on beds may be considered an imposition and subject to an error which has not been addressed through local experience.

A very distinct disadvantage of the model is that it carries forward a static morbidity pattern (including length of stay) even though admissions vary. Logically, one cannot expect the same morbidity patterns but sensibly how does one give a precise definition to morbidity for the future. On the other side of the coin,
there is the practical advantage that each region is provided with its own unique morbidity pattern. Therefore, the needs of the population are not imposed upon local or regional areas. The morbidity pattern in this model assumes that what has been hospitalized required hospitalization and what did not require hospitalization had no morbidity or inpatient needs. One solution to the static morbidity pattern would be to analyze the history of a diagnosis (or cluster) and project a rate for each point in the future.

### Key Observations Regarding the Population Projections

Considering Newfoundland's type and location of population the ratio method should not be used beyond 10 years for small area populations. If populations are below the 3000 level the method could be used but it is still subject to the percent error guideline and application with due caution.

If the ratio method is to be used for health related population projections in Newfoundland two modifications of the method are suggested. Population bases and age sex intervals should be aggregated. This aggregation should increase accuracy, yet, it should provide enough specificity to be practical. For example, the combination of both hospital districts and 3-4 age intervals could be used. This should produce an adequate population base. The intervals chosen could cover the major age groups, 0-14, 15-44, 55-64, 65 and over. It might also be preferable to consider a five year estimate rather than 10 year projection. It would run very close to the four year planning cycle which is being inaugurated within each department of the Newfoundland government. Constant revision of population estimates can only improve upon purpose and
The error involved in the projections could also be controlled by checking with regional or hospital health planners who might be involved in a similar exercise. If provincial estimates are derived by checks upon economic stability, housing starts or actual sampling of the population, a pooled effort might lead to greater precision. If the estimate is not pooled and opinions are asked, a degree of bias might be introduced to the data set.

This study has followed the mathematical process of calculations and has manipulated the data as little as possible. In other words, the data base which has been used is considered clean and its associated methodology clear. From this point of view any user can employ his/her own assumptions and apply a logic process to the data base or calculations. The population breakdown and the appropriate rates are then as important as the final projections.

Accuracy for very small population projections would be enhanced if Statistics Canada would eliminate the random rounding process. To the larger provinces this process would produce negligible amounts of error but as described earlier it could mean a 20% or 30% or 100% error in an age interval in a Newfoundland community. If it is a question of confidentiality, are not the provinces processing morbidity data which has the capability of identifying people in a community with more identifiers. It should be a provincial desire and responsibility to retrieve data from sets which they directly or indirectly contribute to.

Finally, it can be proposed for Newfoundland that planning in health should be organized to the census division and its asso-
ciated network of subdivisions and enumeration areas. This recommendation includes the recording of data by public health nursing, public health inspection, to name but a few divisions. Similarly, Hospital Insurance statistics should be reported by census division. It makes considerable sense to change to this type of system which would then have a variety of data available and organized to this division level by Statistics Canada. Information from this source might prove to be a very useful adjunct to the planning data being collected by the Department on each health statistical district.

Key Observations Regarding the Bed Prediction Model

Observations of occupied beds in the province in the past support the finding that there are and will continue to be a fair number of excess beds. The consequences of this study or any which suggest cutbacks or additional beds requires that the Department of Health accept an undertaking to modify the bed count and to apply alternative strategies of meeting the health care needs of the population.

Unfortunately the concept of 'bed' does not encompass all the components of health care which are associated with both the bed and its occupant, the patient. This study suggests that there are potential savings in terms of capital, manpower, and operating expenses in three of the four regions. These potential savings are offset by an additional requirement of beds in the Eastern Region. For three regions the minimum value of this excess in 1976 dollars will be 9.5 million in 1986 (inflation not considered). In fairness to the populous in these regions, such savings should in part or
whole be returned to these areas in the form of alternative strategies of health delivery.

What are some of these strategies? One which is suggested in this study's bed predictions is that bed allocations should not be made distinctive for long periods of time. Instead they should be capable of being interchanged between services. In practical terms it means that present management must have a degree of flexibility to adapt to changing demands. Structurally, hospitals must be sufficiently flexible to depart from traditional bed and staffing alignments. If hospitals and government desire changes which are designed to reduce or add beds, experimental situations will have to be established and evaluated. Inducements for this strategy could be initiated through the savings and efficiencies which are suggested.

It is one thing to add beds but to add them to the Eastern Region runs against the grain of many health professionals outside the region. Many feel that in comparison to the Eastern Region they have relatively less. Yet 45% of all patients in Newfoundland receive treatment in the Eastern Region. To reduce the excess in these regions would raise consternation. To change existing patterns would raise difficulties. It becomes a question of information, positive incentives and informed cooperation between regional or hospital health planners and government health planners.

It is felt that the eventual approach which will be taken to further rationalize the system will be a formalized regionalization. The key to this approach will be on the planning function and the examination of two way referral lines: the patient must have access to needed medical care, and some needed aspects of medical care and its technologies may have to be delivered to the patient. In the
context of Newfoundland's distinctive geography and population it would seem that either secondary facilities will have to be built or access is going to have to improve significantly if alternatives are desired.

It would therefore appear that rationalizing the existing excessive secondary care type of facilities will take the form of alternatives within a stronger regional framework. At the heart of the issue is the refinement of accessibility to service. It is difficult to envision a drastically improved access which follows a direction from patient to secondary or tertiary care hospital. However, if the direction is reversed then travelling clinics, consultants or programs could significantly improve the access. With the addition of improved communication technologies, a regional framework could effect alternatives and thereby rationalize excess beds.

What is being suggested is that to rationalize the system by creating alternative modes of delivery, it may take some time to demonstrate economics and/or efficiencies. It may also be very costly to develop these alternatives in the start up phases. The net effect of developing alternatives could increase the total expenditures on health. This might occur if the present morbidity pattern in rural areas is an understatement of the actual situation. If there is no clear-cut shift to an alternative mode nor a consequent reduction in demand for traditional modes of delivery, costs will increase. Unfortunately, the monies required to experiment and to develop systems do play a significant part in a decision even if it is rational and altruistic. When the costs are weighed against proposed actions the inefficiencies which appear to be so expensive
may be less costly and as satisfactory to the patients, as systems that ought to be. Herein lies one of the many dilemmas often faced by health care administrators and planners.

This study makes a statement that a real situation of morbidity will arise in 1981 and 1986 which can be translated into both the number and types of beds. Its underlying premises are: the present morbidity patterns will remain constant; the population projections have reasonable assumptions and an acceptable level of precision; and finally, the assumptions of occupancy standards have sound operational and efficiency levels. Although the bed predictions are given in the absence of a probability statement, the entire process leading to the prediction implies that the bed predictions for 1981 and 1986 will adequately cope with the morbidity pattern expected in 1986. Therefore the predictions do in fact have a probability attached, albeit, not specified.

Yet the projections and predictions which are reached within the scope of this study involve many assumptions which have not been put to the test. To be effective for planning the bed prediction model and its components will have to be evaluated. More importantly, the model will probably require more of human acceptance than logic because it eminated from a single source and did not involve the input of health professionals around the province. This model does have the flexibility to broach this potential problem. The finalized statement of beds for the province is a summation of regional bed requirements. Although assumptions are general in nature when applied to a regional analysis of this type, the assumptions are unique to each region and the resulting distribution of resources to each region takes place with the same distinction.
Therefore, this model has the potential flexibility to provide the basis for discussion and cooperation between region and government.

**Future Directions from this Study**

While population sorting of health statistical district was overshadowed by the population and morbidity projections and bed predictions, its importance to a health data base for planning is paramount. The sorted population by district age and sex is the initial step in defining who needs and who consumes or ought to consume health care resources. Consequently, the intention for the future is to investigate alternative methods of making small area projections and to obtain and blend population projections or related information from different sources. Regardless of the method employed, the population data base will have to have adjunct files which will allow for decision rules or modification to the projections. Where possible, each hospital district will have to have separate files on: vital statistics, economic growth and prospects, school enrollments, employment, housing starts and hydro or telephone hook-ups. The collation of these types of data will require the development of a methodology which will help to gather the information on a continuing basis.

The next step in establishing a decent morbidity base and therefore estimation and/or prediction of beds is the retrospective analysis of different diagnoses over the past. In so doing, one might be able to predict a prospective trend in morbidity at some future date. This type of adjustment could then be incorporated into the model.

It is also envisioned that the diagnostic clustering denoting
bed type will cover a wider range. Therefore, the model will give a more specific statement of bed requirements. The program output will be designed so that the particulars of each diagnosis are available, and a summation to a bed cluster will yield a statement of both morbidity and bed need.

As stated in the first paragraph, alternative methods for projections will be pursued. The same is true of the bed prediction. In terms of making a contribution in health planning for beds, this model will be proposed as a method to evaluate. The eventual intent is acceptance and reformulation of the model and processes which would allow for input from the regions.

In doing the bed predictions (and population projections), the accuracy and timeliness of primary and secondary data sources were points of focus. It would have been far better to present morbidity rates from 1978 to more accurately reflect the needs of the population. Developing these health planning data bases in the province will require more technological adjustments to existing methods of collection, processing and output.

The data sources which contributed to both the population projection and morbidity data are from secondary sources. The accuracy of Statistics Canada census figures must be questioned. So, too, must the inpatient morbidity which is reported in summary form from each hospital. It stands to reason, that some population areas within the province will have to be sampled and that the provincial morbidity pattern for a hospital will have to be examined against primary sources at the hospital. Most assuredly, the population projections for the regions will have to be evaluated against the 1981 and 1986 populations.
Finally, there are three planning districts which are distinct in the province. These are: the health statistical, the census and the federal electoral. If the department does not consider the adoption of the census division as the planning base, an attempt to link these planning entities will need to be sought.

Because of the very practical nature of this thesis, the subject matter and interest must necessarily continue into the future. This direction will be required by health planning as a natural but important function.
APPENDIX A

PROBLEMS ASSOCIATED WITH THE DISTRIBUTION OF HEALTH CARE RESOURCES TO RURAL AREAS IN NEWFOUNDLAND
APPENDIX A

PROBLEMS ASSOCIATED WITH THE DISTRIBUTION OF HEALTH CARE RESOURCES TO RURAL AREAS IN NEWFOUNDLAND

Much of the province of Newfoundland can be characterized as being rural. The Brain Commission observed that 63% of the population resided in communities with a population of less than 100 inhabitants and over 50% of the population lived in 1300 coastal settlements. In March 1978 the Provincial Ambulance Programme in its annual report excluded geographical proximity to hospital based ambulance programmes and estimated the rural population at 340,000. This figure constitutes 60% of the population. Even with the resettlement programmes carried out over the last decade, and the known large migrations associated with closures of industries, the rural has stayed rural.

Transportation and communication have improved, yet each study since that by Lord Brain has taken the time to discuss the continuing problems of distributing resources to the rural setting. Invariably each study discusses equitable distribution in terms of availability and access to services. Distance from primary and secondary levels of care has been the most acceptable method of defining the rural problem. In many cases this distance cannot be overcome because communities are geographically isolated or remote. Systems and structure for delivery of health care to rural populations are evident (from author's work files).

Public Health Nursing carries a Curative Care Programme to all segments of the population in three geographical areas where there is no available professional medical service to outlying areas.

Tuberculosis Control carries a BC Vaccination programme which is localized to the Northern Region
of the Province. The programme is conducted by public health nursing in the area.

Dental Health Services provides a net annual income to dentists who practice in the smaller rural areas.

The Central Pharmacy of the Department of Health will mail drugs to individuals in the population where pharmacists are not available. Alternatively, physicians dispense drugs in smaller communities.

The Provincial Food Bank mails special and/or hard to obtain diets for metabolic disorders.

Cystic Fibrotic patients receive drugs through the mail from Central Pharmacy.

The Cottage Hospital System still remains and functions to serve the rural and isolated areas of Newfoundland. There are 12 hospitals with a total capacity of 365 beds. These hospitals are administered and supplied with resources by the Department of Health.

The Education Division has decentralized to regional depots for the dissemination of educational materials.

The Nutrition Division has a regional nutritionist located on the West Coast.

The Provincial Ambulance Programme covers 60 communities in Newfoundland.

The Air Ambulance Programme conveyed over 5,000 patients in addition to emergency supplies and physicians or specialists.

The Medical Services Division has placed a regional Medical Health Officer on the West Coast with the purpose of organizing public health services under one structure.

There are regional hospitals throughout the province. Although regionalization is not formal, many hospitals interact for services on a voluntary basis.

Clinics and Nursing Stations have been constructed for isolated areas. These operate with one physician and/or nurse. In many cases only a public health nurse is available.

What is also an interesting characteristic of the health system is that it is integrated in design in the sense that, with
few exceptions, most facilities are hospitals. This is a product of tradition and geography. When these facilities were built it was necessary to establish a secondary level of care because the isolation and topography prevented access to the larger centers. These small hospitals have continued to survive to the present even though transportation and communication have improved and despite a change in their service roles. Further integration is being discussed by the Department of Health. Boards are being suggested for the Cottage Hospitals. Regionalization and affiliation of smaller hospitals to larger referral centers is also being proposed.

The outcome of these proposals is not just an arbitrary decision, for its eventual success, if adopted, is dependent upon the recognition of both problems and sources of problems peculiar to the rural setting.2-9 In this context, a number of examples are presented from the literature. These examples are intended to infer related and complex situations in which problems have been experienced.

1. Manpower shortages, environment and recruitment difficulties.

2. Education maintenance in current methods and skills for health care, personnel and boards and the corresponding education of government officials regarding rural characteristics.

3. Development of leadership, organization and coordination skills in the community which attend to problem identification and solution and to the adoption of alternatives.

4. Development of precision, accuracy and use of information to define need or to know where and how to procure advice, and to review or monitor care (e.g., surgery levels).

5. Reduction of independence, "chauvanism," air of resignation, status quo and social traditions, to fully
take advantage of cooperation between communities, professionals, community organizations and government agencies.

6. Development of communication such as radio, television, transportation and the means of transportation which foster distribution of resources in terms of geography, distance, time and weather.

7. The application of larger system models, rules and regulations and personnel and service procedure standards on smaller systems.

8. Development of health related environmental areas such as water and sewage systems.

9. Economic dependence on health services for employment.

10. Out migration because of employment opportunities and current movement of urban dwellers into rural (expectations raise) areas.

11. Population structure by age-sex and social organization which may be affected by low income, high unemployment and work migrations.

12. Method of financing, resources and personnel may dictate plentiful but inappropriate resources, or may modify service through constraints. Would also include salary versus fee for service payments.

13. Time and work misuse of professionals because of shortages in support personnel or other factors such as distance and transportation and weather which create delay.

The problems encountered by one community are not necessarily the problems of another even though basic demographic characteristics are similar. These are problems which hinder or facilitate integration with the overall policy of providing health care to the population. As the thesis is focusing upon inpatient beds by region in Newfoundland, there are, in the opinion of the writer, the higher impact problems. Observations relevant to these problems are drawn from the experience of the writer.

Economic Dependence on Hospitals. In the mid-seventies the Department of Health and Government attempted to close down two
smaller hospitals. The communities involved presented stiff opposition to the proposals. As recounted by officials, the primary lobbying position was that hospitals were centres of employment.

**Economic and Cultural Problems.** Many communities, particularly in Northern Newfoundland and Labrador, are areas of low per capita income and high unemployment. These areas also have a higher proportion of native peoples. The combination has resulted in underdevelopment particularly in nutrition and sanitation measures. These areas have often been described as remote pockets of social disintegration with attending social diseases higher than normal. These areas also have difficulty in attracting personnel with organizational skills. Without skills and resources, the responsibility for and operation of health care systems becomes difficult.

**Insularity and Independence of Health Care Professionals.** There are a number of factors which contribute to this situation: a long tradition of having the same facility in the community, the lack of peer contact, a less than optimal educational environment, the building of kingdoms, and remoteness of the individual. A proposal for regionalization in 1972 was adopted, in principle, by the Department of Health. Since that time no formal regionalization has occurred. In the Central region during 1974 and 1975 administrators met to discuss voluntary regionalization prior to formal regionalization so that they could establish their own procedures and structures. The air of cooperation was absent; it was a jealous attitude that prevailed. (The writer was present at the meetings.) Although an informal regionalization does exist for very selected services, there are still gestures against cooperation.
Political Intervention. There have been many occasions when administrators, health professionals or community lobbying groups have bypassed Department of Health channels to present a position to the Minister. Going outside channels, in the opinion of the writer, happens frequently and produces reactions that are not always favorable for the administrators or communities.

Manpower Shortages. Every year the same complaint is heard across the province. There is a shortage of nurses, particularly during the summer months. One 200-bed hospital closes down a ward for two months each year as a solution to this problem. One of the cottage hospitals in 1979, through community representation, threatened to close down all beds because they could not recruit nurses. Part of the problem lies with the larger hospitals which can offer a more attractive employment package. Another element of the problem is the rapid turnover of foreign graduates who are recruited. Time and time again, directors and administrators state that Newfoundland is a gateway to further opportunities. It is here where custom, language and financial bases are formed prior to migration. Black has aptly described the problem for physician shortages in Newfoundland.

Transportation Distance and Weather. There still are areas in the province where it is very difficult to visit or from which it is difficult to refer a patient to a tertiary care center. Northern Newfoundland and Labrador is particularly prone to these problems. In an evaluation of bed needs for one hospital, the regional center, the average length of stay had to be adjusted by a minimum figure of two days which allowed for necessary delay. From the Central Region, the distance to tertiary care could involve 250
road miles or 60 miles to the airport. The Provincial Ambulance Report for 1978 states that it conveyed 9,610 patients 1,356,713 miles for an average of 141 miles per patient. The air ambulance program conveyed 5,317 patients. In total this represents 14% of all separations including newborn and out of province.

Relative Smallness of System. For the most part hospitals in Newfoundland are small. Consequently, the opportunities for advancement are limited. There is a tradition, particularly in administration, of staying at a position for a long time. For those in smaller hospitals, the opportunities to improve administrative skills in the context of larger hospitals is far from bright.

Political Integration. Some of the problems existing for both rural and urban settings is the lack of political integration of services for planning. As determinants of demand, a number of rural areas display low educational levels, high unemployment, low income and less sanitary environments. A health plan for this area should necessarily involve at least six government departments: Health, Education, Rural Development, Public Works, Executive Council, and Social Services. Recent developments at the Cabinet level indicate a movement to some integration. Nursing Home operations were transferred from Social Services and Rehabilitation to Health.

Lack of Skills of Hospital Personnel. Invariably, the Consultant Reports of Hospital Surveys recommend the upgrading of administrative skills. In one hospital visited recently an organizational mess was discovered. The feeling was that the administrator was not keeping current and was in fact unaware of the situation. There are also known situations in which people are in jobs without
the necessary educational and experiential background.

**The Availability of Funds.** In the 1970's budgets had become tighter. Consequently, the monies alloted for pilot projects or experimental methods has been very restricted. The system, both urban and rural, acknowledges very little change, in mode of delivery. Constraint has also led to shortages in manpower within the Department of Health. This shortage is meant in terms of vital areas such as budget review. In the context of the present day to day activities, very few people have the time to "play" and experiment with ideas or alternatives.

**Decision Making Approach of Government.** Numerous studies point to the crisis-oriented approach taken in health care delivery in Newfoundland. This does not foster integrated planning. In the past, aside from the cottage hospitals, budgets were negotiated. The political voice or squeaky wheel sometimes managed to get a greater share of the pie. Therefore, developments at the hospital level were dependent upon the course of negotiations. This attitude is changing in that the budget is determined for all, prior to any argument of the allotment. This does promote a wider view of the system but development still hinges on available funds and remoteness. Perhaps a bigger factor is the lack of personnel for key areas to monitor and plan systems. Current efforts by necessity are concerned with day to day operations.

**Concentration of Facilities and Costs.** Although there are many smaller hospitals in Newfoundland, many are not attended to in the same fashion as the larger hospitals. The assumption is that as there are no serious problems, everything is operating in an effective manner. Much of the concerted efforts at the government
level fall to the city hospitals and six larger hospitals on the island. These hospitals would account for 62% of the approved beds and between 70-80% of the separations.

The problems encountered by rural areas may be many and varied. Often the problems are the same between urban and rural areas; the difference is one of degree. What is important in the planning context is to be aware of the actual and potential difference between and within regions or areas. In the Newfoundland setting, geography, demographic characteristics, and sparsely and varied population densities must be considered in the distribution of resources. It is not enough to evaluate specific needs and decide that resources should be distributed. The planner must know how and to whom he is distributing resources. Therefore, the analysis of demographic data relative to the rural-urban dichotomy must throw light upon and contribute to the development of organization and skills needed to handle the distribution of resources.
Appendix A

Footnotes

These footnotes have been cited in the text of Chapter III. Therefore the bibliographic entries for these footnotes are in Chapter III of the Bibliography.


5 Ibid., pp. 500-502.


8 Robert L. Kane and Sister Diane Moeller, "Rural Service Elements Fall Coordination," *Hospitals* 48 (October 1974): 79-83.

9 Black, pp. 91-95.
APPENDIX B

DETERMINATION OF SAMPLE SIZE
APPENDIX B

DETERMINATION OF SAMPLE SIZE

Without knowing the variance of observations, a sample from these observations cannot be determined without guesswork. As there are no studies in Newfoundland concerning estimates of error for population projections of health statistical districts, an idea of variance could not be obtained.

To estimate variance for the estimates of error which were organized to four population stratum a 25% random sample was taken from each stratum. The variance and standard deviation was calculated for each stratum.

It was anticipated that two sampling strategies would be employed. In the lower population stratum, variance and number of extremes were expected to be high. Further, the majority of observations would fall into this stratum. As a first strategy, this stratum was to be sampled independently of the remaining two stratum. Second, for the 2 larger stratum a sample size was to be determined and optimally allocated. Optimum allocation would allow weighting of both number and variance in determining what the appropriate portion of the sample should be assigned to each stratum.

Note that the 25% random sample to estimate the variance was returned to the set of observations. Subsequent sampling was random within each stratum.

The following formula was utilized to determine the sample size in the ±2999 population stratum and in the ±3000 population strata.
\[ n = \frac{4t^2S^2}{L^2} \]

where \( n \) = sample size

\( t \) = student's \( t \) value, .99 confidence level at degrees of freedom

\( S^2 \) = variance (\( S \) = standard deviation)

\( L \) = confidence interval at .01 significance

To determine the optimum allocation for each strata above 3,000 population the following formula was employed:\(^4\)

\[ n_h = \frac{N_h x S_h^2}{L \sum N_h S_h^2} \]

where \( n_h \) = sample size (optimum allocation) assigned to each strata

\( N_h \) = individuals in each stratum

\( S_h^2 \) = variance in each stratum

\( n \) = sample size already determined

The 25% sample produced the following values:

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<th>Population</th>
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<th>( SE )</th>
<th>( n )</th>
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<tr>
<td>(&lt;2999 )</td>
<td>17.59</td>
<td>2.49</td>
<td>50</td>
<td>193</td>
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<tr>
<td>(\geq3000 )</td>
<td>5.41</td>
<td>1.44</td>
<td>14</td>
<td>27</td>
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The confidence interval 10 (from 0% - 10%) is a desired range for the absolute value for each population projection error. The \( t \) value has been established at .005 for degrees of freedom.

The sample sizes which were determined are:

\(<2999 \) population - 83 (82.3)

\(\geq3000 \) population - 11 (9.6 10, readjusted to 11, see below)

The optimum allocation of the 10 samples from the \(\geq3000 \) strata are:
the 3000-9999 stratum was assigned 5 (4.1) and the 10,000 and over stratum was assigned 6 (5.9).
Appendix B

Footnotes

The following references have been cited in Chapter V of the text and have bibliographic entries in Chapter V of the Bibliography.


3 Feinstein, pp. 225

4 Freese, pp. 34-35
APPENDIX C

TEST FOR BIAS IN THE RANDOM ROUNDING PROCESS

EMPLOYED BY STATISTICS CANADA
APPENDIX C

TEST FOR BIAS IN THE RANDOM ROUNDING PROCESS
EMPLOYED BY STATISTICS CANADA

Signs

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<td>Males</td>
<td>98 (97.5)</td>
<td>113 (111.5)</td>
<td>86 (88)</td>
<td>297</td>
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<tr>
<td>Females</td>
<td>97 (97.5)</td>
<td>110 (111.5)</td>
<td>90 (88)</td>
<td>297</td>
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<tr>
<td>Total</td>
<td>195</td>
<td>223</td>
<td>176</td>
<td>594</td>
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\[ X^2 = .136; X^2_{593} = 2008.1 < .01 \]

Method: Age Sex Intervals for each subdivision were summed and compared with the total age sex population departures with the totals were recorded as: -, + and 0. All unorganized subdivisions were included.
APPENDIX D

ESTIMATES OF ERROR IN THE <2999 POPULATION STRATUM:

TO EXCLUDE UNSTABLE CENSUS DIVISIONS AND

ERRORS >20%
APPENDIX D

ESTIMATES OF ERROR IN THE \(<2999 POPULATION STRATUM:
TO EXCLUDE UNSTABLE CENSUS DIVISIONS AND
ERRORS \(>20\%\)

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<td>C. (&lt;2999 All Census Divisions All Errors (\geq 20%) excluded</td>
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<td>D. Summary of Errors (\geq 20%)</td>
<td>37</td>
<td>42.1</td>
<td>23.3</td>
<td>3.8</td>
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APPENDIX E

THE ARRAY OF ESTIMATES OF ERROR PLOTTED AGAINST POPULATION SIZE
Appendix E

Size of Error vs. Population Size

See Graph Insert
APPENDIX F

POPULATION PROJECTIONS FOR THE HEALTH REGIONS
## Appendix F

Population Projections For The Health Regions;

By Age and Sex, Newfoundland, 1976, 1981, 1986

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BIBLIOGRAPHY

The bibliography has been organized to the chapter level. The chief reason for this type of organization is that the references by chapter, naturally but neatly organize to subject headings. Following this schema, bibliographic entries which appear in more than one chapter will be abbreviated to a short bibliographic entry. If an author has more than one entry the short entry will give surname, short title and date. If an author has only one entry only the surname and date will appear. Both short entries indicate that the work(s) have been fully referenced in preceding entries.

Chapter I
Planning


"How Many Hospital Beds Does Virginia Need?" Virginia Medical (January, 1978): 73-75.


Newhouse, J. P. "Forecasting Demand and the Planning of Services."  


Chapter II

Population Projections


Bright. 1972.


Doyle, Rachel; Ziegler, Joseph A.; Grinstead, Mary Jo; and Green, Bernard L. "Estimating Hospital Use in Arkansas." Public Health Reports (May/June 1977): 211-216.

Fador, J. C., Epidemiologist. Department of Community Medicine, Memorial University. Personal Communication, 15 August 1979.


Harris, Daniel M. "Effect of Population and Health Care Environment on Hospital Utilization." Health Services Research (Fall 1975): 229-242.

Hill, 1974.


Navarro. 1969.


Chapter III

Bed Prediction and Resource Distribution


Brooks and Beenhakker. 1964.


Doyle, Ziegler, Grinstead, and Green. 1977.


Glass. 1966.


Navarro. 1969.


Pierce. 1966.


Umenyi. 1978.


Walsh, Diana Chapman, and Bickness, William J. "Forecasting the Need for Hospital Beds: A Quantitative Methodology." Public Health Reports 92 (May/June 1977): 199-211.


Chapter IV

Methods


Blumberg. 1971.


Chapter V

Estimation of Error

