THE UNIVERSITY OF CALGARY

A GIS Based Statistical Health Risk Model

For

Calgary Communities

by

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ABSTRACT

A community based health risk model was developed with the use of a Geographic Information System (GIS), census data and hospital records. This model was then used to explore the socio-economic context of community health status. The census data and hospital records were linked in the GIS to produce a matrix of values that were mapped and statistically analyzed for 164 Calgary communities.

Community socio-economic profiles were based on a Factor Analysis of the census variables that produced four major "dimensions" for the Calgary community populations. Average income, dwelling values and post-secondary education comprised the most influential variable that differentiate Calgary communities from each other.

Community Health Risk was determined on the basis of the most prevalent diagnostic codes of CRHA patients. Thematic maps indicated that although the patterns and level of health risk varied with each category, clear trends emerged. Higher values for non-maternal health risks were more densely distributed in inner city and lower income communities. However, maternally related classes of health risk did not have any strongly significant correlation with the location of communities, although there were some valid links with some census categories.

A multiple regression using each of the health risk categories as a dependent variable and the census data as independent variables highlighted the socio-economic factors that were most influential for each health risk category.

The thesis concludes with an analysis of the model's performance. Mapped residuals show that the "outlier" communities were mainly a result of the temporal difference in the two datasets. The model under-predicted health risk for communities that experienced substantial growth since the 1991 census because community health risk estimates are based on more recent and larger populations. Conversely, the model over-predicted for communities that had little or no health data for these specific health risk categories. Overall eighty percent of the communities had standardized residuals of 1 or less for the composite health risk category indicating that census variables are reasonable indicators of some health risk categories within the CRHA.

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1.0 INTRODUCTION

In Canada and elsewhere, health care systems are increasingly under pressure to do more with less. They must minimize population health risk while maximizing returns on diminishing health care system investment. This is especially challenging in view of evidence that direct increases in health care funding do not necessarily achieve commensurate improvements in community health levels once a certain threshold of service has been attained (MCHPE: 1993: 2).

Furthermore, the significant variability in the quality of population health has a direct relationship with the social and economic status of communities. The medical establishment, which has traditionally focused on complex diagnostic and curative procedures to "fix" individuals, cannot rationalize these large population health status variations (Evans: 1994: 4).

Research which focuses on the geographic relationship of places and population health can identify trends that would not otherwise be apparent when studying individuals (Evans: 1994: xiii). When community health is viewed in the context of population profiles, e.g., demographic composition and social status, it can provide important data on some of the inputs to health. A comprehensive understanding of the nature of community health must rely on information traditionally provided by the "medical establishment" as well as that attained through analysis of the "upstream" root causes of poor health (MCHPE website: 1997) and development of new tools to measure health (Mathur: 1991).

This thesis uses geographical and statistical methodology to research, assess and report on the socio-economic factors that determine the health and health risk of communities in the Greater Calgary Region (GCR). The findings will establish certain census data as predictors of local health risks and locations where particular health risks are concentrated.

1.1 Rationale for the Study

The significant changes in federal and provincial health care policy in the early 1990s resulted in the creation of 17 health regions in Alberta (see Figure 1.0). Alberta's current health policy reflects contemporary trends in health care modelling which shift the focus from financial inputs to system outputs, or more specifically, the collective health status of users. New clinical practice guidelines stress that treatment decisions be based on *"...documented outcomes of the available options"* and emphasize the importance of identifying the health risk factors and co-variants of health (Alberta Health, Annual Report: 1996: 3).

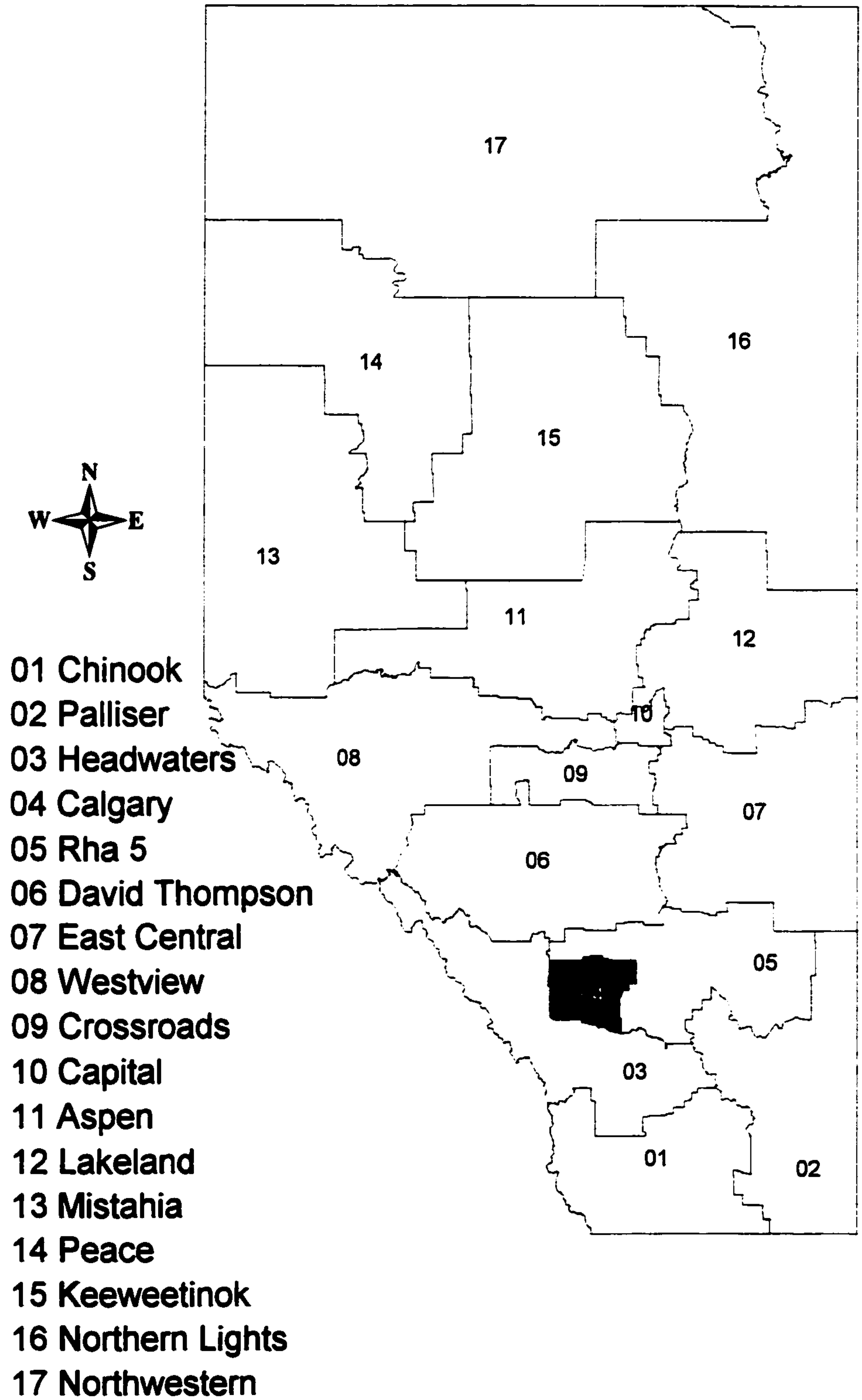
The new policies assume more locally responsive health care delivery systems by creating regional health authorities that assumed many of the spending responsibilities previously managed by the province. The regional focus is reinforced by a provincial per capita funding formula that is adjusted annually for age, gender and socio-economic status of populations within each of the health regions (Alberta Health: HSFAC: 1996: 20).

The Calgary Regional Health Authority (CRHA) was formally established in April 1995 and began its administration with a business plan that highlighted the necessity for a health needs assessment of its residents. The assessment findings were to be used to plan the delivery of future health services as well as to provide a baseline for future health assessments. In late 1994, a health needs assessment methodology was tested in a local pilot project that was expanded to a full regional needs assessment the following year. The latter assessment included an in-depth sample of evaluations by residents on the state of their personal health and their satisfaction with the Alberta health care system. The CRHA population health profile was developed using a variety of health status determinants such as life expectancy, cause specific mortality, Length of Stay (LOS) and diagnostic categories (CRHA: Health Needs Assessment: 1995).

Population health research relies, in part, on indirect measures of morbidity (a measure of wellness) to assess the state of community health. Alberta Health (1996) uses *health determinants* and *health status* as the two main types of indicators for its health assessment and planning. Health determinants measure the factors that directly and

Figure 1.0

Alberta Health Regions



indirectly influence the state of individual health. Table 1.0 lists five major categories of health determinants including some of the more widely recognized lifestyle and socio-economic factors such as income, education and employment (WHO: 1994; Lalonde: 1974; Evans et al.: 1994). Some of these are also good predictors of future health status and health care needs. For example, current lifestyle data on teenage smokers can be used to predict trends in their future health status and their likely collective health care needs.

Table 1.0

Summary of Commonly Used Health Proxy Measures

Health Determinant Indicators	Health Status Indicators
1) Age	**1) Mortality Rates**
	Cause-specific Deaths
2) Gender	Infant Deaths
3) Genetics	**2) Life Expectancy**
	Potential Years Lost (by early death)
4) Lifestyle	
Diet (quality, quantity, practices)	**3) Self Assessments**
Exercise (quality, quantity)	Disability
Alcohol, Tobacco Consumption	Morbidity
5) Physical environment	**4) Health Care Utilization**
Home, Work	Physician office visits
Air, Water, Food Quality	Acute care hospital stays
Climate	
5) Social environment	
Income Levels	
Education Attainment	
Employment Activity	
Cultural Practices	
Housing Standards	

The second indicator, health status, measures the *quality* of population health and traditionally includes proxy measures such as mortality statistics, morbidity data, patient self-assessments and hospital utilization records. Although mortality data are easier to acquire, morbidity data provide a better estimate of disease generation within communities (Giles: 1983). This conjecture is validated in diseases such as cancer where patients can move extensively during its long latency period and prevent correlations of community health quality with cancer mortality rates.

Other less conventional health status indicators, such as low birthweight newborns, may be used to predict health outcomes on the basis of likely health complications and developmental problems (Rivette, personal correspondence, July, 1997).

In Alberta, as in any jurisdiction with responsibility for delivery of health care, there exists a critical need to know the extent, location and nature of adverse health trends. Application of geographic analysis and statistical techniques to social, demographic and health risk trends within specific regions provides health administrators with a deeper understanding of the interconnections between health and social conditions within communities. By working with a model that profiles and identifies high health risk communities, planners can more effectively provide routine and special health services to those in need.

1.2 Objectives

The main objective of this study is to determine if census data variables are reliable indicators of health risk in Calgary. The basis of the assessment is an analysis of 164 Greater Calgary Region (GCR) communities.

To achieve the objective, the following three main questions must be answered:

1) Is there a statistically significant correlation between health risk and socio-economic characteristics in the GCR populations?;
2) If there is a clear correlation, which communities are the most at-risk?; and
3) What are the particular population characteristics of the high-need, high health risk communities identified by the model?

This study builds on the findings of other population health researchers who confirm a link between poverty and individual health. Within the CRHA, the existence of a similar link, although suspected, has not been unequivocally confirmed. Although the socio-economic data collected was not analyzed during the 1995 CRHA Health Needs Assessment, the same report determined that within the CRHA, 46% of single mothers, 19% of children and 26% of seniors live below the poverty line (CRHA: 1996: Health Needs Assessment: 27).

1.3 Methodology

A Geographic Information System (GIS) was used to consolidate census-derived variables with hospital data, to assist with the statistical analysis of the relationship between population profiles and hospital use data, and then to prepare graphic presentations of the findings.

The research premise is that there is a significant link between health and socio-economic status. This study tests the validity of using accepted social status indicators to predict health status using multivariate analysis techniques. The health status measures are based on hospital use data that include hospital stays of one day or more. If the associations between hospital use and socio-economic indicators are statistically significant, then it is reasonable to suggest that census data can yield reliable health status indicators which can then be used to predict future health care service needs.

The selection of appropriate indicators was based on specific criteria for both data categories. A range of census-derived social status indicators that would accurately profile Calgary communities was chosen after an extensive review of the urban ecology literature. The indicators had to have sufficient variability to enable *differentiation* of communities from one another. A factor analysis was then applied to the selected indicators to verify their suitability for distinguishing Calgary communities.

The selection of appropriate hospital records-derived health status indicators was based on slightly different criteria. Hospital use categories were chosen for their perceived *sensitivity* to the social class of the patient. Appropriate indicators were chosen after a medical geography literature review, which focused on discussions of health status indicators, particularly in Canadian populations, and personal correspondence with CRHA personnel.

The census data and hospital records, were transformed and merged into compatible spatial units by use of the MapInfo GIS (MapInfo: 1995) in preparation for statistical analysis. A factor analysis of the census dataset highlighted the main differentiating community characteristics and contributes to and informs discussions of the results in the later chapters. Finally, linear regression equations that employ census variables as "predictors" of health risk was used to produce relative health risk values.

1.4 Statement of Philosophical Intentions

The study is exploratory in nature and conforms to the accepted standards in population health research by applying the scientific method. The rationale for this approach is considered with respect to both an indepth review of the philosophy as well as a consideration of other, alternative approaches.

The Positivist Approach

Broadly speaking, the scientific method is applied for two main reasons. One is to ascertain and discover facts about the subject and its processes, and the other is to construct hypotheses and theories in order to explain them (Von Wright: 1971: 1).

Most current research in medical geography is empirical in nature, and rooted in the philosophy of scientific understanding, logical positivism, and its associated methodology, "the scientific method" (Mayer: 1992). This approach informs the development of empirical and deductive science methodologies including those employed by medical geographers (Johnston: 1986).

The positivist approach is ideally suited to medical geographers, particularly epidemiologists, because their deductive techniques are based on descriptions of disease patterns which are observable, replicable and presumably, controllable. In population health research, the postivist approach is uniquely suited to identification of disease patterns, the recognition of causal relationships and the prediction of resulting phenomena.

Alternatives to the Positivist Approach

According to Bennet (1991) medical geographers seldom recognize the deeper philosophical significance of their technological and methodological concerns. Philosophical perspectives such as phenomenolgy, political ecology, and marxism are less commonly employed in epidemiology but can enhance the scientific method because they depend on more than strictly "observable and verifiable facts" (Mayer: 1992: 583). In a philosophical approach, the goal is to penetrate the surface and to uncover processes and structures which are not immediately apparent in order to provide explanations.

Phenomenology

The phenomenological approach emphasizes the importance of perceptions, feelings, and thoughts of individuals to the study. The perspective is inherently subjective because it relies on the interpretation, of both subject and researcher, of their environments. The most appropriate techniques to record subjective experience include open-ended interviews, dialogue, literature, art and music.

Though the phenomenological approach is infrequently used in geography and rarely in epidemiology, Mayer (1992) contends that it should be synthesized with the positivist approach in order to enhance research results. Although the positivist tradition dominates studies of the distribution of disease, Mayer argues that the experiential nature of disease is also important. This is confirmed by clinicians and community health workers who know that the way in which individuals experience diseases is to a large extent socially and culturally conditioned (Stewart et al: 1983: 233-245).

Kleinman's (1978) models of health care are distinguishable by their unique socio-cultural system of beliefs, values and norms. Within each of these frameworks though the disease and illness aspect of sickness are separate. Illness is defined as the way a person *experiences* sickness within a complex universe of symbols and meanings. The main assumption is that perception of illness by different cultural groups is determined by their personal interpretations of the meanings assigned to human-environment interactions.

Political Ecology

The Political Ecology approach is a more recent intellectual trend in the social sciences which attempts to merge the influences of politics, political economy and ecology (Mayer: 1992: 583). It is an interpretive approach in that it penetrates a set of observable phenomena and attempts to give relational meaning to causal mechanisms, not immediately apparent, by examining the environment in a social and political context.

Within this framework, the state and social relations exert subtle influences on the environment. In attempting to explain the patterns of disease the economic social and political determinants of health are considered and share many of the same arguments as social medicine (Mayer: 1992: 583). Applications of this method are appropriate to large regional development projects such as the Aswan Dam in Egypt. Despite the predictable health risks, the priorities determined by political ideology and initiated by political process resulted in severe environmental changes. A large regional environment was modified in response to political and social influences and the environmental modifications result in increased disease rates.

Realism and Structualism

Realism deals with fundamental structures and processes as well as those hidden from positivist observation. From the realist perspective, causal explanations are based on the discovery of regular relations between phenomena and the mechanism which links them. To accomplish this the underlying mechanism of the phenomena must be understood (Keat R. and Urry, J. 1982). The realist philosophy proceeds from "*...a world view that accepts the existence of social structures that both influence and are influenced by the actions of individuals*" (Lawson and Staeheli: 1990: 20).

Structualism and realism consider the interactions between society, groups and institutions when developing theories of explanations. The social and political processes are the basis of understanding the fundamental processes and the approach is similar to political ecology. A Marxist interpretation goes further than realism and political ecology by considering social class, political power, domination, and subordination to explain a phenomenon such as disease distribution.

Conclusion

In medical geography and population health research there is no substitute for the scientific method in identifying and recognizing patterns and for establishing statistical causation. The scientific method ensures replicability, objectivity and observation. However, other alternative outlooks such as phenomenology, realism, and structuration are available to enhance the understanding of the positivist approach to health assessments. Mayer (1992) argues for a synthesis of positivism with the strengths of other philosophies to identify processes that lie beneath the surface phenomena in order to enhance population health research. However, this study is considered exploratory in nature and therefore only employs the scientific approach. Future research in this area might well be enhanced by the other approaches discussed here.

1.5 Outline of the Study

This thesis has seven chapters. Chapter 2 is a brief historical account of important related developments in medical geography and the methodological trends in modern population health research. It provides the background and context for the study.

Chapter 3 includes a description of the data sources and the treatments required to prepare them for analysis. A conceptual framework of the health status indices is provided along with the final table of index values listed by the 164 Calgary communities.

Chapters 4 and 5 provide analytical descriptions of the two main datasets. These two chapters establish the frame of reference for the statistical analysis that follows in Chapter 6. The hospital records are summarized by categories used in the statistical analysis. Barcharts and tables support the mapped distribution of hospital-use categories. The factor analysis described in Chapter 5 includes an assessment of the community characteristics in order to identify discernible "dimensions" which distinguish communities from each other. An account of each of the main differentiators is provided along with maps showing their locations.

Chapter 6 recounts the multiple linear regression results for each of the individual and the composite health risk indices. The residuals from the composite health risk equation are mapped and discussed as a critique of that health risk model's performance.

Chapter 7 is a formal interpretation of the results of the analysis and a discussion of the broader implications of the study. All references are listed in Chapter 8, and the appendix details the census variables described in Chapter 3 and Chapter 4.

2.0 BACKGROUND OF THE STUDY

This chapter offers a brief overview of some of the relevant literature on medical geography and population health research in order to provide context and background for this study. Particular emphasis was placed on Canadian population health studies. The Manitoba Centre for Health Policy and Evaluation (MCHPE) at the University of Manitoba has one of the most comprehensive health information systems in North America and their published reports provided valuable direction for the methodology used in this project. The decision to pursue a population health related project was due as much to the opportunities created by the massive restructuring in the federal and provincial health care sector, (discussed in the previous section) as it was due to the desire to make a contribution to the field of Canadian population health research.

2.1 Medical Geography (Historical Themes)

The Ancient Greeks were the first to document their observations on the geographic patterns of health problems and their writings continued to influence medical geography throughout the ages. In fact, until the middle of the nineteenth Century, physicians were still inspired by a medical treatise, *Airs, Waters and Places* written by Hippocrates over two thousand years ago (Dubos: 1980: 39; Larson: 1985: 6).

Today, the spatial perspective of medical geographers continues the tradition of focusing on the areal aspects of health, disease, and health care issues. In the last two centuries, major thematic transitions in medical geography have accompanied the rapid advances in medicine and health care. The result has been a gradual shift in focus from regional studies of disease-ecology and mapping to population-based studies heavily influenced by the social sciences (Paul 1985; Pyle: 1979: 3).

Regional health studies postdated the invention of the microscope, the discovery of viruses and the understanding of contagious diseases. Nevertheless, James Lind's (1768) treatise was a comprehensive study of the site, location and the characteristics of places so that "*...observant men could and did make meaningful recommendations that reduced morbidity and mortality*". Although the specific causes of diseases were poorly understood at the time, Lind recognized the associative occurrences between "tropical fevers and fluxes" and insect transmitted diseases and his ecological study provided the measures to help avoid malaria 125 years before its cause was known (Barrett: 1980: 352).

Similarly, disease diffusion maps such as those produced by Seaman and Pascal in 1798 plotted cases of yellow fever in New Slip, New York using simple cartographic techniques to produce dot maps. Little has changed in the basic methods used by medical geographers for Disease Mapping, except for the use of modern digitizing techniques and Geographic Information Systems (GIS) which allow automation and significantly more information to be added to the maps (Paul: 1985).

John Snow's 1853 study of Cholera used a technique of associative analysis to identify disease risk factors. Snow was a London physician who began to plot the distribution of cholera deaths and discovered that the majority of the victims lived within a specific city block and all had drawn their water from the same source (Eyles and Woods: 1983: 80).

In the early 20th Century, the transition from regional mapping to more in-depth examinations of health-related factors was enabled by the growth of knowledge about the causes of contagious diseases. As evidence of environmentally caused illnesses accumulated, works focusing on diseases of the industrial cities began to appear. The link between health and social conditions became well established during the industrial revolution when medical geographers began to focus on the health problems of specific cultural and subcultural groups. Roundtree's (1901) study of York, England placed considerable emphasis on the associations between poverty and health and concluded that the contemporary unsanitary conditions in which the lower class workers lived was the main contributing risk factor in the spread of disease (Pyle: 1979: 5; Paul: 1985).

The first report of the Commission on Medical Geography, May (1952: 2) identified population distribution, population density, and standard of living factors such as housing, diet, clothing, sanitation, and income, as the socio-economic influences that most profoundly influenced human health.

Today, medical geographers employ a multitude of approaches and apply a vast array of analytical tools to the research of health issues. Pyle (1979: 5), a noted medical geographer who has written extensively on the subject, uses several spatial and conceptual approaches encompassing the environmental, genetic, epidemiological, sociological and socio-economic sciences to study medical health problems. He defines medical geography as "*...the spatial analysis of most aspects of human health problems, so long as there are geographical variations in time and space, whether related to naturally occurring or artificial environment*" (Pyle: 1979: 9).

2.2 Statistics and Geography

Regardless of the conceptual approach, medical geographers largely depend on scientific methods for their conclusions. The statistical methods commonly employed, evolved from earlier political analysis methods that relied on record keeping to gauge the performance of government state functions. This *statist* tradition evolved from the works of seventeenth century English political arithmeticians such as Gaunt and Petty who pursued the idea that social problems could be subjected to quantitative analysis, and that causal relationships existed between these variables. The term "statistics" was coined to describe this analysis of the characteristics of a state (Berry and Marble: 1968: 2).

Quantitative methods in geography flourished and in 1871, when the American Geographical and Statistical Society dropped "and Statistical" from its name, their statement of objectives retained "*...the collection, classification and scientific arrangements of statistics and their results ... collection and diffusion of geographical, statistical and scientific knowledge*" (Berry and Marble: 1968: 2).

"Statistical description" later emerged as a tool in urban geography to provide unbiased summaries of spatial variations within cities using rigorous, quantitative methodology. Charles Booth provided detailed interpretations of the data collected on urban poverty in late nineteenth century London. Later refinements of these methods gradually evolved into the contemporary techniques for measuring various "dimensions" of community characteristics (Davies: 1975: 234). Current methodologies are derived from the works of Shevky and Bell (1955) who first documented "dimensions" of populations based on the Los Angeles and San Francisco areas' intra-urban census tract data (Johnston: 1979: 79). According to Shevky and Bell, increasing levels of economic development in societies inevitably lead to occupational differentiation. Social stratification follows and manifests itself in a wider range of lifestyles, changed family roles in society and population redistribution (Johnston: 1973: 79; Shevky and Bell: 1955).

The major dimensions of differentiation within communities in developed countries and particularly in large cities, are socio-economic with the most obvious indicator being residential location. The desirability of living in certain communities is reflected in part by the prices people are prepared to pay for housing. Because social stratification is characterized by variations in income, this ensures that only higher income groups can afford to live in the more expensive areas. Thus, property values and dwelling styles are widely accepted as measures of community prestige. They are also widely used indicators of socio-economic differentiations between population groups because they are easily measured and remain fairly constant for decades, even though residents may change several times over (Johnston: 1979: 79).

2.3 Population Health (Current Themes)

Medical geographers who study health status variation between regions and communities conduct population health research at various scales, ranging from the global to the local community. By studying population groups that differ in geographic location, culture, occupation, education and social class, inferences can be made on determinants of health that are not apparent when studying individuals (Evans: 1994: xiii). In both public and private sectors, comprehension of population distribution, composition and changes at the macro and micro scales is critical to making health management and planning decisions (Plane and Rogerson: 1994).

Measuring Health (Indicators)

In population health research, conceptual problems begin with attempting to define and measure human health and with identifying the full range of factors that affect health quality. Although there is little doubt that the effects of environment which are hazardous, contaminated, or stressful, are likely to reduce the quality and length of lives quantifying their effects on health status poses immense challenges (Lomas and Constandriopoulos: 1994).

Audy (1971: 143) defines health as *"a continuing property that can be measured from a wide range and considerable amplitude of insults; the insults being chemical, physical, infectious, psychological and social"*. According to this definition, health is a dynamic quality that varies in degree until death. However, scientific methodology demands an objective definition of health that enables researchers to measure its quality and quantity; measure how the environment affects it; and assess various health service alternatives.

Conflicting evidence and opinions on the contributing factors of health and illness complicate assessment of health quality. A host of "environmental insults" may be responsible for a particular health condition, or alternatively, a single environmental factor may trigger a multitude of health symptoms. Assessment is further complicated by the interaction between the contributing factors; environmental, genetic and congenital, which make precise diagnosis difficult. Also long time lapses, sometimes years, between some causes and their effects makes quantitative evidence difficult to accumulate (Evans: 1994: xiii). This general lack of "scientific proof" in health research has, until very recently, enabled the tobacco industry to defend its trade even though a link between cigarette smoking and lung cancer was established over 40 years ago (CMA website: http//www.cma.ca/canned/policy/1997/tobacco.html).

Health Outcomes

Because the "wellness" of a patient or a population is difficult to quantify and reliable morbidity data is scarce, proxy measures of health outcomes are used for comparative health studies between populations. These outcome measures include census and vital statistics, diagnosed disease data and cause-specific mortality and life expectancy estimates among others. Cause-specific and infant mortality rates are the most widely used measures because *"Reliable and continuous morbidity data are harder to get than mortality data simply because in our society dying is a legal event, being ill usually is not"* (Bennet: 1991: 340).

Although they offer little information about morbidity (one measure of health quality) at the time of death, mortality statistics have the advantage of being absolute and not easily manipulated (Plain: 1996: 8). Other measures of health status include morbidity, hospital-use and health surveys that record subjective self-ratings of individual health (Roos et al.: 1996: 23; Alberta Health, Evidence Based Decision Making: 1995).

2.4 Health Determinants

The range of potential and proven environmental influences on health is immense but can be generally categorized into two main groups; i.e., the physical environment and the social environment. Although these are convenient classifications, the high degree of inter-relatedness among influences makes them somewhat ambiguous.

Physical Environment

The physical environment affects humans in two ways. One is by direct contacts that affect physical comfort and includes factors such as the quality of air, food and water. The second way the physical environment affects humans is by indirect contact. The environmental conditions such as seasonality, climate and elevation that directly influence our comfort level, also shape the habitat for disease-causing agents. Lind's (1798) regional ecological study is a classic example of the exploration of interactions between humans and their physical environment. Modern themes in related types of ecological studies, such as the areal geographic variation of nutrition in developing countries, are heavily influenced by the political and social sciences. The link with the ecological approach is through the physical factors involved with nutrition such as topography, soil, and climate.

Seasons

Greek and Roman physicians were aware that the health of individuals was intimately linked to the seasons and depression was thought to be a kind of internal darkness that corresponded to the shorter, darker days of winter (Rosenthal: 1989). Seasonal effects on morbidity trends are today covered by research on Seasonal Affective Disorder (SAD), a depressive condition that is caused by insufficient natural light. Winter depression is aggravated by the short days of winter and prolonged overcast periods

(Booker: 1992). Canadian mortality trends examined by Kevan and Chapman (1980) show that death rates are highest in the winter months of December to February and lowest during the summer months of August and September. Most industrialized western countries show similar trends. As would be expected, the incidence of winter SAD symptoms increases with latitude. Populations in Fairbanks, Alaska have a higher incidence of the disorder than populations at latitudes south of the 45th parallel (Booker: 1992; Rosenthall and Blehar: 1989).

Social Environment

The effects of the social environment on human health comprise "*chance occurrences, and improvements to the environment, including nutrition, housing sanitary conditions, and standards of living...*" (Bennet: 1991: 341). Overall health risk includes factors over which individuals have no control such as the "chance occurrence" of demographic membership. Other factors, which are to a large extent established at birth, are in fact, ameliorable during a person's lifetime. Social and economic environments, and other lifestyle influences can be improved by individual and societal efforts (Renauld: 1994).

Social Status

Social rank has one of the most powerful statistical correlations with health status. In developing countries, population segments with the lowest socio-economic status whether the measure is income, education, occupation or residence are the least healthy and live shorter lives, while those in the top social ranks are the most healthy and live the longest (Evans: 1994: 3).

Federal Health Minister Lalonde's (1974) report, *A New Perspective on the Health of Canadians*, identified four main health risks to Canadians;

- Physical Environment – conditions and quality of life at home and work
- Access to Health Care – distance and mobility of patient
- Lifestyle Choices – diet, tobacco use, alcohol consumption and physical exercise
- Heredity – susceptibility of individuals to certain health risks

All of these health risks are conditioned by social rank, including a predisposition to ailments such as heart disease or cancers which results in reduced mortality rates for the higher status populations (Marmot and Mustard: 1994).

Health Minister Epp's 1986 sequel to the Lalonde report, *Achieving Health for All,* emphasized the role of social status by focusing on the two most detrimental factors in Canadian healt: poverty and Aboriginal status. The report concluded that poverty increased mortality averages by 5.5 years for men in the lowest tenth percentile income category compared with men in the top tenth percentile. More alarmingly, Canada's First Nation populations experienced double the infant mortality rate of other Canadians (CMA: 1992: 4). Moreover, these inequalities persisted, despite the fact that universal, prepaid access to medical care has been in place since 1971. The report suggested that the greatest improvements to the quality of life for natives in settlements and on reserves would occur, not by better access to health care, but when issues such as poverty, unemployment, alcohol and substance abuse, substandard housing, high suicide rates, child welfare and family violence are satisfactorily addressed (CMA: 1992: 22).

Health gradients between the social classes seem to persist even after epidemiological transitions occur within regions. The Black report (1988) has recorded mortality, separated by social class, in Britain for most of this century. In the early 1900s, death from infectious diseases was the greatest killer, and the lower social classes suffered the highest mortality rates. Heart disease and cancer are currently the main causes of mortality in the U.K. and the lower social classes continue to suffer the highest rates (McKeown: 1979). Although the disease patterns change, the gradient persists and reinforces the theory that there is an underlying influence on mortality and morbidity which is associated with economic hierarchy and which expresses itself through the incidence of particular diseases (Evans: 1994: 9).

Demographic / Life cycle

In all industrialized countries, age and gender are the main demographic variables that determine the health risk of individuals. When measured by health service utilization, overall hospital use is higher for infants, women during their reproductive years and for the elderly (Alberta Health: HSFAC: 1996: 11). The high level of use for infants and females during their reproductive years is a reflection of the fact that most birth-related services are dispensed through hospitals. The sharp increase during the senior years suggests that aging is accompanied by deteriorating health and a higher need for hospital services.

When separated by age and gender, the *types* of health risk also differ. Very young children and boys in particular, are most susceptible to being victims of burns and poisoning while men, manual workers and young car drivers are most at risk for trauma events. Seniors' overall health risk increases with their age and they become more susceptible to illness than trauma while their chance of recovery is generally lower than the other age groups (Beland: 1990: 58).

Even marital status may affect health risk. In a US study on the effects of marital status on hospital usage, single people had a higher admittance rate and longer stays. Two explanations emerged: one was that the incidence of illness differed between the two groups and the second suggested that clinicians are more likely to admit and keep single patients longer because they believe the patient has an inadequate support structure at home (Butler and Morgan: 1977).

Culture

There is sufficient evidence to support a theory that there are inherent health risks associated with cultural lifestyle that, in turn, determine individual health risk. Epidemiological studies of recent immigrants show that those who adopt the local social habits also take on the disease patterns of the host country (Marmot: 1975). Studies of Japanese in Hawaii, California and their home islands, indicate that successive out-migrations experience greater risk for heart disease than the remaining populations (Marmot and Theorell: 1988; Marmot and Syme: 1976).

Even more compelling evidence of the link between cultural lifestyle and health is found in Japanese population health status transitions. Since 1960, Japanese mortality statistics have improved from a position markedly below most North American and European countries to markedly above them. Increased longevity of the Japanese does not appear to be due to better medical care, physical environments or diet, as these variables have not changed as drastically as their health status. However, it is quite likely that the country's increased per capita wealth, relative to the rest of the world, which resulted from profound post-war cultural and economic transformations are responsible for the improvements (Evans: 1994: 15).

Access to Health Care

Although inadequate access to health care is not a major contributor to poor health, it may threaten the health of society's more vulnerable populations. As in most countries and in other provinces, Alberta's health service utilization rates are higher for lower socio-economic groups (Alberta Health, Annual Report: 1996). Notwithstanding the debate on the relationship between health care needs and health service usage, the level of medical service utilization is a recognized indicator of health status. Therefore, the higher use of health services by low socio-economic groups, particularly in urban areas, is recognized as valid evidence of need (Eyles and Woods: 1983: 160).

In both rural and urban areas, a higher health risk caused by inadequate access to health care may be due to a variety of conditions that are largely influenced by social status. Distance compounded by lack of transportation affects the elderly, the poor, and the physically and mentally handicapped, particularly in the absence of good social support structures. Distance between patient and health services affects utilization rates in metropolitan areas where hospitals are near deprived and working class sectors. In low-income neighbourhoods, hospital utilization rates are higher where public transportation is good and lower where public transportation is poor (Beland et al.: 1990). For mothers with preschool children, with no access to a car during the day, public transportation may still pose difficulties. Poor bus and train designs that do not accommodate strollers and otherwise impede mobility, effectively discourage trips beyond a comfortable walking distance (Coupland: 1982).

2.5 Canadian Health Models

Proxy measures that are used to assess health inputs and outputs are increasingly being used to predict future health care needs and to plan and measure the performance of health care systems (Evans et al.: 1994; Alberta Health: 1995: 28). For national scale population health studies, American and Canadian policy analysts use proxy health measures and apply microsimulation techniques to model the effects of proposed policy changes (Citro and Hanushek: 1991: 101). At Statistics Canada, population analysis methodologies and computer programs are customized to focus on specific demographic sectors. The POpulation HEalth Model (POHEM) generates statistics on health status, including health expectancy adjusted for 'disability free' status of populations. POHEM is used to analyze 'what if' scenarios such as the potential years of life lost due to various factors such as smoking, drinking or other risky behaviors (Wolfson: 1990: 19).

A provincial scale Population Health Information System (PHIS) developed at Manitoba's Centre for Health Policy and Evaluation (MCHPE) measures the efficiency of that province's health care system by comparing health proxy input with output measures. It is designed to focus on the link between health care utilization and health outcomes in order to gauge how well the health care system produces "health" in the Manitoba population. Health status indicators, which capture various dimensions of regional health, are generated from administration data, vital statistics and hospital discharge records. The system is population-based and identifies socio-economic characteristics that co-vary with specific health risks (MCHPE: 1994). The socio-economic characteristics are used as proxy measures of health inputs for comparison with actual health outcomes.

2.6 GIS in Health Research and Planning

The unique and evolving capabilities of GIS provide population health researchers with new and highly effective ways to examine their health data. The system allows otherwise incompatible datasets to be incorporated into geographically referenced databases. New information can be derived from complex queries that use mathematical or geographical operators for graphical and mathematical analysis. The ability to support statistical and exploratory analysis and spatial modeling makes GIS an important tool for addressing significant health issues at the international, national and local level (Clarke et al: 1996).

One of the most useful functions in GIS for dealing with demographic data and address matching is geocoding. Street addresses or postal codes represented by points can automatically be placed into an administrative unit. This provides a means to link an addressed dataset to any other geographically referenced database. Health statistics can be incorporated from a wide range of administrative bases such as census units, land management units or provincial health authorities, and re-aggregated to or from almost any spatial unit (Gesler: 1986).

A GIS relational database allows queries to be based on value or spatial attributes whether they are being used for disease prediction or health resource allocation. A researcher wishing to create a subset based on elevation, vegetation or temperature could focus on known habitats of specific diseases. A researcher wishing to analyze health care resources could base the search on population characteristics, available resources, or by distance from a specific health service centre.

Health Risk Analysis

The dependence of epidemiology on maps to visualize associative occurrences between environment, humans and disease makes it ideally suited to GIS analysis. In addition, GIS applications in public health monitoring, and health care administrating which utilize multi-source data are building on methodologies already established in "business geographics" (Clarke et al: 1996).

Disease Prediction

Landscape epidemiology analyses the interactions between humans and the environmental determinants of diseases (Meade: 1977; Beck and Wood: 1995) which include elevation, temperature, precipitation and humidity. Vegetation type and distribution are also influenced by these environmental factors making them good predictors of diseases with an environmental component. GIS provides innovative tools for disease surveillance because of its ability to integrate remotely sensed information at a variety of scales and over large areas. This enables landscape-disease relationships to be identified and mapped over large areas so that responsible health agencies can target resources where they are most needed. The National Aeronautical and Space Administration's (NASA) global monitoring program identifies environmental factors that affect the patterns of disease risk and transmission by combining remotely sensed data and GIS technologies for malaria surveillance and controls in Chiapas, Mexico.

Public Health Monitoring

GIS models are also used to express the relationships between people and places in order to understand spatial diffusion of disease and social problems. These spatial interaction models analyze and predict the movements of people, information and goods from place to place and are widely used to identify high-risk areas for disease transmission and for targeting intervention efforts (Meade: 1988).

By linking health administrative data and socio-demographic information, health assessment based on spatial variation can also provide readily interpreted information for resource allocation. In a study of geographic variation of low birthweight risk in the city of New York, the "clustering" of occurrences in low income areas revealed high risk locations where prenatal health care services were inadequate (McLafferty and Tempalski: 1995)

By examining health statistics in relation to high risk sites, the Agency for Toxic Substances and Disease Registry is able to establish the spatial relationships of cancer and birth defects' distribution with respect to known radiation sites. Health statistics are reviewed and a spatial analysis of both disease patterns can determine if proximity to the contaminated sites is related to higher incidences. Assessment of the radiation sites relative to neighbourhood characteristics such as income, rent, housing value, poverty and high school education reveals that most of the high risk sites are in low socio-economic areas (Waller: 1996).

The University of Connecticut merged census information and power utility information to study the relationship of leukemia risk to the electromagnetic fields generated by power transmission lines. Data on location of transmission lines, street networks, public and private schools and the distribution of children under 18 were merged and analyzed to correlate risk factors with disease incidence. The resulting maps include exposure fields and the child population living or attending school within these fields, although findings of the study have not been released (Barnes and Peck: 1994).

Health Care Planning and Utilization

GIS techniques for selecting health facility sites and allocating health resources differ little from programs used for retail site location and marketing. The utility of GIS in site location stems from its ability to analyze many variables more quickly and efficiently than would otherwise be possible. Information on facility size, distance to current location, land use characteristics, site availability, slope, and infrastructure can be combined with demographic information including trends and projections to create a weighted ranking system that is used to evaluate site alternatives and model potential scenarios (Barnes and Peck: 1994).

2.7 Summary

The preceding literature review highlights the historical trends in medical geography as well as more recent developments in population health research in this century, particularly in findings emphasizing the relationships between health risks and the social-economic and cultural environment. Profound changes in the outlook on health and health care have occurred in this decade and can be traced to the downsizing of the health care system, and evolving paradigms in health care administration which focus on health rather than facilities. Population health researchers recognize the complex relationship between socio-economic status, health status and health service utilization although the dynamics are poorly understood. The current drive to understand these connections is stimulated to some degree by the obligation of health administrators to improve the outputs (health) of the health care system at a time when resources are severely strained (CRHA: April 1996).

The current trends in methodologies of Canadian population health research, particularly of medical geographers concerned with the relationships between human health and social environments, provide the precedents and rationale to support the objectives of this study.

3.0 DATA PREPARATION

This chapter describes the manipulations that were necessary to prepare the two original datasets, i.e., CRHA hospital records and Statistics Canada Census data, for the statistical and geographical analysis. The hospital-use variables were extracted from the CRHA hospital records and are the basis of the health status indices. The socio-economic variables were derived from Statistics Canada census data and comprise the social status indices.

Measures of social status capture many of the preconditions that place individuals at-risk for poor health (Frolich and Mustard: 1994; Plain: 1996). Therefore, social status indicators are widely considered to be reliable predictors of health service utilization because they demonstrate correlations with medical service and hospital care utilization. Although their degree of association is not well defined (Carstairs and Morris: 1991), the Manitoba Centre for Health Policy and Evaluation (MCHPE: 1994) and Alberta Health endorse the use of census indicators and hospital-use profiles to measure health status (Young et al 1991; Roos and Roos: 1994; CRHA: 1995).

The main reason for using these types of administrative data to assess population health status is that they already exist. Since they provide data for virtually all members of their population, the assessments can be relatively comprehensive. Traditional health surveys are extremely intensive in terms of time and cost, and may take several years to produce results. This is particularly true for large-scale studies at the provincial or national scales. At the community scale, data sources appropriate for assessing health status are often limited or nonexistent. Therefore reorganization of broad-based, systematically collected data can be the most economical method. Another advantage of using existing data instead of surveys is that the research can be more easily repeated over time, which can be useful for analyzing changing population health status or epidemiological transitions (Deyno et al: 1994: 2083S).

The main disadvantage of using administrative data is that the data can often be highly generalized. Many of the "lifestyle" and behavioural factors (such as smoking, diet and exercise) that are known health risk factors are not included or quantified and therefore cannot be known nor subsequently assessed. However, the existence of such behaviours can often be inferred to some extent from the diagnosis and their established relationships with those factors (e.g. lung cancer, high blood pressure, heart disease). Another disadvantage is that, unlike health surveys, the investigator has no control over composition or quality of the data elements that comprise the database or of the data collection methods (Deyno et al: 1994: 2084S).

Using administrative data to develop a predictive health risk model is further complicated by uncertainties. The main difficulty is deciding which measures should be included in the analysis. Canadian census data has over 200 variables that can be considered potential health status predictors and there are at least as many proxy health status indicators that hospital administrative data could yield. The objective assignment of weights to the individual socio-economic and health status variables is another problem. Not all health determinants have the same degree of influence on health and not all variables are equally or consistently valid or useful as predictors (Evans: 1994: 12).

Notwithstanding these uncertainties, this study builds on the findings of current population health research. The selection of variables was based on previous results then tested to determine which socio-economic characteristics were valid indicators of health status for Calgary populations. The usefulness of census variables for predicting health status was measured by correlating census-derived social status profiles with hospital-use profiles of the Calgary patient population.

3.1 Data Sources / Software Tools

The community socio-economic characteristics used in the present research were derived from Canadian national census data while the hospital-use profiles were based on Calgary Regional Health Authority (CRHA) hospital records. Computer analysis, using statistical and GIS methods was performed on the two datasets to produce a predictive model of health status for CRHA patients. The following is a summary of the datasets, software tools and hardware that were used for this project.

The Data

CRHA 1995-96, Acute Care, Inpatient Separation Records

These records were provided by the CRHA's Corporate Data department and were used to create the hospital-use profile, an important health status indicator, for each community. Patient records contain basic demographic information, such as age and sex, and health status information such as diagnosis and length of stay. The records include all patient overnight stays in a CRHA hospital between April 1, 1995 and March 31, 1996. In order to maintain confidentiality, specific identifying information such as the patient's name, address, health history, SIN, hospitalization number, were not provided.

1991 Statistics Canada Population Census Records

The data source for the socio-economic status indicators used in this analysis is the 1991 Census of Populations (P-Census) that was compiled and published by Statistics Canada (Statistics Canada: 1991). These records were retrieved from University of Calgary's census database via the MacKimmie library computer terminal and were used to create the socio-economic profile, an important health status *predictor*, for each community. Population census records contain important social, demographics and economic information such as income, education, and housing.

Digital Map Layers

The digital mapping layers are the equivalent of map "transparencies" where different physical or social aspects of an area such as community bounds (boundary files), roads (line files), or hospital locations (point files) are each stored as a separate layer. Each of these map layers are files containing both the graphic elements and a table of their associated elements such as enumeration area number, or community name:

Boundary files	1)	Alberta Enumeration Areas (EA) retrieved from the University's database
	2)	Greater Calgary Region (GCR) communities provided by CRHA, Corporate Data
Point file	3)	Alberta postal codes provided by CRHA, Corporate Data

These three map layers provided the framework for computer statistical analysis and mapping of the community indicators.

The Software

MapInfo GIS, Version 4.02 for Windows '95 (MapInfo Corporation)
This desktop GIS and mapping tool is the platform that was used for restructuring the data, the geographic analysis and generating thematic maps.

SPSS Version 6.1 for Windows '95 (SPSS Inc.)
Statistical software that was used to define and edit the data as well as for statistical analysis and data management.

Microsoft Excel '97 (Microsoft Corporation)
Spreadsheet software that was used to transform data between MapInfo and SPSS and to create descriptive statistics graphics such as scatterplots, histograms and piecharts.

Microsoft Word '97 (Microsoft Corporation)
This software was used for all word processing and document formatting.

Microsoft Office '97, Visio Pro (Microsoft Corporation)
This software was used to make the workflow diagrams shown in later sections of this chapter.

The Hardware

All data processing and analysis was performed with the aid of a personal computer with a 133 MHz Intel Pentium processor and 80 Mb of random access memory. Printouts, including colour maps, were produced from a Hewlett Packard Desk Jet 870 Cxi printer.

3.2 Description of the Hospital Records

The type of patient records used in this project, acute care, is an area of health service that is dispensed through programs in hospitals and communities, which covers primary, secondary, and tertiary services, rehabilitation and mental health liaison services. Hospital admittance for acute care can be on an inpatient, day or emergency basis. The type of records used in this study, inpatient hospital care, refers only to contacts where patients had hospital stays of one or more days (Alberta Health: 1996).

Hospital separations are the end of an inpatient hospital event consisting of at least one day of care. The number of separations indicates the number of hospital contacts by patients within the CRHA. Technically the number of admissions and separations should be equal, but the lag time between the dates for inpatient care means that for some cases admission and separation dates occur in different fiscal years. The dataset used for this project includes all patients, regardless of origin, who occupied a bed in a hospital within the CRHA jurisdiction and were discharged between April 1, 1995 and March 31, 1996 (CHRA: 1996: 4).

Each inpatient record has the following 14 data elements; a computer-generated Encounter number (which is unique for each patient stay), Postal code, CRHA Admitting facility, Admission date, Discharge date, Birthdate, Age, Sex, Admission code, Entry Code, Exit-Alive code, Length of Stay (LOS), Adjacent Diagnostic Related Group (ADRG- a detailed diagnostic code), and Major Diagnostic Category (MDC-a general diagnostic category). Table 3.0 details the parameters of the patient record variables.

The hospital-records file, containing approximately 94,000 patient records, was provided by the CRHA in delimited ascii format. All individual records had been stripped of identifying information except for the six digit postal code, which was used to geocode the records. Table 3.1 is a sample of the original patient records (encounter numbers and postal codes are altered here to maintain confidentiality).

Table 3.0

CRHA Inpatient Record Data Elements

CRHA Encounter	Character	System generated number	
CRHA_facility_id	Character	3Character Facility ID	ACH - Alberta Children's BVC - Bow Valley Centre, FHH - Foothills Hospital HCH - Holy Cross Hospital PLC - Peter Lougheed, RVH - Rockyview Hospital SAG - Grace Hospital
Admit	Date Admit hour	Admit date HH (rounded up to next hour)	(YYYYMMDD)
Discharge	Date Discharge hour	Discharge date HH (rounded up to next hour)	(YYYYMMDD)
Postcode (FSA)	Post code	Forward Sort Area	First three Pcode digits
POSTCODE	Post code	Last three post code	If unknown: 00 - Nfld 08 - AB 01 - PEI 09 - BC 02 - NS 10 - NWT 03 - NB 11 - YUKON 04 - QB 12 - USA 05 - ONT 13 - OTHER 06 - MAN 14 - N/A 07 - SASK 20-80 - hospital assigned
Birth	Date	Birthdate	(YYYYMMDD)
CRHA age-calc	Number	Age (calculated)	Admit minus Birthdate
Sex	Character	Sex	M - Male F - Female
Admit_Category	Character	Admit Category	L - Elective U - Urgent E - Emergency Blank - new & stillborn
Entry Code	Character	Entry Code	D - Direct E - Emergency N - Newborn S - Stillborn
Exit Alive Code	Character	Exit Code	D - Discharged " " - Died
LOS	Character	Length of Stay	Discharge minus Admitdate
CRHA_ks_adrg	Character	Karen Sneider RDRG Grouper -Associated Diagnostic Related Group	The subgroup patients are assigned to (except those classified "early death"
CRHA_ks_mdc	Character	Major Diagnostic Category	1 - 25

Data Elements courtesy of Corporate Data, CRHA

Table 3.1

Sample of CRHA, Acute Care Inpatient Records

ENCNTR	PCODE	FAC	ADMIT-DT	DISCHARGE	BIRTH-DT	AGE	SEX	AD	ENT	XT	LOS	ADRG	MDC
81891	y8y8y8	PLC	30-SEP-95	30-SEP-95	25-SEP-75	20.0	F	E	E	D	1	383	14
85685	y8y8y8	BVC	26-APR-95	01-MAY-95	17-JUN-41	53.9	M	E	D	D	5	132	5
71937	y8y8y8	BVC	05-OCT-95	08-OCT-95	01-JAN-37	58.8	M	L	E	3	2	132	5
96483	y8y8y8	BVC	17-OCT-95	09-NOV-95	01-JUN-49	46.4	M	E	D	D	23	430	19
97336	y8y8y8	FHH	27-MAY-95	27-MAY-95	17-MAY-70	25.0	F	E	E	S	1	428	19
51974	y8y8y8	BVC	06-JUN-95	13-JUN-95	02-MAY-59	36.1	M	E	E	D	7	121	5
97847	y8y8y8	BVC	25-JUL-95	27-JUL-95	25-NOV-47	47.7	F	E	E	D	2	218	8
81251	y8y8y8	PLC	24-SEP-95	25-SEP-95	24-SEP-95	.0	F	N	N	D	1	391	15

Patient Records courtesy of Corporate Data, CRHA

The last two columns of the patient record are the ADRG and MDC which are the two diagnostic codes on which the health status indicators are based. The MDC is a general diagnostic classification system based on the organ systems of the body and is defined in Table 3.2.

Table 3.2

Description of Major Diagnostic Categories (MDC)

0	No MDC
1	Diseases and disorders of the Nervous system
2	Diseases and disorders of the eyes
3	Diseases and disorders of the ear, mouth and throat
4	Diseases and disorders of the respiratory system
5	Diseases and disorders circulatory system
6	Diseases and disorders of the digestive system
7	Diseases and disorders hapatobiliary system and pancreas
8	Diseases and disorders musculoskeletal system and connective tissue
9	Diseases and disorders of the skin, subcutaneous tissue and breast
10	Diseases and disorders of the endocrine, nutritional and metabolic
11	Diseases and disorders of the kidney and urinary tract
12	Diseases and disorders of the male reproductive system
13	Diseases and disorders of the female reproductive system
14	Pregnancy, childbirth and the puerpenium
15	Newborns and other neonates with conditions originating in perinatal period
16	Diseases & disorders of blood/blood forming organs; immunological disorders
17	Mycloproliferative diseases and disorders / poorly differentiated neoplasms
18	Infectious and parasitic diseases
19	Mental diseases and disorders
20	Alcohol/drug use and associated organic mental disorders
21	Injuries, poisonings and toxic effects of drugs
22	Burns
23	Factors influencing health status and other contacts with health services
24	HIV infection
25	Multiple significant trauma

MDC Table courtesy of Corporate Data, CRHA

The Adjascent DRG (ADRG) code is a refinement of Diagnostic Related Groups (DRGs), and is a patient classification scheme, developed at Yale University, which provides a means of relating the type of patient a hospital treats to the costs incurred by the hospital. DRGs provide a framework for Medicare's hospital reimbursement system by grouping inpatients receiving acute hospital care according to their principal diagnosis. In a DRG system, a patient episode of care is initially classified in one of the MDCs then further classified as either surgical or medical. Surgical episodes are sorted according to the type of surgical procedure and medical episodes are sorted according to the principal diagnosis. Factors such as age, sex, and the presence of complications or co-morbidities (CC) and their severity affect further grouping into the ADRGs. The ADRG code used by Alberta Health describes approximately 1200 statistically homogeneous groupings of diseases and clinical procedures. Each of the codes represents a category of patients who are deemed medically comparable and who require approximately equal expenditures of health care resources (Columbia Presbyterian Medical Center website: 1997; MCHPE website: 1997). Table 3.3 is a sample of the list of ADRG codes.

Table 3.3

Sample of ADRG Codes

0010 CRANIOTOMY EXCEPT FOR TRAUMA WITH NO CC
0011 CRANIOTOMY EXCEPT FOR TRAUMA WITH CLASS C CC
0012 CRANIOTOMY EXCEPT FOR TRAUMA WITH CLASS B CC
0013 CRANIOTOMY EXCEPT FOR TRAUMA WITH CLASS A CC
0020 CRANIOTOMY FOR TRAUMA WITH NO CC
0021 CRANIOTOMY FOR TRAUMA WITH CLASS C CC
0022 CRANIOTOMY FOR TRAUMA WITH CLASS B CC
0023 CRANIOTOMY FOR TRAUMA WITH CLASS A CC
0040 SPINAL PROCEDURES WITH NO CC
0041 SPINAL PROCEDURES WITH CLASS C CC
0042 SPINAL PROCEDURES WITH CLASS B CC
0043 SPINAL PROCEDURES WITH CLASS A CC
0050 EXTRACRANIAL VASCULAR PROCEDURES WITH NO CC
0051 EXTRACRANIAL VASCULAR PROCEDURES WITH CLASS C CC
0052 EXTRACRANIAL VASCULAR PROCEDURES WITH CLASS B CC
0060 CARPAL TUNNEL RELEASE WITH NO CC
0061 CARPAL TUNNEL RELEASE WITH CLASS C CC
0062 CARPAL TUNNEL RELEASE WITH CLASS B CC
0063 CARPAL TUNNEL RELEASE WITH CLASS A CC
0070 PERIPH & CRANIAL NERVE & OTHER NERV PROC WITH NO CC
0071 PERIPH & CRANIAL NERVE & OTHER NERV PROC WITH CLASS C CC
0072 PERIPH & CRANIAL NERVE & OTHER NERV PROC WITH CLASS B CC
0073 PERIPH & CRANIAL NERVE & OTHER NERV PROC WITH CLASS A CC
0091 SPINAL DISORDERS & INJURIES WITH CLASS C CC
0092 SPINAL DISORDERS & INJURIES WITH CLASS B CC

ADRG list courtesy of CRHA, Corporate Data

DRG classification of patients has several important applications. DRG grouped patients are the basis for comparison and evaluation of treatment options, resource consumption, average length of stay and quality of care between hospitals. Without a method of classifying diagnosis and complications there would be no way to assess the effectiveness of treatment options used by different hospitals. DRGs may also be used to compare average costs for specific treatments, to calculate the average cost per ADRG and to predict the cost for similar procedures.

Selecting Hospital-Use Categories

The selection of suitable hospital-use categories for the health status indicators was influenced by the findings of Canadian medical geography and population health researchers (e.g. Evans et al.: 1994; Roos et al.: 1996; Plain: 1996). Using mainly the ADRG and MDC codes assigned to the patient, the indicators had to meet a number of basic criteria:

- Diagnostic categories had to be identified in the literature review as being sensitive to variations in socio-economic conditions within populations.

- Diagnostic categories had to be identified in the literature review as being good predictors of chronic medical conditions with high costs either in terms of reduced quality of life for the patient, potential years of life lost or high health care costs.

- Cases had to have unambiguous, easily identifiable MDC or ADRG codes, so that a non-medical researcher could work with the selection.

- Where possible, criteria matching the health risk indicators used in the MCHPE Population Health Information System (PHIS) were selected.

- At least 200 cases had to be present in the hospital-use category (otherwise random fluctuations in counts between the communities could have a disproportionate influence on the results of the statistical analysis).

The last criterion was added after a preliminary analysis with a test set of hospital-use indicators. The results of an exploratory multiple regression analysis, using the diagnostic groups HIV and Respiratory Infections, indicated that there were not enough cases in these two categories to support valid analysis and consequently they were dropped.

The selected hospital-use categories for the health status indicators along with their parameters, summarized in Table 3.4, are as follows:

Low Birthweight Newborns

All Entry codes "N" (newborns) were selected and a subset created of ADRG code 386-388 (birthweight <= 2500 grams (5.5 lbs.)).

Teen Pregnancies

All admissions coded MDC 14 (Pregnancy and Childbirth) were selected and a subset created from patients with age <=18 yr.

Alcohol and Drug Related Problems

All admissions with ADRG codes 433-437

Injuries, Poisonings and Toxic Effects of Drugs

All Cases with MDC = 21

Premature Deaths from all Causes

A subset of female <= 80 yr. old and males <= 75 yr. old was created from cases with blank "Exit Alive" codes (indicating deceased)

Mental Diseases and Disorders

All Cases with MDC = 19

From a total of 71740 cases for the GCR, the 6234 cases selected for the health risk categories represent approximately 8.3% of the dataset.

Table 3.4

Summary of Community Health Status Indicators

Hospital-Use Category	*MDC*	*ADRG Code*	*Other Criteria*	*# of Cases*
Teen Pregnancies	14		Age <= 18 yr.	279
Low Birthweight Newborns	15	386 - 388		893
Mental Diseases & Disorders	19			3559
Alcohol and Drug Use	20	433 - 437		431
Injury, Poison & Toxic Effects	21			1276
Early Death ("exit-alive" code is blank)			F <= 80 yr. M <= 75 yr.	1072
TOTAL				6234

3.3 Description of Census Records

The data source for the socio-economic status indicators used in this analysis is the 1991 P Census – Canada: 1991 Census 2a and 2b Statistics [computer file]. P Census is published by Tetrad Computer applications, Vancouver and are based on Statistics Canada's (1991) census.

The "Census of Population" provides a full statistical "snapshot" of Canadians on one day and takes place every ten years (1991, 1981,...) and there is also a "mini" census conducted at the midpoint of the full census period to update the base information. The censuses are designed to collect information about the demographic, social and economic characteristics of populations for small geographic areas for small population groups. Census variables are grouped into 12 main categories; population counts and demographic data, ethnic origin and immigration data, language, aboriginal status, schooling, religion, labour force, income, family and household data, housing, institutions and other collectives and disability compiled at various geographic scales. The smallest areal entities defined in the census are Enumeration Areas (EA) which are the discrete building blocks of all standard geographic areas used by Statistics Canada.

Two types of census forms are mailed out to households. The 2a-census form is a short questionnaire containing 9 questions and is given to 80% of all private households. The 2b-census form is a long questionnaire containing 53 questions given to 20% of all private households. The population profile census (P-Census) database used for this study contains the combined data from the 2a and 2b Statistics Canada census forms, reported at the Enumeration Area (EA) level. In 1991, there were 4602 populated enumeration areas in Alberta, including 1026 within the CRHA jurisdiction and 963 in the Greater Calgary Region (GCR).

The basic census data selected for this study originally consisted of counts for approximately 40 Census variables for all 4602 Alberta Enumeration Areas. To reduce the data set, EAs were sorted by total population, and 606 with no population counts were removed leaving a total of 3996. To prepare the values for geographic analysis, some variables had to be disaggregated. For example, the census variable "average single family dwelling value" was multiplied by the number of single family dwellings to create the variable "total single family dwelling value" for each EA. Later, in the new geographic scale, the average dwelling value was recalculated and expressed as an average dwelling value for the new areal units.

Selecting Socio-economic Characteristics

The selection of social status indicators was based on findings in the urban ecology literature review. The population profiles were defined by a factor analysis. Qualification of census categories appropriate for socio-economic indicators was based on the following criteria:

- There had to be significant variability in the values for categories among the EA geographic units within the Greater Calgary Region;
- The census variable had to be appropriate to an urban geographic area. For instance, categories addressing rural or agricultural characteristics were not useful or valid for this study;
- Each geographic unit had to have enough data within each category to be statistically valid.

The most important characteristic of appropriate social status indicators was their ability to differentiate communities from each other. Because the indicator had to have a significant degree of variability, factors such as sex ratios were unsuitable because they are fairly constant among Calgary communities and if used in a statistical analysis would contribute little to the outcome.

A full description of the final selection of census variables is provided in the appendix. Twenty variables were selected and two more were calculated. Age dependency ratios were calculated as a ratio of infants to seniors, and Aggregate income was calculated as an average of the three income variables. The selected variables correspond to ten sub-categories and seven main categories of community socio-economic characteristics. The values for each of the census variables became the Greater Calgary Region (GCR) community profiles. The list of variables, with the sub-category names, variable names and variable labels are summarized in Table 3.5.

Table 3.5

Summary of Socio-economic categories and variable labels

CATEGORY	***SUB CAT***	***VAR NAME***	***VAR LABEL***
CULTURAL		English first language	ENGLISH
	Culture	Aboriginal heritage	ABORIG
DEMOGRAPHIC		Seniors over 65 yr.	SENIORS
	Age	Infants under 4 yr.	INFANTS
		Adults 15-65yrs	ADULTS
		Elderly dependency ratio	ELDR DEP
	Fertility	Average child/family	FERTLTY
SOCIAL	family	Single female parent families	LONE PAR
	Mobility	Less than 5 years	MOVERS
HOUSING	Housing	Average dwelling value	DWEL VAL
	Economic	> 30% gross wages to mortgage	OVP MORG
		> 30% gross wages to rent	OVP RENT
		Low income families	LWINC FM
EMPLOYMENT	Employed	Unemployment rate	UNEMPLYD
		Participation rate	PARTI RT
INCOME	Income	Individual income	IND INC
		Family income	FAM INC
		Household income	HOUS INC
		Aggregated income(of above 3)	AGGR INC
EDUCATION	Education	Less than grade 9 education	LESS GR9
		High school certificate	HSC CERT
		Post Secondary certificate	POST SEC

3.4 Data Preparations

Data integration is the process of making different datasets compatible with each other so that their relationships can be analyzed. The process allows many different types of data to be combined and displayed together. While a relational database management system can link data in different tables based on a primary key in one table, GIS can link the data in different tables based on their geographic location. This unique feature is the main factor differentiating GIS from a database management or a computer mapping system.

Population data are typically collected and referenced to predefined zones of various types whose areal units rarely coincide and usually overlap. In GIS, boundaries are features represented by closed polygons. A polygon overlay is an operation where the records associated with those polygon features are matched based on the location of their associated geographical features.

GIS Polygon Overlay Operation

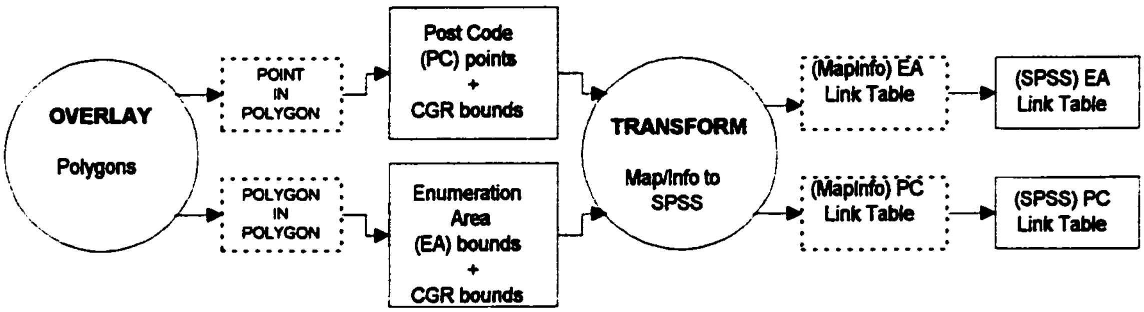
Prior to the overlay operation, several tests with different geographic units determined the most suitable one in which to merge the EA census variables and the postal coded hospital data. EA units produced too many empty cells in the health risk category, which threatened the integrity of the regression model, and therefore were determined to be too small. Census Subdivision (CSD) units were rejected because they were too large to convey the diversity of urban neighbourhood characteristics, especially in the high-density Calgary downtown core. The Greater Calgary Region (GCR) community level was therefore chosen because the divisions are numerous enough to illustrate the variation of social and economic profiles within the GCR while minimizing the number of empty cells in the hospital-use columns.

In the overlay operation shown in Figure 3.0, the boundary map layer of Calgary communities was first combined first with the boundary map layer of EA's and then with the point layer of postal code centroids to create a new "link" table for each dataset containing attributes from both layers.

To create the EA / community link table, the two MapInfo boundary files, EA and GCR communities, were opened together and MapInfo's Structured Query Language (SQL) "based on geographic relationships" enabled generation of a table of all communities with their associated EAs. These two link tables were then transformed to SPSS to be merged with the indicator census variables.

To produce the postal code (PC) / community file, the PC point file and the community boundary files were opened together and the SQL query "based on geographic relationships" was used to generate a table of all communities with their associated PCs.

Figure 3.0
GIS Polygon Overlay



1) Based on Geographic Relationships produces a Link Table of:
GCR communities - Postal Codes
GCR communities - Enumeration Areas

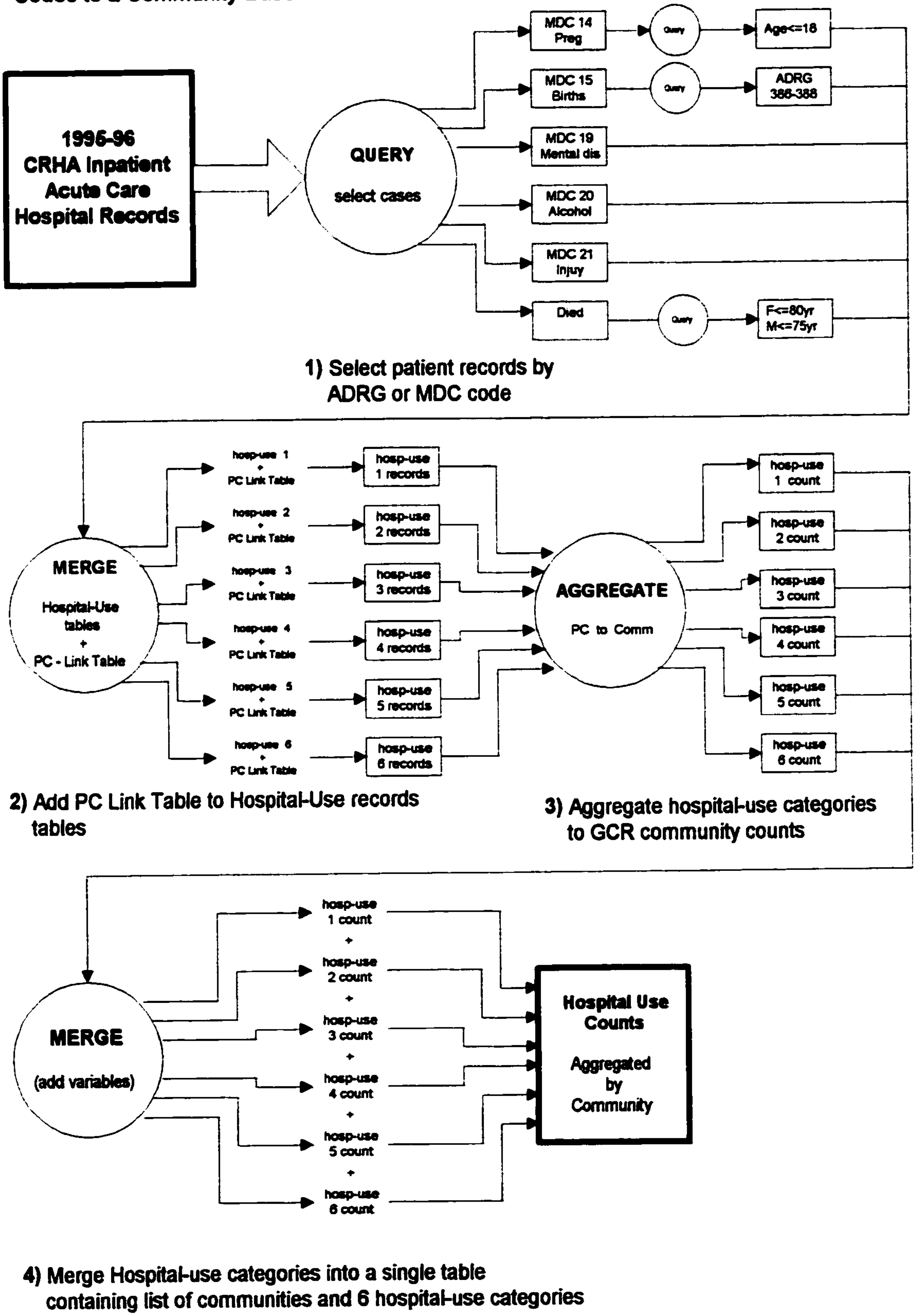
2) Transform Link Tables from MapInfo to SPSS

Aggregating the Health Status Variables

To produce a hospital record subset of health status indicators, the original inpatient hospital database provided by the CRHA was queried in SPSS and cases were selected which met the criteria for each of the hospital-use categories previously described. The query produced six separate files each containing the patient records for a hospital-use category. The six hospital-use files were then separately merged with the MapInfo generated PC-community link table. This produced six tables of hospital records tagged with community names. Then each hospital-use file was aggregated to communities (using the *count cases* option) with counts in their respective hospital-use category. Finally the six tables were merged (using the *add variables* option) into one single file of communities with counts for each of the six hospital-use categories. Figure 3.1 illustrates the steps taken to convert the hospital records to hospital-use counts for each of the health status variables.

Figure 3.1

Transformation of Hospital Records from Postal Codes to a Community-Based Database

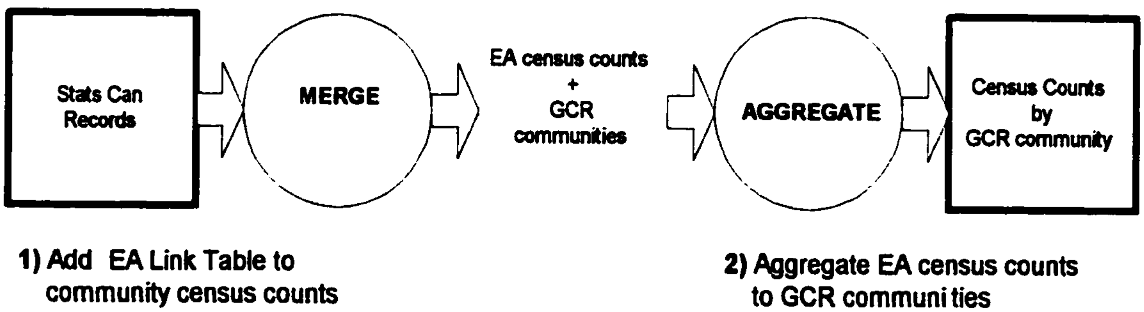


Aggregating the Socio-Economic Variables

To produce a census record subset of socio-economic indicators, the census table was merged (using the function *append* and *add variables*) with the MapInfo generated EA data table to produce a list of all census variables aggregated by EA and tagged with their associated community name. This file was aggregated by community, using the *sum values* command option, to produce a table of communities and counts for each census variable. Figure 3.2 illustrates the steps taken to convert the census records to socio-economic indicator categories.

Figure 3.2

Transformation of Census Variables



Standardizing Both Sets of Variables

Calculating indices for each variable was a two-stage process; first a ratio was calculated as a percentage of each community population; then the ratio was standardized by inserting the community ratio as the numerator and the GCR ratio as the denominator.

Calculating the GCR Community Rates

Ratios for each community socio-economic and hospital-use variable were calculated by basing the numerator for all the community rates on the number of cases in each indicator cell and basing the denominator on counts of the total population in the specific community for the 1991 census year. The ratio for each indicator cell was also calculated for the overall GCR.

$$\text{COMMUNITY RATIO} = \frac{\text{Indicator Community Count}}{\text{Community Total Population}}$$

Calculating the GCR Community Indices

The index for a community indicator is a direct comparison of a community ratio with the Greater Calgary Region (GCR) ratio. The community indices were calculated by using the indicator Community Ratio as the numerator and the indicator GCR ratio as the denominator. The value of the GCR ratio for each variable is 1. For any particular characteristic (e.g. dwelling value) a value greater than 1 means that that community has a higher rate than the GCR overall. Thus a dwelling value index of 1.7 would mean that the average dwelling value of that community was 70% higher than the GCR dwelling value overall.

$$\text{COMMUNITY INDEX} = \frac{\text{Indicator Community Ratio}}{\text{Indicator GCR Ratio}}$$

Community Index Values

The index values for each of the 164 GCR community's health and socio-economic status indicators are presented in Table 3.6. These community indices describe each of the community rates in relation to the GCR averages, and are used in the statistical and spatial analyses, which follow in Chapters 4, 5 and 6.

3.5 Summary

Because the census tables and the patient records are based on different geographic units, several data transformations were required to prepare the datasets for analysis. First the EA census table and the PC hospital-use table were aggregated to a common geographic base. Using a polygon overlay function, two link tables were generated in MapInfo; one of GCR communities listed by associated postal codes and the other of GCR communities listed by their associated EAs. Both were transformed to SPSS tables where they were linked to the indicator tables and then aggregated to communities. Once the census and hospital tables were in compatible units, sums,

Table 3.6
Indicator Index Value

Community	WARD	Total-pop	english-INDX	aborig-INDX	seniorINDX	infantsINDX	adultsINDX	elder-depINDX	child/famINDX	lone_parINDX	low_inc_famINDX	moversINDX	av_dwel_valINDX	ovpay_morgINDX	ovpay_rntINDX	unemplydINDX	particINDX	ind_incmINDX	fam_incmINDX	hous_incmINDX	aggr_incINDX	less_gr9INDX	hs_certINDX	post_secINDX	Early_deathINDX	alc_drugsINDX	LBWINDX	teen_prgINDX	injury_INDX	depress_INDX	HEALTH RISK
		Demographic							Social				Housing			Employ		Income				Education			Hospital Utilization						
02A	2	927	0.91	0.00	0.25	1.50	0.79	0.30	1.13	0.36	1.14	1.63	1.33	2.21	2.09	1.25	1.14	1.17	1.07	1.23	1.16	0.33	1.00	1.30	4.42	0.00	1.19	0.35	3.17	3.11	2.04
09A	9	679	1.06	3.60	1.13	0.75	1.13	1.00	0.60	0.91	1.50	0.98	0.91	0.00	0.59	2.25	1.04	0.79	0.69	0.66	0.71	1.83	0.69	0.98	1.01	0.00	0.00	3.11		1.06	0.86
09D	9	2377	0.96	3.87	0.25	1.38	0.94	0.30	1.23	1.36	0.79	0.88	0.66	1.14	0.41	1.00	1.08	0.81	0.78	0.97	0.85	1.33	1.15	0.79	0.58	1.39	0.76	0.82	0.93	1.11	0.93
09E	9	401	0.85	0.00	0.63	2.50	0.81	0.80	1.27	3.91	4.86	1.47	0.10	2.07	0.84	2.25	1.00	0.61	0.42	0.47	0.50	1.33	0.77	0.28	0.00	0.00	0.00	7.78		0.60	1.40
09H	9	1526	1.07	0.80	1.50	1.25	0.92	1.70	1.02	1.64	1.07	0.92	0.71	1.07	1.44	0.75	1.03	0.78	0.69	0.78	0.75	1.17	1.08	0.74	0.45	1.08	0.82	0.00	1.44	2.21	1.00
12A	12	425	1.15	2.88	1.50	0.75	1.16	1.30	0.73	1.09	0.50	0.97	0.19	0.00	1.56	2.00	1.09	0.71	0.68	0.70	0.70	2.00	1.00	0.42	0.00	0.00	1.58	0.00	3.45		0.84
ABBEYDALE	10	7658	0.93	2.56	0.25	1.38	0.87	0.30	1.34	1.09	1.36	0.98	0.71	1.29	1.06	1.25	1.07	0.83	0.76	0.92	0.84	1.50	1.00	0.74	0.18	1.30	0.93	1.05	1.34	0.50	0.88
ACADIA	12	11574	1.02	0.64	1.38	0.63	1.08	1.30	0.80	1.09	1.07	0.90	0.76	0.71	1.06	1.00	1.00	0.85	0.86	0.85	0.85	1.33	1.15	0.88	1.12	1.86	0.56	1.83	1.01	0.89	1.21
ALBERT PARK / RADISON HEIGHTS	10	6732	0.83	2.64	0.88	1.13	1.01	0.90	1.04	1.64	2.14	1.10	0.69	1.29	1.28	1.63	0.92	0.65	0.58	0.66	0.63	2.50	1.08	0.63	1.12	1.97	1.85	0.24	1.42	1.32	1.32
ALTADORE	11	5255	1.07	0.70	1.75	0.88	1.09	1.60	0.71	1.18	1.07	0.92	0.93	1.14	0.63	1.25	0.95	0.95	0.92	0.85	0.91	0.83	0.85	1.07	0.78	1.57	1.01	1.25	0.70	1.33	1.11
APPLEWOOD PARK	10	1597	0.94	0.77	0.63	1.13	0.94	0.60	1.08	1.09	2.29	1.22	0.56	1.21	1.41	1.00	1.04	0.82	0.74	0.87	0.81	1.83	1.23	0.70	0.86	1.04	1.59	2.22	2.76	1.81	1.71
BANFF TRAIL	7	3138	1.04	0.40	2.38	0.63	1.14	2.20	0.58	1.00	0.64	0.86	0.92	0.57	0.75	1.13	0.91	0.87	0.90	0.85	0.87	0.67	0.77	1.16	2.18	1.05	0.00	0.00	2.34	1.15	1.12
BANKVIEW	8	5028	1.02	3.87	0.75	0.63	1.17	0.60	0.50	1.82	1.64	1.37	0.96	1.14	0.94	1.38	1.07	0.77	0.83	0.57	0.72	0.83	0.92	1.05	0.54	2.30	1.95	1.13	1.17	1.53	1.44
BAYVIEW	13	1069	1.05	0.00	1.88	0.50	1.09	1.80	0.97	0.27	0.21	0.56	1.70	0.00	0.00	0.88	0.87	1.87	2.10	2.22	2.06	0.17	0.46	1.47	1.28	1.55	0.00	0.00		0.68	0.59
BEDDINGTON HEIGHTS	3	12852	0.94	0.91	0.38	1.38	0.91	0.40	1.20	1.09	0.93	1.02	0.83	1.21	0.88	1.00	1.09	0.96	0.92	1.07	0.98	1.00	0.92	1.07	0.69	0.64	0.30	1.32	0.51	0.45	0.65
BEL AIRE	11	1092	1.07	0.00	2.00	0.88	1.04	2.10	0.95	0.45	0.36	0.78	2.64	0.29	0.00	0.38	0.82	3.55	4.22	4.00	3.92	0.50	0.54	1.30	1.25	0.00	0.00	0.00	1.34	1.54	0.69
BONAVISTA DOWNS	14	1407	1.05	0.87	0.25	1.00	0.97	0.30	1.14	0.82	0.43	0.80	0.84	1.21	0.00	0.88	1.03	0.98	0.95	1.07	1.00	0.33	1.54	0.79	0.00	1.18	1.98	3.34	0.52	1.71	1.46
BOWNESS	1	12533	1.09	2.98	1.13	1.13	1.00	1.20	0.94	1.64	1.79	0.98	0.74	1.36	1.34	1.50	0.95	0.76	0.69	0.74	0.73	1.50	1.00	0.77	1.75	1.72	1.16	1.23	1.17	1.27	1.38
BRAESIDE	13	7090	1.05	0.43	0.63	1.00	1.00	0.60	1.03	1.00	0.86	0.88	0.86	0.93	1.00	0.88	1.04	1.00	0.98	1.06	1.01	0.33	1.15	1.02	0.77	0.47	0.72	0.00	0.72	0.54	0.54
BRENTWOOD	2	7657	1.02	0.40	1.63	0.63	1.12	1.50	0.79	0.64	0.36	0.63	0.98	0.36	0.69	0.75	0.91	1.06	1.13	1.15	1.11	0.67	0.69	1.26	1.43	0.22	1.44	0.00	0.96	0.60	0.78
BRIDGELAND / RIVERSIDE	4	4651	0.91	1.72	3.00	0.75	0.97	3.30	0.63	1.91	2.50	1.07	0.71	0.93	1.22	1.63	0.91	0.66	0.70	0.53	0.63	2.00	1.00	0.81	2.79	1.07	0.91	0.59	1.73	2.33	1.57
BRITANNIA	11	735	1.15	0.00	1.75	0.88	0.99	1.90	1.08	0.64	0.36	0.71	2.29	0.57		0.25	0.95	2.78	2.69	3.04	2.84	0.00	0.31	1.60	2.79	0.00	0.00	0.00	1.00	0.65	0.74
CAMBRIAN HEIGHTS	4	1555	1.05	0.79	2.00	1.00	1.08	2.00	0.78	0.55	0.64	0.80	0.99	0.21	1.09	1.00	0.86	1.14	1.13	1.15	1.14	0.33	0.92	1.26	0.44	1.06	2.37	5.39	0.94	0.46	1.78
CANYON MEADOWS	13	8773	1.07	0.00	0.38	0.88	1.01	0.40	1.12	0.91	0.43	0.97	1.15	1.00	0.53	0.75	1.05	1.12	1.19	1.27	1.19	0.33	1.15	1.00	1.25	0.75	1.21	1.62	0.75	0.52	1.02
CAPITAL HILL	7	4396	1.05	0.28	2.13	0.63	1.14	1.90	0.56	1.27	1.00	1.10	0.83	0.86	0.91	1.13	0.97	0.87	0.86	0.77	0.83	1.17	0.69	1.14	0.62	1.13	0.57	0.66	0.83	0.88	0.78
CASTLERIDGE	3	7492	0.93	1.47	0.25	1.63	0.87	0.30	1.33	0.82	1.36	1.07	0.83	1.71	1.03	1.13	1.07	0.88	0.84	0.98	0.90	1.17	0.92	0.86	0.46	1.10	0.81	0.93	1.57	0.87	0.96
CEDARBRAE	13	6986	1.05	0.26	0.38	1.25	0.94	0.40	1.19	1.18	0.93	0.93	0.88	0.86	1.31	0.88	1.08	0.98	0.96	1.05	1.00	0.50	1.31	1.12	0.68	0.47	0.55	1.13	1.47	0.62	0.82
CFB-CURRIE	11	2232	1.12	1.90	0.50	1.75	0.92	0.50	1.13	0.45	0.43	1.59			0.28	0.75	1.11	0.94	0.86	0.94	0.91	0.33	1.54	0.79	0.31	1.48	0.74	0.00	1.31	0.54	0.73
CHAPARRAL	14	1792	1.07	0.00	0.13	1.13	0.82	0.20	1.42	0.36	0.79	1.61	1.63	1.21	2.09	0.25	1.03	1.52	1.43	1.63	1.53	0.17	0.77	1.28	0.76	0.00	0.47	0.00	0.41	1.88	0.59
CHINATOWN	7	807	0.11	0.00	3.75	0.75	1.09	3.50	0.63	1.55	4.29	1.05			1.72	2.13	0.61	0.43	0.45	0.31	0.40	8.50	0.54	0.30	1.69	0.00	1.40	0.00	0.91	1.79	0.97
CHINOOK PARK	11	1502	1.11	0.00	2.75	0.88	0.94	3.10	0.88	0.55	0.14	0.59	1.31	0.00	1.25	0.63	0.91	1.72	1.61	1.86	1.73	0.33	1.08	1.30	0.46	0.00	0.00	0.00	0.98	1.60	0.51
CHRISTIE PARK	6	1025	0.98	0.00	0.38	1.50	0.90	0.40	1.08	0.18	0.21	1.69	1.79	1.29	0.00	1.00	0.99	1.77	1.63	1.86	1.75	0.33	1.38	1.42	0.67	0.00	0.99	0.00	1.43	0.94	0.67
CLIFF BUNGALOW	8	1930	0.98	1.27	1.38	0.38	1.22	1.20	0.38	1.18	0.71	1.29	0.95	1.36	0.66	1.13	1.07	0.85	0.90	0.61	0.79	0.67	1.00	1.09	1.06	0.86	0.99	1.61	0.38	2.24	1.19
COACH HILL	6	3152	1.00	0.39	0.88	0.88	1.04	0.90	0.82	0.45	0.43	1.02	1.25	1.07	0.66	0.50	1.03	1.38	1.34	1.38	1.37	0.50	0.69	1.44	0.65	1.05	1.83	1.61	0.70	0.69	1.09
CONNAUGHT	8	10712	0.94	0.97	1.50	0.38	1.21	1.30	0.37	1.00	3.36	1.41	0.96	1.14	1.09	1.13	1.04	0.81	0.87	0.59	0.76	0.83	0.92	1.09	1.66	1.85	0.66	1.16	1.10	2.11	1.42
CORAL SPRINGS	5	1461	0.93	5.44	0.25	1.63	0.84	0.40	1.30	1.73	1.93	1.14	0.60	2.36	0.94	1.63	1.04	0.74	0.59	0.73	0.69	1.17	1.31	0.60	0.94	1.13	1.40	0.00	3.01	0.99	1.25
COUNTRY HILLS	3	582	0.90	0.00	0.25	1.38	0.82	0.30	1.06	0.27	0.79	1.69	1.15	2.29	0.00	1.00	1.12	0.99	0.94	1.14	1.02	0.00	1.15	1.09	9.39	5.69	1.20	0.00	5.04	4.96	4.38
CRESCENT HEIGHTS	7	6004	0.96	1.12	1.50	0.63	1.18	1.30	0.50	0.82	2.14	1.22	0.99	0.50	0.81	1.00	1.03	0.92	0.87	0.75	0.85	1.33	0.92	1.14	1.02	1.10	0.91	1.81	0.98	1.24	1.18

CORAL SPRINGS	5	1461	0.93	5.44	0.25	1.63	0.84	0.40	1.30	1.73	1.93	1.14	0.60	2.36	0.94	1.63	1.04	0.74	0.59	0.73	0.69	1.17	1.31	0.80	0.94	1.13	1.40	0.00	3.01	0.99	1.25
COUNTRY HILLS	3	582	0.90	0.00	0.25	1.38	0.82	0.30	1.06	0.27	0.79	1.69	1.15	2.29	0.00	1.00	1.12	0.99	0.94	1.14	1.02	0.00	1.15	1.09	9.39	5.69	1.20	0.00	5.04	4.96	4.38
CRESCENT HEIGHTS	7	6004	0.96	1.12	1.50	0.63	1.18	1.30	0.50	0.82	2.14	1.22	0.99	0.50	0.81	1.00	1.03	0.92	0.87	0.75	0.85	1.33	0.92	1.14	1.02	1.10	0.91	1.81	0.98	1.24	1.18
DALHOUSIE	2	10249	1.01	0.71	1.00	0.88	1.04	1.00	1.04	1.00	0.93	0.83	0.92	0.57	0.97	1.00	0.95	1.00	1.06	1.08	1.05	0.67	0.85	1.19	0.67	0.97	0.66	0.55	0.57	0.38	0.63
DEER RIDGE	12	4767	1.06	1.03	0.25	1.38	0.87	0.30	1.26	1.18	0.93	1.05	0.88	1.21	0.72	0.63	1.13	1.02	0.96	1.05	1.01	0.33	1.23	0.98	0.14	0.35	0.86	0.61	1.54	0.56	0.68
DEER RUN	12	7236	1.09	0.68	0.25	1.25	0.88	0.30	1.25	0.64	0.64	1.03	1.02	1.07	0.72	0.63	1.08	1.19	1.15	1.28	1.21	0.33	1.23	1.18	0.09	0.46	0.35	0.50	0.41	0.60	0.40
DIAMOND COVE	12	1457	0.99	0.00	0.38	1.00	0.94	0.40	1.18	0.36	0.43	0.92	0.94	1.21	1.03	0.75	0.96	0.94	0.96	1.15	1.02	0.50	1.23	1.05	0.47	3.41	0.00	0.00		0.99	0.81
DOUGLASDALE ESTATES	12	2626	1.07	0.00	0.25	0.88	1.00	0.30	0.98	0.09	0.00	1.64	1.47	1.00		0.50	1.08	1.55	1.59	1.85	1.66	0.17	1.00	1.02	1.04	0.00	0.18	0.00	1.12	1.01	0.56
DOVER	9	10807	0.93	1.87	0.50	1.13	0.94	0.60	1.26	1.45	1.79	0.98	0.61	1.71	1.00	1.25	0.99	0.72	0.66	0.77	0.72	1.67	1.15	0.58	1.58	1.07	0.90	2.43	1.09	0.65	1.29
DOWNTOWN COMMERCIAL CORE	7	5401	0.90	1.35	1.63	0.13	1.25	1.30	0.21	0.91		1.32	0.55	0.00	0.97	1.50	1.03	0.78	0.90	0.61	0.76	1.00	0.92	0.98	1.77	3.98	1.50	0.00	2.44	3.12	2.14
DOWNTOWN EAST VILLAGE	7	1200	0.83	2.55	6.00	0.00	1.21	5.20	0.09	0.00		1.02			1.47	3.50	0.38		0.90	0.63		6.67	0.46	0.35	12.53	19.30	1.83	1.37	1.22	9.02	7.55
DOWNTOWN WEST END	7	1322	0.90	0.93	0.63	0.25	1.25	0.50	0.32	1.09	1.07	1.47	1.25	1.93	0.88	0.88	1.07	0.84	0.90	0.67	0.80	0.83	0.54	1.05	2.07	2.50	2.97	1.73	1.11	2.18	2.09
EAGLE RIDGE	11	526	1.10	0.00	5.38	0.25	0.71	7.80	1.07	0.55		0.51	3.07	0.00		0.00	0.82	2.61	1.18	3.34	2.38	0.50	0.00	1.40	2.60	3.15	0.00	0.00		0.46	1.04
EAST SPRINGBANK	6	1649	1.02	0.00	0.75	0.75	1.05	0.80	1.12	0.27	0.57	0.69	2.49	0.71	0.00	1.25	0.95	1.73	1.98	2.13	1.95	1.17	1.23	1.02							0.00
EAU CLAIRE	7	809	0.88	2.28	1.50	1.25	1.13	1.40	0.57	2.45	3.43	1.32	2.05	0.00	1.03	0.25	0.91	1.80	1.39	1.21	1.47	1.50	1.00	1.19	0.84	0.00	0.00	0.00	0.91	1.19	0.49
EDGEMONT	2	12628	0.90	0.34	0.38	1.13	0.94	0.40	1.24	0.55	0.43	1.15	1.45	0.86	0.75	0.63	1.03	1.46	1.52	1.69	1.56	0.67	0.77	1.37	0.87	0.00	0.83	0.22	1.05	0.48	0.58
ELBOW PARK	11	2631	1.14	0.00	1.63	0.88	1.03	1.70	1.05	0.73	0.36	0.66	1.84	0.43	1.75	0.50	0.92	1.74	1.69	1.95	1.79	0.17	0.31	1.60	0.78	0.63	0.88	0.00	0.28	0.27	0.47
ELBOYA	11	1896	1.11	1.94	2.63	0.75	1.08	2.50	0.77	0.64	0.29	0.51	1.45	0.14	0.41	1.00	0.84	1.60	1.57	1.62	1.60	0.50	0.77	1.33	0.72	0.87	1.98	0.00	0.39	0.63	0.77
ERIN WOODS	9	2970	0.96	2.27	0.13	1.63	0.87	0.20	1.24	1.00	1.29	1.31	0.77	2.07	0.72	1.13	1.14	0.79	0.72	0.87	0.79	1.00	1.15	0.88	0.46	1.11	0.86	1.70	1.98	0.57	1.11
EVERGREEN ESTATES	13	1261	1.05	0.00	0.50	0.88	1.04	0.40	1.13	0.36	0.29	1.58	1.67	1.57	0.00	1.00	1.01	1.27	1.42	1.56	1.42	0.00	1.23	1.05	2.71	0.00	0.00	0.00		0.38	0.52
FAIRVIEW	9	3935	1.02	2.49	1.25	0.75	1.09	1.20	0.77	0.82	1.29	0.64	0.76	0.79	1.25	0.88	0.91	0.80	0.79	0.87	0.82	1.17	1.15	0.79	1.56	1.68	1.17	1.77	1.86	0.73	1.46
FALCONRIDGE	5	9037	0.93	1.42	0.25	1.63	0.87	0.30	1.28	1.36	1.64	1.20	0.66	2.14	1.03	1.13	1.07	0.76	0.67	0.81	0.75	1.17	1.15	0.79	0.38	0.00	1.02	0.98	1.06	1.09	0.76
FOREST HEIGHTS	10	7713	0.81	0.95	0.88	1.13	0.96	1.00	1.19	1.55	2.07	1.10	0.66	1.86	1.50	1.63	1.00	0.69	0.67	0.81	0.72	2.33	1.15	0.53	1.24	0.21	0.64	3.15	1.24	1.09	1.26
FOREST LAWN	9	8082	0.90	3.18	0.88	1.13	0.99	0.90	1.09	1.82	2.71	0.98	0.67	1.36	1.78	1.75	0.89	0.63	0.60	0.65	0.63	2.83	1.15	0.44	1.18	2.25	1.90	3.04	1.27	1.70	1.89
GLAMORGAN	11	6412	1.06	0.00	1.63	0.88	1.04	1.60	0.79	1.18	1.07	0.90	0.86	0.50	0.81	0.75	0.96	0.93	0.86	0.90	0.90	0.67	1.08	1.00	1.28	0.52	1.70	0.51	0.80	1.05	0.98
GLENBROOK	6	7279	1.00	3.02	1.00	1.13	0.99	1.00	1.03	1.64	1.64	0.97	0.76	1.00	0.94	0.88	0.99	0.86	0.79	0.83	0.83	1.17	1.08	0.88	1.13	0.23	0.51	2.68	1.01	0.83	1.07
GLENDALE	6	2815	1.05	0.00	2.00	0.88	1.03	2.10	0.83	0.64	0.57	0.66	0.92	0.64	1.13	0.50	0.84	1.09	1.06	1.06	1.07	0.50	0.85	1.12	1.70	0.59	1.44	5.05	1.82	1.71	2.05
GREENVIEW	4	2552	1.04	0.72	0.50	0.88	1.06	0.50	0.76	1.36	1.00	1.15	0.74	1.07	0.59	1.13	1.04	0.88	0.79	0.81	0.83	1.00	0.92	0.81	1.34	0.65	1.81	2.55	0.86	0.57	1.30
GREENWOOD / GREENBRIAR	1	1030	1.12	2.38	1.88	0.88	1.09	1.80	0.53	1.00	0.64	1.10	0.24	0.93		1.50	0.89	0.74	0.72	0.70	0.72	1.17	0.85	0.84	0.00	0.00	2.97	0.00	0.71	0.47	0.69
HAWKWOOD	2	7735	0.95	0.00	0.25	1.25	0.91	0.30	1.23	0.27	0.29	1.24	1.40	1.21	1.56	0.75	1.03	1.37	1.36	1.55	1.43	0.33	0.77	1.40	0.62	0.64	1.01	1.04	0.38	0.37	0.68
HAYSBORO	12	7073	1.06	0.17	1.75	0.88	1.10	1.70	0.73	0.73	0.71	0.75	0.86	0.79	1.28	1.00	0.93	0.95	0.92	0.92	0.93	0.83	1.00	1.02	1.06	1.87	0.66	0.57	1.35	0.65	1.03
HIDDEN VALLEY	2	1014	0.99	0.00	0.13	1.88	0.91	0.10	1.02	0.00	0.57	1.69	1.03	1.50	0.00	0.63	1.11	1.29	1.21	1.37	1.29	0.33	0.92	1.23	0.67	1.63	1.19	0.00	0.72	0.24	0.74
HIGHLAND PARK	4	3990	1.00	2.61	1.88	0.88	1.10	1.70	0.72	1.45	1.79	0.98	0.77	1.07	1.16	1.50	0.89	0.69	0.67	0.61	0.66	1.83	0.77	0.81	1.54	1.66	0.67	1.51	0.92	1.27	1.26
HIGHWOOD	4	1677	1.09	0.00	2.25	0.88	1.09	2.10	0.65	0.73	1.07	0.61	0.80	0.71	1.34	0.75	0.84	0.87	0.85	0.89	0.87	1.67	0.62	1.09	0.82	1.97	1.58	0.00	0.87	0.86	1.02
HILLHURST	7	5249	1.05	0.93	1.75	0.75	1.09	1.60	0.65	1.45	1.29	1.17	1.05	0.64	1.13	1.00	1.00	1.00	0.94	0.87	0.94	0.83	0.77	1.26	1.17	0.00	0.91	1.44	0.56	1.37	0.91
HOUNSFIELD HEIGHTS / BRIAR HILL	7	1863	1.05	0.00	5.38	0.63	0.78	7.20	0.60	0.55	0.43	0.73	0.99	0.57	0.69	1.00	0.74	1.09	1.04	1.14	1.09	1.50	0.38	1.30	1.47	1.78	1.48	0.00	0.79	1.03	1.09
HUNTINGTON HILLS	3	15637	0.96	0.59	0.63	1.00	1.00	0.60	1.08	1.27	1.14	0.88	0.79	1.00	1.13	1.00	1.03	0.86	0.85	0.94	0.88	1.33	1.08	0.88	1.01	0.53	0.96	1.41	0.23	0.68	0.80
INGLEWOOD	9	2457	1.05	3.99	1.50	0.75	1.14	1.30	0.70	1.18	1.57	0.90	0.68	0.43	0.75	1.75	0.89	0.72	0.73	0.61	0.69	2.00	0.54	0.77	2.23	4.04	1.11	0.99	1.49	2.35	2.04
KELVIN GROVE	11	2176	1.09	0.00	3.25	0.75	0.87	3.90	1.00	0.73	0.50	0.86	1.52	0.71	1.72	1.00	0.79	1.63	1.69	1.59	1.64	0.83	0.85	1.21	0.63	0.00	0.00	2.03	1.01	1.66	0.89
KILLARNEY / GLENGARRY	6	5395	1.02	1.82	1.88	0.88	1.12	1.80	0.69	1.27	1.21	1.00	0.80	1.29	0.78	1.13	0.88	0.78	0.74	0.69	0.74	1.17	0.85	0.95	0.63	1.23	1.35	0.44	1.09	1.20	0.99
KINGSLAND	11	4649	1.04	0.53	1.88	0.50	1.14	1.70	0.62	1.18	1.07	1.05	0.77	0.36	0.88	1.00	0.92	0.83	0.84	0.70	0.79	1.00	1.08	1.05	0.88	1.78	1.06	2.22	0.95	0.83	1.29
LAKE BONAVISTA	14	12058	1.07	0.20	0.63	0.75	1.00	0.60	1.26	0.55	0.29	0.75	1.23	0.64	1.22	0.75	1.01	1.36	1.54	1.69	1.53	0.50	0.92	1.18	1.02	0.27	0.84	1.02	1.09	0.84	0.85
LAKEVIEW	11	5610	1.07	0.00	1.25	0.75	1.10	1.20	0.81	0.82	0.50	0.63	1.11	0.43	0.50	0.88	0.96	1.24	1.26	1.36	1.29	0.50	1.00	1.26	1.10	1.47	0.00	0.00	0.78	0.30	0.61

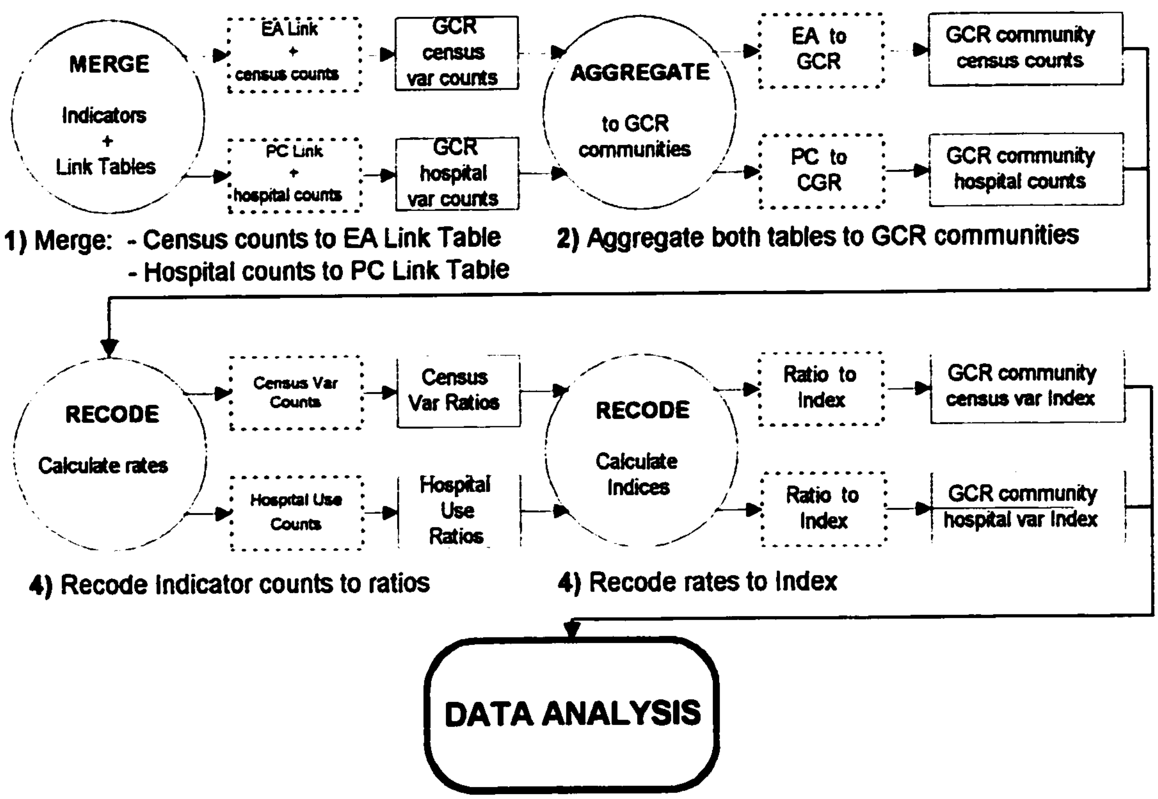
LINCOLN PARK REDEVELOPMENT	11	1199	1.05	0.00	1.63	1.38	0.96	1.80	1.06	1.18	1.57	1.22	0.78	4.29	0.13	1.13	0.80	0.77	0.66	0.65	0.69	0.67	1.08	0.81	0.57	1.38	0.89	0.00	3.06	0.80	1.12
LOWER MOUNT ROYAL	8	1161	0.96	2.11	2.00	0.13	1.13	1.90	0.23	1.36	2.93	1.42	2.68	0.00	0.53	1.13	0.99	0.76	0.75	0.52	0.68	0.33	1.00	0.95	1.77	2.85	2.97	0.00	3.16	1.24	2.00
MACEWAN	2	2890	1.01	0.00	0.38	2.00	0.87	0.50	1.13	0.82	0.71	1.19	0.92	1.50	0.56	0.75	1.07	1.11	1.00	1.12	1.08	0.50	1.00	1.16	1.89	0.00	1.50	0.44	0.76	1.08	0.95
MANCHESTER	9	1379	1.04	0.89	0.88	0.75	1.18	0.80	0.53	1.00	1.36	1.32	1.00	0.86	0.69	1.38	1.08	0.88	1.01	0.76	0.88	0.67	1.31	0.95	1.49	1.20	0.00	1.95	0.53	3.31	1.41
MAPLE RIDGE	12	2081	1.11	0.59	0.75	0.63	1.10	0.70	0.93	0.45	0.36	0.47	1.02	0.36	1.56	0.63	0.97	1.06	1.20	1.33	1.20	0.17	1.38	0.95	0.66	0.00	0.00	0.00	1.76	1.27	0.62
MARLBOROUGH	10	9452	0.89	0.84	0.63	0.88	1.04	0.60	1.12	0.91	0.86	0.78	0.74	1.21	1.06	1.00	1.03	0.78	0.82	0.94	0.85	1.67	1.38	0.67	1.16	0.70	0.99	0.99	0.93	0.97	0.96
MARLBOROUGH PARK	10	9452	0.94	2.01	0.38	1.00	0.95	0.40	1.26	1.00	1.14	0.85	0.76	1.36	1.16	1.13	1.03	0.81	0.79	0.94	0.85	1.33	1.31	0.74	0.51	0.70	1.10	1.43	0.47	0.76	0.83
MARTINDALE	3	1355	0.99	2.26	0.13	1.75	0.90	0.10	1.10	0.64	0.57	1.32	0.71	2.14	0.63	1.50	1.07	0.90	0.84	0.97	0.90	0.67	1.15	1.07	0.00	1.22	1.62	0.00	3.25	0.89	1.16
MAYLAND HEIGHTS	3	6273	1.00	1.76	0.75	1.00	1.05	0.70	0.86	1.36	1.00	0.97	0.81	0.79	0.94	1.25	1.03	0.85	0.83	0.87	0.85	1.33	1.08	0.81	0.98	0.79	1.06	0.43	0.70	1.04	0.83
MCKENZIE LAKE	14	3995	1.11	0.00	0.13	1.88	0.83	0.20	1.26	0.64	0.79	1.42	1.18	1.29	1.28	0.88	1.13	1.30	1.21	1.38	1.30	0.33	1.15	1.14	0.17	0.00	0.88	0.00	0.92	0.84	0.47
MEADOWLARK PARK	11	1371	1.04	3.13	2.63	0.50	1.19	2.30	0.39	0.91	0.71	1.02	0.89	0.93	0.56	1.00	0.95	0.92	0.85	0.79	0.85	1.17	0.92	0.86	1.50	3.62	3.96	0.00	1.07	2.63	2.13
MIDNAPORE	14	6758	1.07	0.00	0.88	1.13	0.91	1.00	1.19	1.09	0.79	1.02	0.98	1.07	0.88	0.75	1.03	1.04	1.00	1.06	1.03	0.50	1.23	1.05	0.61	0.98	0.27	0.00	0.11	0.96	0.49
MILLRISE	14	3874	1.06	0.00	0.38	1.63	0.92	0.40	1.05	0.55	0.43	1.22	1.02	1.50	0.91	0.75	1.07	1.15	1.08	1.22	1.15	0.17	1.15	1.26	0.35	0.43	0.43	0.93	0.57	0.75	0.58
MISSION	8	3101	1.00	1.19	1.88	0.25	1.25	1.60	0.28	1.18	0.57	1.25	1.21	0.57	0.78	0.88	0.97	1.06	1.18	0.72	0.99	0.67	0.85	1.26	0.66	2.67	0.00	2.92	0.95	2.87	1.68
MONTEREY PARK	5	4714	0.93	0.00	0.50	1.00	0.92	0.60	1.20	0.64	0.64	1.14	0.84	1.07	1.56	0.88	1.08	0.97	0.95	1.09	1.00	0.83	1.15	0.95	0.72	0.70	1.14	1.80	0.78	1.02	1.03
MONTGOMERY	1	4054	1.05	3.17	1.88	1.00	1.00	2.00	0.81	1.36	1.71	0.85	0.75	1.29	1.22	1.50	0.99	0.77	0.70	0.74	0.74	1.50	0.85	0.95	1.35	2.45	1.54	2.97	1.27	1.31	1.82
MOUNT PLEASANT	4	4303	1.07	0.99	1.88	0.75	1.12	1.80	0.66	1.18	1.00	0.95	0.88	0.57	0.75	1.25	0.93	0.86	0.81	0.78	0.82	1.17	0.69	1.14	1.91	0.77	0.38	0.41	1.88	1.57	1.15
NORTH GLENMORE PARK	11	2998	1.02	0.00	1.50	0.75	1.09	1.50	0.82	0.73	0.36	0.64	1.13	0.50	0.81	0.50	0.93	1.09	1.14	1.18	1.14	0.67	1.00	1.07	1.60	2.76	1.02	0.00	1.71	0.64	1.29
NORTH HAVEN	4	3189	1.04	0.00	1.00	1.00	1.03	1.00	0.99	0.91	0.50	0.81	0.95	0.71	0.97	0.75	1.00	1.05	1.06	1.14	1.08	0.83	1.00	1.16	0.86	0.00	0.30	0.00	0.23	0.23	0.27
OAKRIDGE	13	7062	1.04	0.17	0.38	0.75	1.00	0.40	1.19	0.73	0.57	0.83	1.15	0.64	1.34	0.63	1.01	1.31	1.36	1.49	1.39	0.33	1.08	1.19	0.48	0.94	0.00	0.61	0.73	0.48	0.54
OGDEN	9	9237	1.06	1.19	0.75	1.25	0.97	0.80	1.07	1.45	1.29	0.93	0.68	1.29	1.13	1.38	1.01	0.78	0.71	0.80	0.76	1.17	1.08	0.70	0.52	1.25	1.29	0.68	1.27	0.70	0.95
PALLISER	13	2821	1.06	0.00	2.38	0.50	1.14	2.10	0.68	0.82	0.57	1.00	1.01	0.86	0.72	0.63	0.83	1.21	1.19	1.12	1.17	0.33	0.92	1.14	2.18	0.00	0.70	0.00	2.08	1.02	1.00
PARKDALE	7	2352	1.06	0.00	2.13	0.50	1.18	1.80	0.44	0.73	0.36	0.98	0.83	1.64	0.84	0.50	0.95	1.09	0.98	0.98	1.02	1.17	0.54	1.33	0.87	0.00	1.19	1.73	0.31	1.12	0.87
PARKHILL / STANLEY PARK	11	842	1.10	1.45	1.63	0.88	1.12	1.50	0.70	1.09	0.79	1.10	1.43	0.79	0.72	1.63	1.07	1.23	1.25	1.15	1.21	0.50	1.00	1.19	1.62	3.93	0.00	0.00	2.61	0.57	1.46
PARKLAND	14	4767	1.10	0.51	0.38	0.63	0.97	0.40	1.33	0.36	0.21	0.69	1.18	0.57	0.69	0.75	1.04	1.34	1.49	1.68	1.50	0.33	0.92	1.19	0.00	1.39	1.27	0.00	0.62	0.50	0.63
PATTERSON	6	1385	0.98	0.00	0.63	0.75	1.09	0.60	0.71	0.73	0.29	1.37	2.26	1.57	0.75	0.88	1.08	1.59	1.55	1.38	1.51	0.50	0.92	1.30	1.48	2.39	0.49	0.00	1.06	1.04	1.08
PENBROOKE MEADOWS	10	8764	0.79	1.47	0.50	1.25	0.94	0.60	1.31	1.36	1.93	1.03	0.65	1.71	1.44	1.50	0.97	0.66	0.62	0.78	0.69	2.50	0.92	0.51	0.94	1.13	1.29	2.52	0.75	0.49	1.19
PINERIDGE	5	9690	0.94	1.89	0.50	1.13	0.94	0.50	1.21	1.27	1.50	1.02	0.76	1.43	1.16	1.00	1.04	0.82	0.76	0.87	0.82	1.50	1.23	0.79	0.71	0.34	1.31	2.55	0.83	1.22	1.16
POINT MCKAY	7	601	1.09	0.00	0.50	0.63	1.14	0.50	0.56	1.36	0.00	1.00	1.00	0.00	0.00	0.38	0.96	1.57	1.17	1.40	1.38	0.00	0.85	1.47	1.14	0.00	0.00	0.00	1.22	1.20	0.59
PUMPHILL	13	1916	1.00	0.00	2.88	0.50	0.96	3.20	1.19	0.45	0.50	0.85	2.25	0.79	0.56	0.88	0.86	1.72	2.11	1.82	1.88	0.83	0.62	1.33	1.43	0.00	2.97	0.00	1.53	1.13	1.18
QUEENS PARK VILLAGE	4	802	1.07	1.53	0.75	1.13	1.06	0.70	0.68	1.64	1.64	1.34	0.85	0.00	1.06	0.88	1.03	0.81	0.68	0.75	0.75	0.33	1.08	1.00	0.00	0.00	2.09	2.59	0.91	0.60	1.03
QUEENSLAND	12	3974	1.05	0.00	0.38	1.25	0.92	0.40	1.29	1.55	0.93	1.00	0.76	1.36	1.13	0.75	1.05	0.86	0.79	0.96	0.87	0.50	1.08	0.86	0.34	0.42	0.70	2.33	0.18	0.42	0.73
RAMSAY	9	2174	1.02	0.56	1.88	0.88	1.12	1.80	0.72	1.45	2.50	0.90	0.67	1.21	1.28	1.75	0.88	0.71	0.73	0.64	0.69	1.67	0.85	0.72	1.26	3.04	0.77	1.02	2.02	1.88	1.67
RANCHLANDS	2	8440	1.01	1.38	0.25	1.25	0.92	0.30	1.17	1.36	0.93	1.03	0.91	1.14	1.13	0.50	1.09	1.12	1.04	1.14	1.10	0.50	0.69	1.23	0.32	0.00	1.35	0.34	0.52	0.46	0.50
RED CARPET / MOUNTVIEW MOBILE	10	840	1.15	0.00	0.88	1.25	1.00	0.90	0.83	1.00	1.43	1.34	0.18	1.50	1.88	2.13	0.92	0.64	0.54	0.62	0.60	1.67	0.92	0.63	4.07	1.97	0.47	7.78	1.75	2.29	3.06
RENFREW	4	5519	0.96	1.22	2.13	0.75	1.10	2.00	0.64	1.18	1.21	0.95	0.82	1.14	0.81	0.75	0.88	0.84	0.78	0.75	0.79	2.00	1.15	0.95	1.73	2.10	0.99	0.55	1.20	0.96	1.26
RICHMOND	8	5166	1.05	0.00	1.88	1.00	1.08	1.80	0.70	1.00	1.07	0.98	0.83	0.64	0.91	1.13	0.96	0.88	0.79	0.81	0.83	1.17	0.85	1.05	2.12	2.56	1.28	0.00	1.70	1.40	1.51
RIDEAU PARK	11	910	1.15	0.00	1.50	1.00	1.05	1.40	1.06	0.73	0.00	0.69	2.10	0.36	0.00	0.63	1.00	1.82	1.98	2.12	1.97	0.00	0.54	1.63	0.75	0.00	1.48	0.00 .		3.44	0.95
RIVERBEND	9	4943	1.06	0.74	0.13	1.50	0.94	0.20	0.95	0.36	0.29	1.47	1.01	1.71	0.00	0.75	1.17	1.10	1.03	1.19	1.11	0.33	1.23	1.16	1.11	0.33	0.74	0.31	2.08	1.12	0.95
ROSEDALE	7	1950	1.09	0.00	1.63	1.00	0.97	1.70	0.88	0.64	0.64	0.85	1.29	0.50	0.41	1.13	0.88	1.38	1.53	1.31	1.41	0.50	0.54	1.42	0.70	1.70	0.47	0.00	1.13	0.74	0.79
ROSEMONT	4	847	1.02	0.00	2.13	0.63	1.08	2.10	0.73	1.00	0.43	0.69	0.96	0.57	0.00	1.25	0.95	0.97	1.02	0.94	0.98	1.00	0.77	1.05	0.81	0.00	1.48	0.00	0.87	0.28	0.57
ROSSCARROCK	2	3278	0.91	2.05	1.25	1.13	1.04	1.20	0.91	2.27	2.00	1.07	0.88	1.64	0.91	1.50	0.95	0.68	0.60	0.62	0.63	2.00	0.92	0.74	1.67	1.51	1.23	0.74	0.90	1.91	1.33
ROXBORO	11	617	1.12	1.99	3.13	0.38	1.17	2.80	0.63	0.55	0.64	0.71	1.50	1.07	0.00	1.00	0.91	1.84	1.90	1.62	1.79	0.33	0.85	1.44	1.11	0.00	2.37	0.00	1.19	0.78	0.91

ROYALVIEW HEIGHTS	2	216	1.04	5.70	0.88	1.13	1.21	0.80	0.98	0.73	.	1.08	1.84	1.79	.	1.13	1.16	.	0.89	0.63	.	0.00	1.38	1.33	.	.	.	.	.	.	0.00
RUNDLE	5	11803	0.88	0.52	0.38	1.00	0.96	0.40	1.25	1.00	1.36	0.97	0.81	1.21	1.31	1.25	1.04	0.80	0.77	0.93	0.83	1.33	1.31	0.79	0.75	0.56	1.33	0.93	0.99	0.55	0.85
RUTLAND PARK	11	2154	1.10	1.99	2.38	0.63	1.01	2.50	0.89	1.09	0.64	0.63	0.80	0.71	0.22	1.00	0.92	0.86	0.90	0.92	0.89	0.67	1.38	0.79	2.54	0.77	0.00	0.00	0.68	0.78	0.80
SADDLE RIDGE	3	991	1.02	0.00	0.00	1.88	0.96	0.00	0.93	0.64	0.64	1.68	0.68	2.57	1.78	0.75	1.12	0.90	0.78	0.97	0.88	0.00	1.62	0.81	1.38	1.67	0.24	0.79	1.48	0.73	1.05
SANDSONE VALLEY	3	5500	0.79	0.00	0.38	1.50	0.91	0.50	1.21	0.27	0.64	1.42	1.18	1.71	0.81	1.00	1.05	1.05	1.02	1.18	1.08	1.17	1.08	1.07	0.62	0.00	1.22	0.00	1.60	0.48	0.65
SCARBORO	8	1712	1.09	3.58	1.00	0.88	1.10	1.00	0.83	0.91	1.14	1.07	1.57	0.36	0.97	1.50	1.03	1.22	1.38	1.11	1.24	0.33	0.77	1.26	0.40	4.83	0.85	0.00	1.71	0.28	1.35
SCARBORO / SUNALTA WEST	6	489	1.10	0.00	2.50	0.50	1.10	2.40	0.78	0.64	0.50	0.37	1.36	0.57	.	0.88	0.91	1.76	1.72	1.79	1.76	0.67	0.54	1.42	.	.	.	.	.	.	0.00
SCENIC ACRES	1	2238	1.04	1.10	0.25	1.75	0.88	0.20	1.20	0.45	0.14	1.07	1.16	0.93	0.00	0.50	1.12	1.35	1.34	1.53	1.41	0.33	1.00	1.30	0.31	0.00	0.46	0.00	0.98	0.54	0.38
SHAGANAPPI	6	3015	0.88	3.24	2.00	0.88	0.92	2.30	0.97	2.00	2.43	1.12	0.83	0.79	0.94	1.38	0.91	0.80	0.62	0.64	0.69	1.67	1.08	0.91	1.81	1.65	0.90	1.53	2.19	2.47	1.76
SHAWNESSY	14	4923	1.09	0.25	0.13	1.88	0.87	0.20	1.09	0.55	0.50	1.37	1.01	1.21	0.97	0.88	1.13	1.12	1.03	1.13	1.09	0.33	1.00	1.16	0.83	0.00	0.65	0.29	1.04	0.59	0.57
SIGNAL HILL	6	3222	0.93	0.00	0.25	1.25	1.00	0.30	0.97	0.55	0.57	1.59	1.44	2.14	0.56	0.38	1.07	1.21	1.18	1.33	1.24	0.67	1.00	1.33	1.91	1.03	0.47	0.25	2.05	0.97	1.11
SILVER SPRINGS	1	10181	1.05	0.00	0.50	1.00	0.95	0.50	1.20	0.64	0.36	0.80	0.98	0.71	0.72	0.63	1.03	1.28	1.29	1.34	1.30	0.50	0.92	1.26	0.47	0.65	0.87	0.00	0.79	0.83	0.60
SOMERSET	14	765	1.10	0.00	0.13	1.50	0.91	0.20	1.08	0.64	0.79	1.27	0.94	0.64	0.94	0.38	1.20	1.05	0.99	1.18	1.07	0.00	1.08	1.19	0.89	0.00	0.81	0.85	.	2.83	0.90
SOUTH CALGARY	8	2436	1.05	1.01	1.00	1.00	1.09	1.00	0.60	1.55	2.21	1.25	0.88	0.79	1.25	1.13	1.03	0.78	0.64	0.64	0.69	1.17	0.92	0.98	0.56	1.36	0.81	0.93	0.90	1.78	1.06
SOUTHVIEW	9	2083	0.94	4.12	1.63	1.00	0.97	1.80	0.98	1.64	2.43	0.95	0.67	1.14	1.09	1.75	0.91	0.71	0.67	0.74	0.71	2.17	0.62	0.63	1.97	1.59	0.91	1.80	1.76	1.96	1.67
SOUTHWOOD	12	6130	1.06	1.20	0.63	0.88	1.05	0.70	0.92	1.36	1.21	0.86	0.81	0.93	0.97	1.38	1.01	0.89	0.85	0.92	0.89	0.50	1.08	0.98	1.00	0.54	0.84	2.16	0.96	1.37	1.15
SPRUCE CLIFF	6	1546	0.96	0.79	3.75	0.63	0.95	4.10	0.74	1.82	1.50	0.95	0.87	0.93	1.06	1.13	0.82	0.68	0.67	0.58	0.64	1.83	1.08	0.86	3.98	1.07	0.00	0.00	2.37	2.18	1.60
ST ANDREWS HEIGHTS	7	2056	0.98	0.00	2.88	0.75	0.92	3.20	0.73	0.36	0.21	1.08	1.17	0.21	0.44	1.25	0.97	1.26	1.32	1.23	1.27	0.17	0.54	1.60	2.66	0.80	2.37	1.73	1.43	1.52	1.75
STRATHCONA PARK	6	4931	1.01	0.00	0.50	1.50	0.95	0.60	1.01	0.73	0.64	0.93	1.33	0.79	1.16	0.63	1.08	1.47	1.42	1.58	1.49	0.33	0.77	1.51	0.42	0.34	1.23	0.00	1.34	0.44	0.63
SUNALTA	8	2383	1.02	4.13	0.50	0.50	1.17	0.40	0.46	1.09	2.43	1.47	0.80	1.21	0.88	1.38	1.13	0.71	0.82	0.52	0.68	0.50	0.77	1.07	0.86	4.17	1.98	2.83	2.15	2.32	2.39
SUNDANCE	14	7822	1.07	0.16	0.25	1.50	0.84	0.30	1.36	0.45	0.21	1.24	1.13	1.21	0.69	0.63	1.08	1.24	1.18	1.35	1.26	0.33	1.15	1.14	0.52	0.21	1.08	0.77	0.66	0.31	0.59
SUNNYSIDE	7	3509	1.09	1.57	0.88	0.38	1.21	0.80	0.44	1.36	1.29	1.24	0.88	1.00	0.81	1.13	1.11	0.91	0.85	0.70	0.82	0.50	0.85	1.30	0.97	2.83	2.28	0.00	0.84	0.96	1.31
TARADALE	3	1796	1.00	0.00	0.13	1.75	0.90	0.20	1.18	0.55	0.79	1.36	0.69	2.36	0.91	1.25	1.00	0.87	0.85	0.98	0.90	1.00	1.54	0.86	0.00	0.00	2.30	1.09	0.41	0.40	0.70
TEMPLE	5	10562	0.91	0.99	0.25	1.25	0.90	0.30	1.33	1.09	1.21	0.90	0.81	1.43	0.94	1.00	1.03	0.89	0.83	0.98	0.90	1.17	1.08	0.88	0.32	0.16	1.15	1.42	0.76	0.84	0.78
THORNCLIFFE	4	10081	0.98	0.97	1.38	1.00	1.04	1.40	0.95	1.27	1.21	0.88	0.84	0.64	1.06	1.25	0.92	0.89	0.87	0.93	0.90	1.50	0.85	0.93	1.08	0.49	1.44	0.61	0.36	0.84	0.80
TRIWOOD	4	4928	1.05	0.00	2.13	0.75	1.12	1.90	0.75	0.73	0.57	0.66	1.02	0.36	0.44	0.75	0.84	1.15	1.20	1.23	1.19	0.67	0.85	1.23	0.97	0.34	0.95	0.00	0.30	0.83	0.57
TUSCANY	1	2200	1.04	0.00	0.25	1.38	0.94	0.20	1.18	0.09	0.14	1.59	1.53	1.21	0.00	0.63	1.13	1.35	1.47	1.68	1.50	0.17	1.00	1.23	0.62	0.00	0.89	0.00	0.67	0.77	0.49
TUXEDO PARK	4	4153	1.01	3.10	1.75	0.75	1.12	1.70	0.66	1.27	1.57	1.02	0.73	1.00	1.25	1.25	0.93	0.80	0.72	0.68	0.73	1.67	0.85	0.95	1.48	1.99	0.88	0.00	1.06	1.27	1.11
UNIVERSITY HEIGHTS	1	736	1.01	0.00	0.63	0.63	1.10	0.60	0.91	1.64	0.64	1.17	1.48	0.93	0.31	1.38	1.12	1.01	1.03	0.64	0.89	0.00	0.46	1.35	1.86	2.25	0.00	0.00	.	0.65	0.79
UNIVERSITY OF CALGARY	1	2828	0.98	1.53	0.75	0.88	1.06	0.80	0.86	0.91	1.43	1.08	1.51	0.29	0.63	1.25	0.91	0.91	1.02	0.99	0.97	0.50	0.38	1.47	0.24	0.59	0.25	0.00	1.30	1.70	0.68
UPPER MOUNT ROYAL	8	4400	1.05	1.39	1.13	0.50	1.13	1.10	0.75	0.64	0.71	1.02	2.31	0.57	0.91	1.00	1.01	1.61	1.97	1.38	1.65	0.33	0.77	1.28	0.78	0.75	0.35	0.93	1.67	1.86	1.06
VARSITY	1	12942	0.99	0.52	1.38	0.50	1.10	1.30	0.91	0.73	0.57	0.81	1.28	0.57	1.03	0.88	0.92	1.29	1.47	1.35	1.37	0.50	0.62	1.28	0.53	0.77	0.93	0.75	0.74	0.84	0.76
VICTORIA PARK	8	5148	0.85	2.61	1.50	0.63	1.18	1.40	0.61	1.45	.	1.32	0.83	0.00	1.19	2.00	0.92	0.65	0.90	0.51	0.69	2.17	1.08	0.60	1.99	5.14	1.94	1.20	1.71	3.78	2.63
VISTA HEIGHTS	3	2464	0.95	1.49	0.38	1.50	0.90	0.40	1.23	1.82	2.14	1.15	0.80	1.43	1.53	1.50	1.05	0.77	0.74	0.82	0.78	1.33	1.31	0.79	0.55	1.34	1.66	0.00	1.79	0.88	1.04
WEST HILLHURST	7	5030	1.07	1.46	2.00	0.75	1.13	1.90	0.61	1.09	1.14	1.02	0.85	1.21	1.06	1.00	0.92	0.88	0.83	0.80	0.84	1.17	0.69	1.19	0.68	1.64	0.71	1.37	0.58	0.91	0.98
WESTGATE	6	3850	1.04	0.32	1.63	0.75	1.05	1.60	0.88	1.18	0.93	0.58	0.87	0.50	0.78	1.13	0.91	0.94	0.89	1.01	0.95	1.50	1.00	0.98	1.78	1.29	0.30	0.93	0.19	0.81	0.88
WHITEHORN	5	12127	0.84	0.76	0.38	1.13	0.92	0.50	1.33	0.82	0.86	0.90	0.81	1.43	1.03	1.00	1.05	0.85	0.86	1.04	0.92	1.33	1.08	0.86	0.96	0.41	1.34	0.44	0.85	0.75	0.79
WILDWOOD	6	2811	1.07	1.30	2.00	0.88	1.05	2.00	0.79	0.64	0.36	0.68	1.02	0.36	0.41	1.13	0.83	1.16	1.16	1.20	1.17	0.83	0.85	1.21	0.97	0.00	1.90	0.00	0.52	0.68	0.68
WILLOW PARK	12	6180	1.06	0.00	1.13	0.63	1.09	1.00	0.90	0.82	0.57	0.73	1.21	0.57	1.22	0.75	0.99	1.25	1.37	1.41	1.34	0.33	1.08	1.12	0.66	0.54	1.19	0.00	0.59	0.97	0.66
WINDSOR PARK	11	2411	1.06	1.77	1.88	0.63	1.18	1.60	0.43	1.18	0.79	1.34	0.84	1.50	0.66	1.13	1.03	0.84	0.79	0.69	0.77	0.83	1.31	0.95	2.83	0.69	1.32	3.50	1.22	1.50	1.84
WINSTON HEIGHTS / MOUNTVIEW	4	4091	1.04	0.00	2.88	0.88	1.01	3.00	0.72	0.82	1.29	0.86	0.85	0.71	0.88	1.38	0.80	0.81	0.75	0.74	0.77	2.00	0.85	0.86	1.50	0.40	2.21	0.00	0.90	1.59	1.10
WOODBINE	13	11243	1.01	0.22	0.25	1.25	0.88	0.30	1.28	0.55	0.43	1.10	1.24	0.79	0.63	0.63	1.07	1.34	1.30	1.48	1.37	0.33	1.00	1.28	0.43	0.29	0.73	0.37	0.52	0.34	0.45
WOODLANDS	13	6456	1.01	0.47	0.38	1.00	0.95	0.50	1.12	1.00	1.00	1.02	1.13	0.86	0.63	0.88	1.05	1.22	1.19	1.30	1.24	0.33	0.92	1.21	0.42	0.77	0.47	1.54	1.14	0.60	0.82

ratios and indices were calculated for each variable to produce a table suitable for the statistical analysis and GIS thematic mapping. Figure 3.3 portrays the manipulation techniques used to prepare the raw census and hospital-use counts for statistical analysis.

<u>Diagram 3.3</u>

Data Manipulation Techniques



4.0 ANALYSIS OF HEALTH STATUS INDICATORS

This chapter is an analysis of the health status indicators that were derived from the GCR residents' hospital records. The dataset was assessed at two stages; the first stage was prior to the transformation of the individual records into hospital-use categories. The second stage occurred after the records were reduced to obtain hospital-use categories and focussed on those that were selected as health status indicators. The chapter ends with a brief discussion, supported by maps, of the spatial distribution of the health status indicators.

Clarification of some of the terms used to describe the hospital dataset and its subsets is important to this chapter (see Table 4.0). *Hospital Records* are the base data provided by the CRHA. They are a set of individual patient records that comprise 14 variables including postal code, age, and diagnostic categories (see Table 3.1 in the previous chapter). *Hospital-Use Categories* are based on the discharge codes or diagnostic categories (ADRGs or MDCs) assigned to each patient record (see Table 3.2 and 3.3). *Health Status Indicators* were derived from the hospital records and are the specific hospital-use categories selected to represent community health status in the final analysis (shown in Table 3.4).

Table 4.0

List of terms derived from the main hospital record dataset

CATEGORY	DESCRIPTION
Data Source	Hospital Records (individual patient records)
Data Groups	Hospital Use Categories (i.e., diagnostic categories)
Data Trends	Hospital Use Patterns (frequencies)
Data Derivatives	Health Status Indicators

4.1 Summary of Stay Categories

The hospital records for GCR residents used for the analysis are selected from the 1995-96 CRHA acute inpatient hospital care dataset and their description is based on hospital separations grouped by age, length of stay (LOS), admit code and MDC. Each of the tables for the categories presented here is separated by gender and includes counts, percentages and a chart in four tables numbered 4.1 to 4.4.

Hospital Stays by Age Category

Table 4.1 – Infants less than one year old comprise the largest single age category for hospital use although 10,717 of the 12,324 cases are newborns. The largest hospital services consumer group comprises females in the main reproductive years (25-40 yr.). This patient group accounts for over 40% of hospital services within the female category, and 24% of total acute care hospital services. The third largest consumer group for hospital services is seniors. Declining health in their later years results in increased hospital service demand by patients over 60 years old.

Hospital Stays by Length of Stay (LOS)

Table 4.2 - Trends in LOS categories for male and female patients are similar in that the duration distribution of hospital stays for both declines rapidly after one and two days. The bar chart records the number of days for inpatient hospital stays. Zero day stays for surgical outpatients are therefore not included. Although females have more total hospital days than males (44,660 versus 30,080), males have a higher average mean and median number of days spent in hospital (see summary statistics box). This is due to the slightly higher percentage, within their sex category, of LOS greater than 5 days. The apparent rise in cases for both groups after the 10-15 day category is a result of changing the LOS consolidation period on the chart from a one day interval to increasingly wide range after the 9 day stay category.

Hospital Stays by Admission Category

Table 4.3 - More than half of the admissions for males are through emergency, 18% are elective and less than 10% are urgent. For females, emergency and elective are the two largest admission categories (41% and 30.7%) and 16.5% are urgent. Baby delivery for the mother can be classified as either emergency or urgent depending on the circumstances. According to the CRHA, a large proportion of male and female emergency admissions results from injuries such as falls and traffic accidents (CRHA: 1995: Health Needs Assessment).

Table 4.1
Age Categories for GCR Acute Care Inpatients

AGE CAT	FEMALES		MALES	
Label	*Freq*	*Perc*	*Freq*	*Perc*
< 1	5981	13.4	6343	21.1
1-5	756	1.7	1072	3.6
5-10	663	1.5	810	2.7
10-15	604	1.4	722	2.4
15-20	1753	3.9	793	2.6
20-25	3228	7.2	863	2.9
25-30	5335	11.9	1139	3.8
30-35	5931	13.3	1332	4.4
35-40	3663	8.2	1475	4.9
40-45	2060	4.6	1464	4.9
45-50	1731	3.9	1478	4.9
50-55	1374	3.1	1368	4.5
55-60	1341	3.0	1599	5.3
60-65	1530	3.4	1791	6.0
65-70	1763	3.9	2200	7.3
70-75	1921	4.3	2077	6.9
75-80	1868	4.2	1639	5.4
80-85	1620	3.6	1121	3.7
85-90	994	2.2	560	1.9
90-100	544	1.2	234	0.8
Total	44660	100	30080	100

SUMMARY STATISTICS	
FEMALES AGE	
Mean	37.75
Median	33.30
Variance	644.65
Std dev	25.39
Valid cases	44660

SUMMARY STATISTICS	
MALES AGE	
Mean	39.23
Median	41.70
Variance	855.84
Std dev	29.26
Valid cases	30080

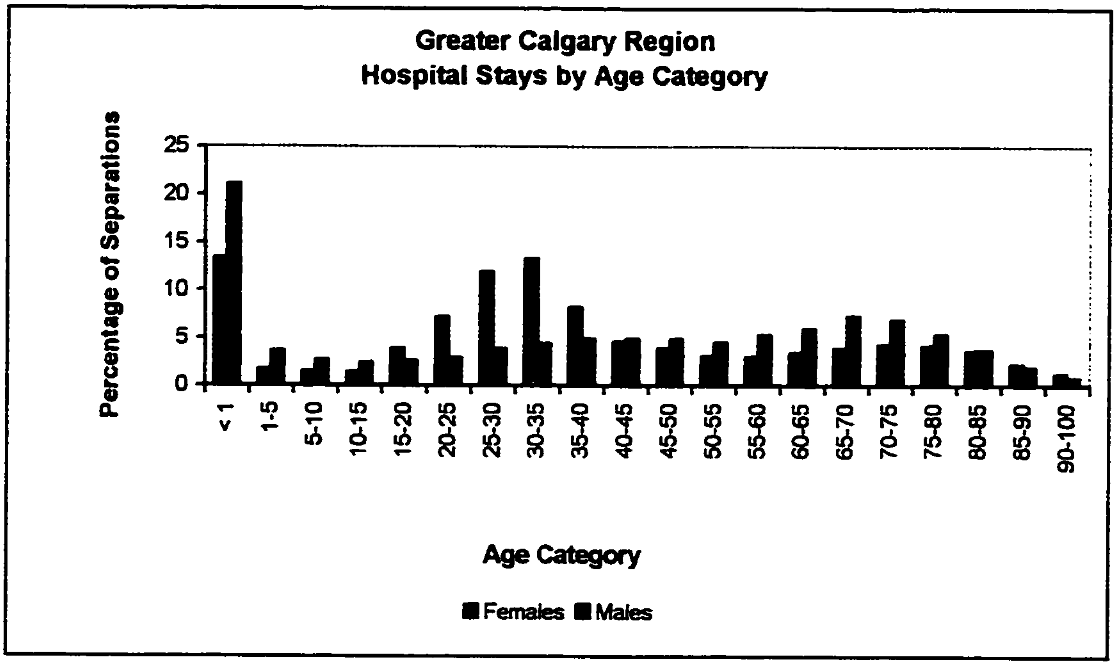


Table 4.2
Length of Stay (LOS) Categories for GCR Acute Care Inpatients

LOS CAT	FEMALES		MALES	
Value	Freq	Perc	Freq	Perc
1	14080	31.5	9171	30.5
2	9905	22.2	5184	17.2
3	5154	11.5	3074	10.2
4	3393	7.6	2187	7.3
5	1946	4.4	1567	5.2
6	1434	3.2	1294	4.3
7	1328	3.0	1097	3.6
8	1030	2.3	884	2.9
9	801	1.8	715	2.4
10-15	2485	5.6	2276	7.6
16-25	1543	3.5	1329	4.4
26-35	679	1.5	595	2.0
36-50	426	1.0	387	1.3
51-75	279	0.6	190	0.6
76-100	104	0.2	74	0.2
101-150	60	0.1	37	0.1
151-200	8	0.0	10	0.0
201-250	4	0.0	5	0.0
251-300	1	0.0	3	0.0
301-500	0	0.0	1	0.0
Total	44660	100	30080	100

SUMMARY STATISTICS	
FEMALES AGE	
Mean	5.38
Median	2.00
Variance	104.86
Std dev	10.24
Valid cases	44660

SUMMARY STATISTICS	
MALES AGE	
Mean	6.26
Median	3.00
Variance	135.08
Std dev	11.62
Valid cases	30080

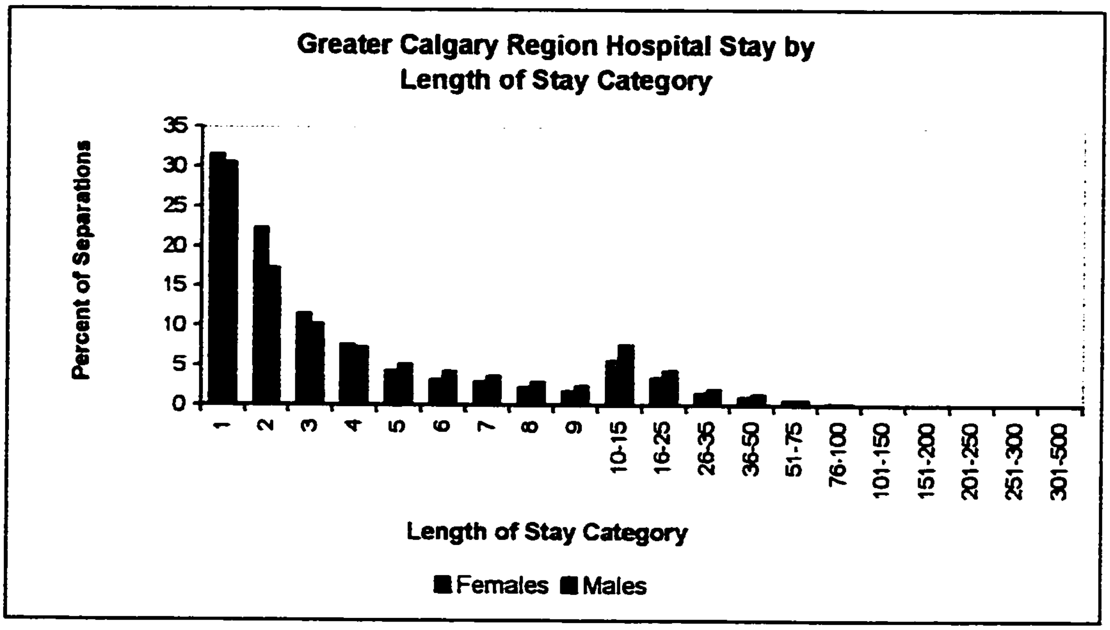
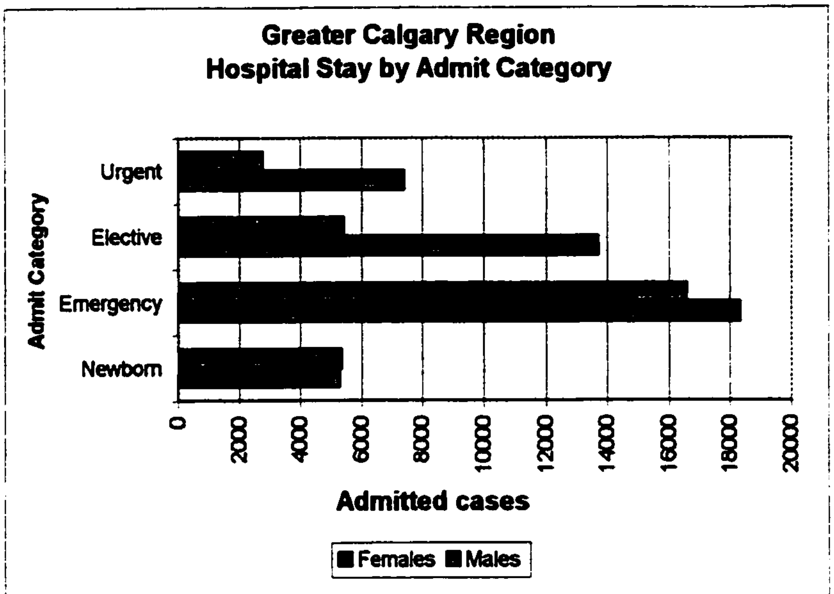


Table 4.3
Admit Categories for GCR Acute Care Inpatients

ADMIT_CATEGORY	FEMALES		MALES	
Label	*Freq*	*Perc*	*Freq*	*Perc*
Newborn	5270	11.8	5330	17.7
Emergency	18306	41	16579	55.1
Elective	13708	30.7	5414	18
Urgent	7376	16.5	2757	9.2
Total	44660	100	30080	100



Hospital Stays by MDC

Table 4.4 lists a description of the MDC codes and Table 4.5 shows the relative proportion of total inpatient hospital cases represented by each MDC. Maternal Newborn services, which comprises MDC 14 (Pregnancy / Childbirth / Puerpenium), and MDC 15 (Newborns and Neonates), account for the largest category of hospital services for GCR patients. Overall the Maternal Newborn category represents 41.4% of GCR total female acute care inpatient hospital services.

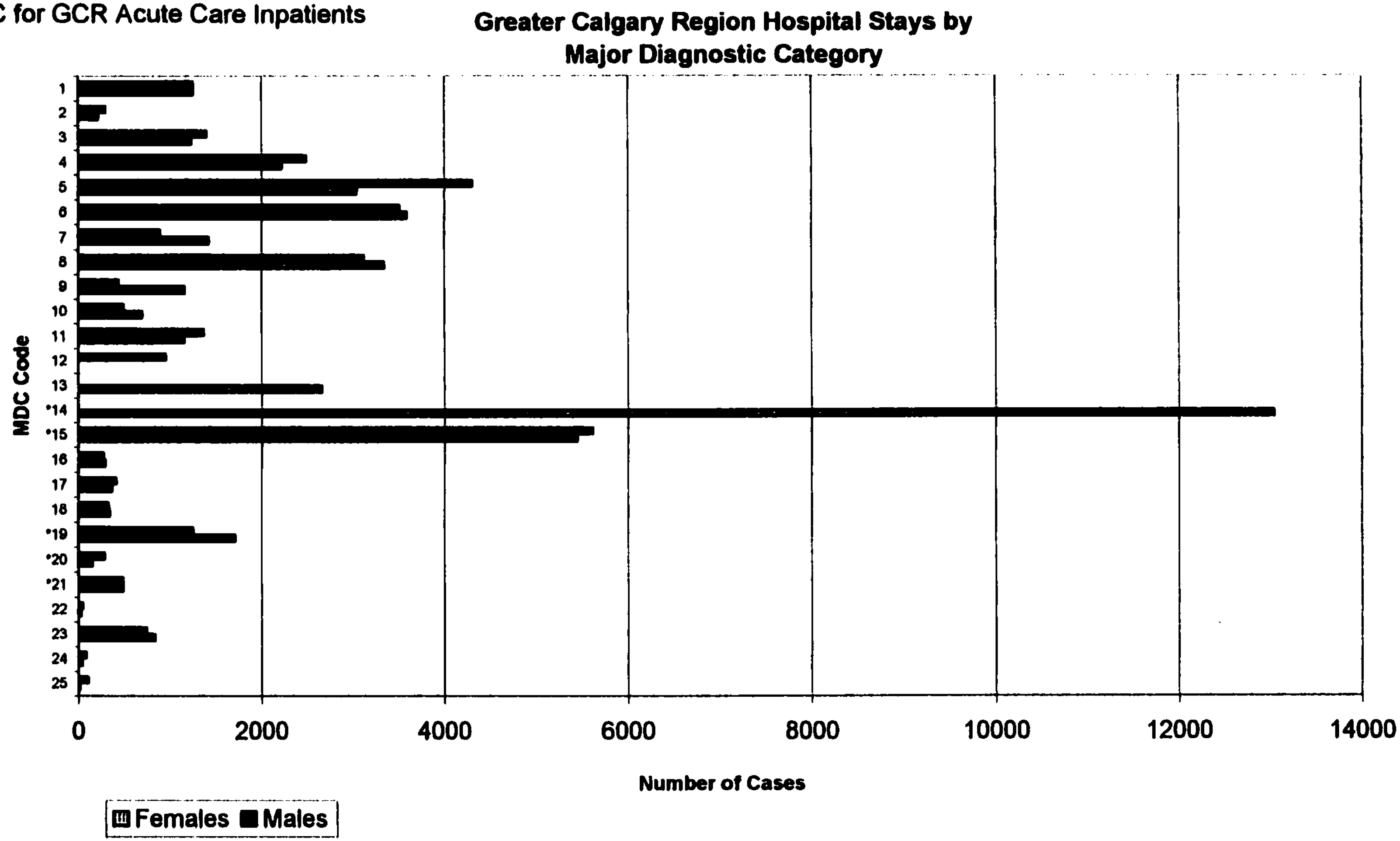
For males, MDC 15 (newborns and neonates) accounts for 18.5% of their stays; Diseases and Disorders of the Circulatory System (MDC 5) accounts for 14.5%, Diseases and Disorders of the Digestive System (MDC 6) accounts for 11.6%, and

Table 4.4
Major Diagnostic Categories (MDC) for GCR Acute Care Inpatients

MDC	
0	No MDC
1	Diseases and disorders of the Nervous system
2	Diseases and disorders of the eyes
3	Diseases and disorders of the ear, mouth and throat
4	Diseases and disorders of the respiratory system
5	Diseases and disorders circulatory system
6	Diseases and disorders of the digestive system
7	Diseases and disorders of hapatobiliary system and pancreas
8	Diseases and disorders musculoskeletal system and connective tissue
9	Diseases and disorders of the skin, subcutaneous tissue and breast
10	Diseases and disorders of the endocrine, nutritional and metabolic
11	Diseases and disorders of the kidney and urinary tract
12	Diseases and disorders of the male reproductive system
13	Diseases and disorders of the female reproductive system
* 14	Pregnancy, childbirth and the puerpenium
* 15	Newborns and other neonates with conditions originating in the perinatal period
16	Diseases and disorders of blood, blood forming organs & immunological disorders
17	Mycloproliferative diseases and disorders and poorly differentiated neoplasms
18	Infectious and parasitic diseases
* 19	Mental diseases and disorders
* 20	Alcohol/drug use and associated organic mental disorders
* 21	Injuries, poisonings and toxic effects of drugs
22	Burns
23	Factors influencing health status and other contacts with health services
24	HIV infection
25	Multiple significant trauma

* *Denotes the MDCs used in the health status indicators*

Table 4.5
MDC for GCR Acute Care Inpatients



Diseases and Disorders of the Musculoskeletal System and Connective Tissue (MDC 8) accounts for 10.4%. Overall, 55 percent of male admissions are accounted for by these four categories.

As shown by the preceding discussion of the patient-use categories, a large proportion of hospital services is devoted to maternity and birth related services. Of the 74,740 GCR hospital patient cases, 13,034 were pregnancy-related services. When this category is subtracted from the dataset, the hospital usage becomes very consistent with the overall gender ratios in the GCR, i.e., there are 31,626 (51.25%) remaining female hospital cases versus the 30,080 (48.75%) male cases.

4.2 Summary of Health Status Indicators

The health status indicators, which were discussed in Chapter 3, are summarized here prior to their standardization and the results are shown in Table 4.6. The health status indicators are arranged and described in descending order of importance.

- *Mental Diseases and Disorders* (MDC 19), is the largest health status category. The 2958 cases represent almost 4% of the total inpatient acute care admissions.

- *Early Death*, calculated from hospital discharge codes, are patients who died at a younger age than the Canadian average (approximately 80 years old for females and 75 for males). There were 1041 such cases or 1.4% of the total number of the GCR hospital cases.

- *Injuries, Poisonings and Toxic Effects of Drugs*, (MDC 21) has 970 cases which account for 1.3% of the total admissions.

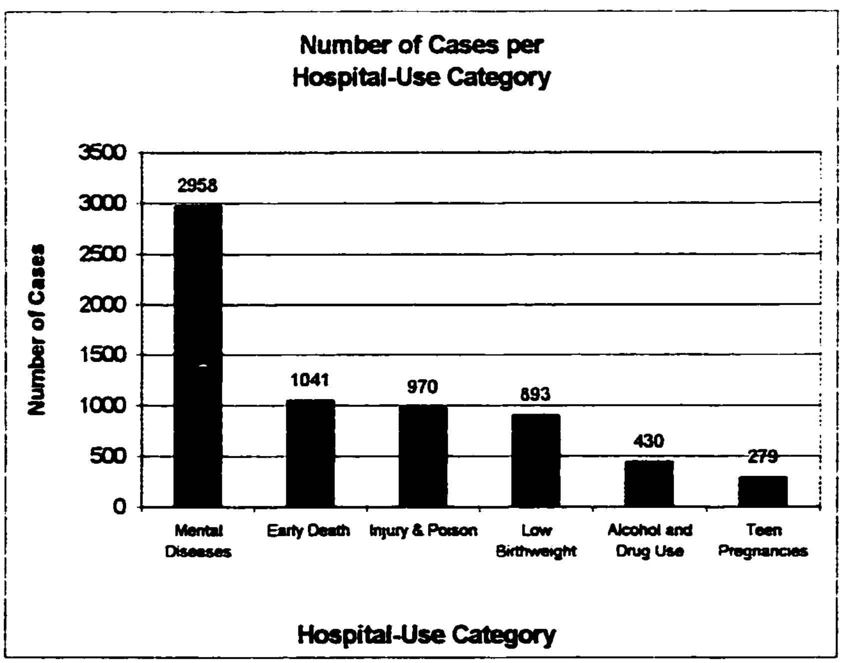
- *Low Birthweight Newborns* form a category of 893 cases which represents 1.2 % of total acute care hospital care. However within the MDC 15 group (Newborns and Neonates) low birthweights account for 8% of the total 11,065 births.

- *Alcohol and Drug Abuse, and Toxic Effects of Drugs* (MDC 20) has 430 cases which accounts for 0.5% of total inpatient admissions.

- *Teen Pregnancy* is the smallest category and applies to females 18 years old or younger. Overall, the 279 cases represent 0.3% of total acute care hospital admissions but approximately 2% of the 13,034 cases in the MDC 14 category, (Pregnancy, Childbirth and Puerpenium). The category also represents 28% of admissions for females aged 14 to 18 years old.

Table 4.6
Summary of Community Health Status Indicator Variables

Hospital-Use Category	Count
Mental Diseases & Disorders	2958
Early Death	1041
Injury, Poison & Toxic Effects	970
Low Birthweight Newborns	893
Alcohol and Drug Use	430
Teen Pregnancies	279
TOTAL	6571



The selected health status indicators have a collective population of 6,571 cases which represents about 8% of the 74,740 cases of 1995-96 CRHA acute care inpatient hospital admissions.

4.3 Spatial Distribution of Health Status Indicators

A discussion of the spatial distribution of the health status indicators is useful as an overview prior to their mathematical analysis. A graphic analysis will assist in interpretation of the results that are discussed in later chapters.

Prior to a description of the spatial distribution of the health and social status indicators, a view of Calgary communities in terms of urban structures is presented. It provides a frame of reference and the terminology for the type of communities discussed in this and the following chapters.

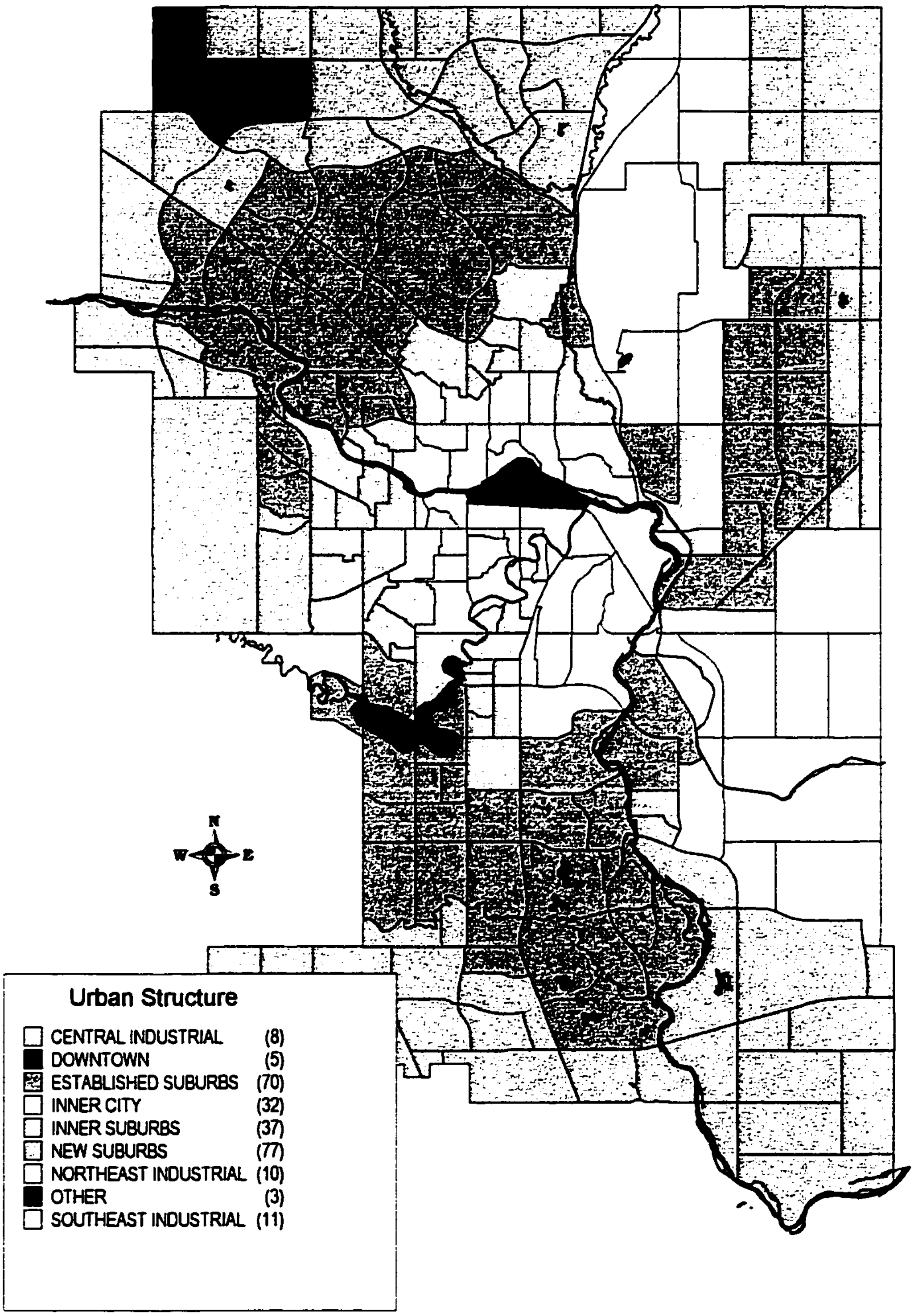
Spatial Distribution of Urban Structures

The downtown commercial sector lies west of the confluence of two rivers, the Bow River which flows east then south, and the Elbow River which flows northeast into the Bow (see Figure 4.0). The city's commercial sector is ringed by a series of inner city communities. The north, west and south inner city communities are the inner boundary of a series of inner suburbs while the southeast edge is adjacent to a large tract of industrial land. Two main clusters of established communities lie south, north and northwest of this perimeter, while the northeast contains a large industrial sector where the airport is located. The outer city fringe contains new suburbs except for a large tract of industrial land on the east side.

There are approximately 255 communities, which roughly correspond to the boundaries of the "community areas" used in the Davies (1975) study, although the city has expanded considerably in all directions since then.

Figure 4.0

Calgary Communities
Urban Structures



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Spatial Distribution of Individual Health Risk Categories

In this section, the distribution of the health risk categories are shown in a series of thematic maps. The distribution of each community health risk category is discussed and the range of index values for each category is provided. For example, because the Alcohol and Drug Abuse risk category ranges in value from 0 to 19.3, the community with the highest index value has over nineteen times the rate of admittance for this category than the average rate for the Calgary Region. The section concludes with a discussion of the range of index values used in the thematic maps.

Alcohol and Drug Abuse

Figure 4.1 - The Drug Abuse Risk index values range from 0 to 19.3. Except for Country Hills in the northwest, which is a special case discussed later in the thesis, the majority of the highest at-risk communities are in the east downtown and immediately east and west of the downtown. High values occur in the inner city and inner suburb communities as well as in clusters of established and new suburbs representing both high status new suburbs and low status established suburbs.

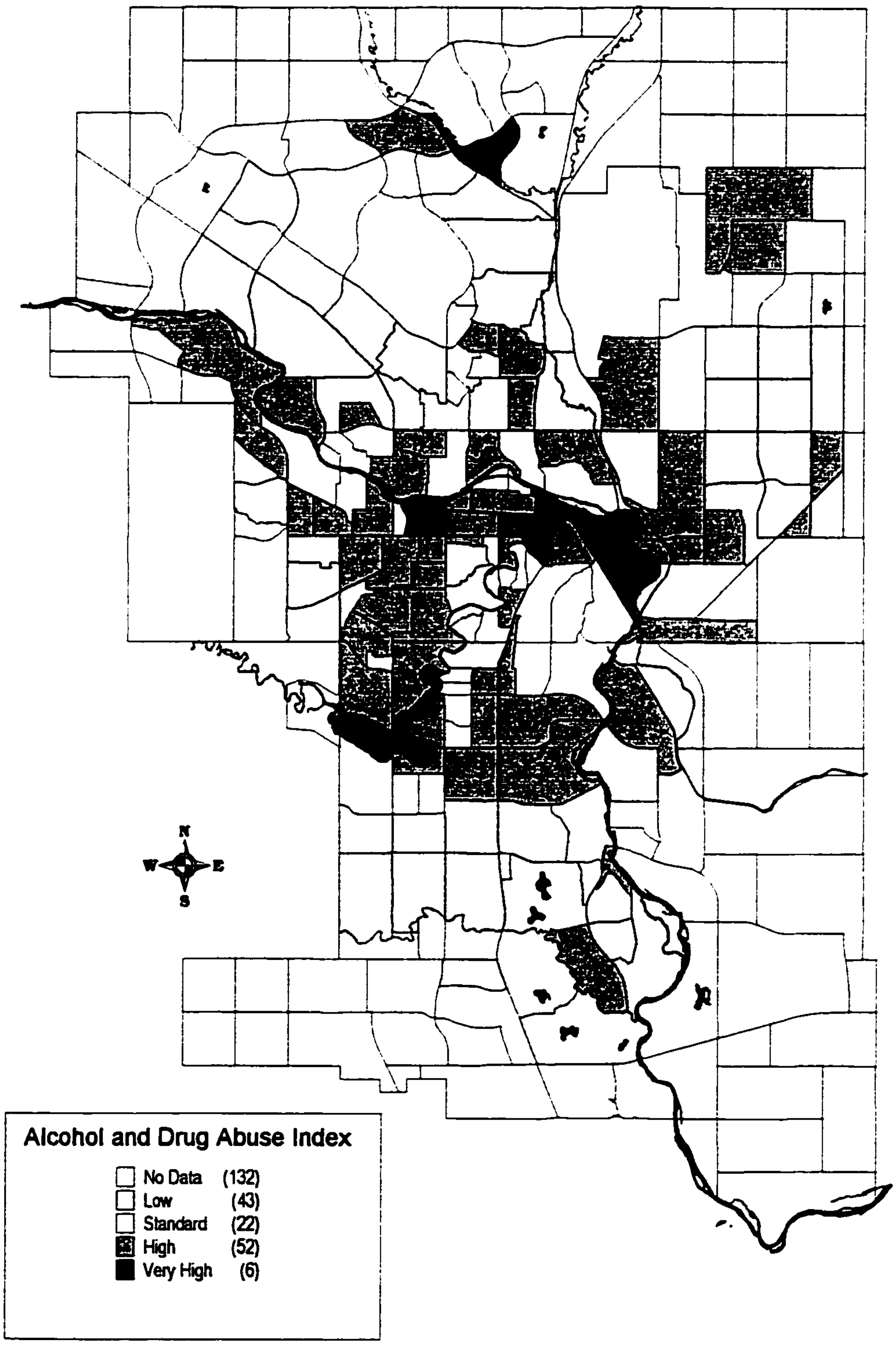
This category has the highest range of values, but the location of the extremely high value communities should be cautiously assessed. Though they may may well indicate a substance abuse proble in the community, they should be viewed in light of the social class of the residents. Certain health risk categories especially ones with a social stigma attached to it, would not show up in the wealthier communities simply because the residents have alternative treatment options while in the poorer communities there is no choice but to seek local, social services.

Mental Diseases and Disorders

Figure 4.2 - The Mental Health Risk index values range from 0 to 9.02. With the exception of Country Hills in the Northwest, the very high-risk communities are clustered in the southeast downtown and southeast inner city. High values also occur in communities to the west, south of the Bow River and include some of the high socio-economic communities such as Upper Mount Royal, Bankview, and South Calgary.

Figure 4.1

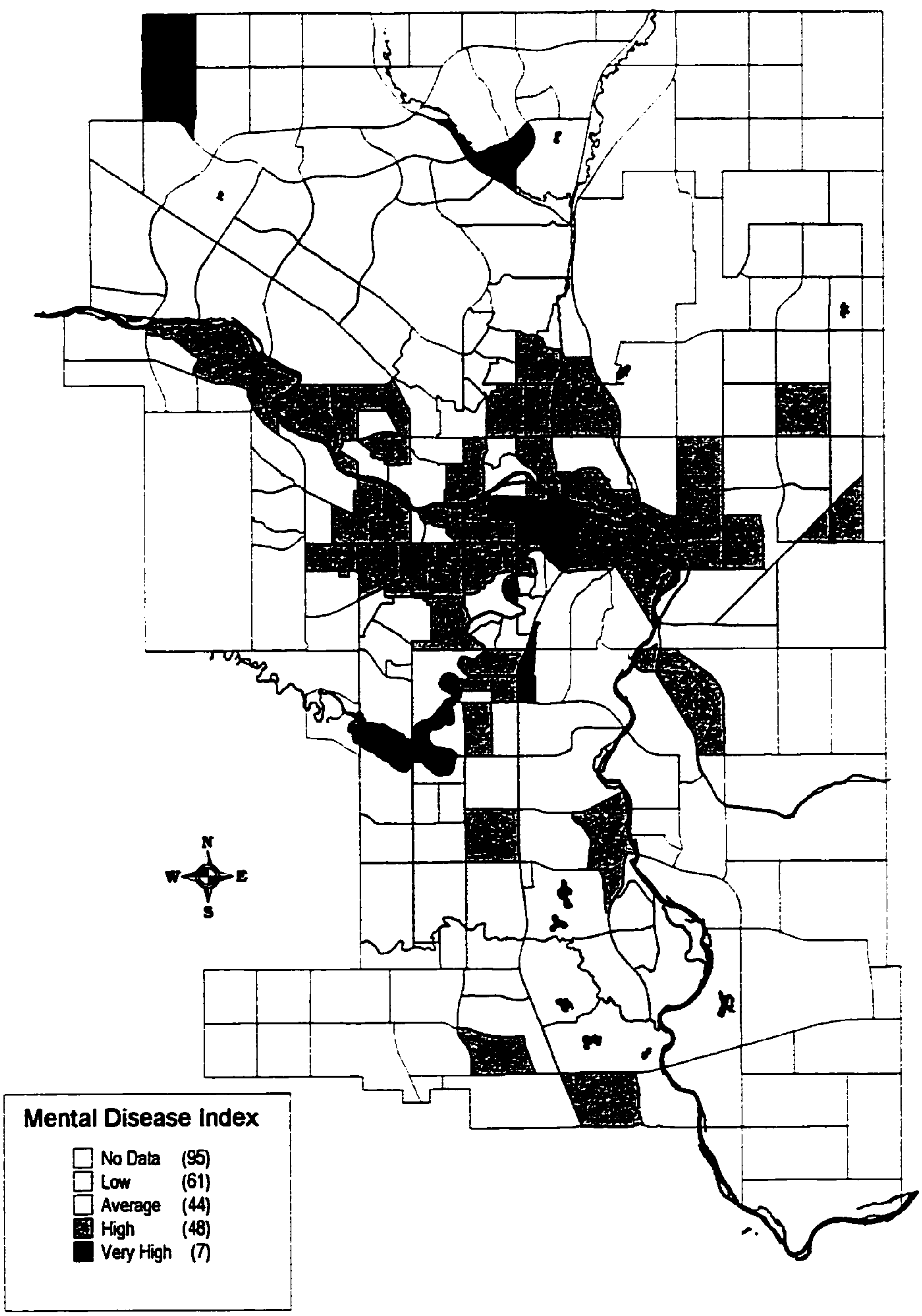
Calgary Communities
Alcohol and Drug Abuse Risk



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Figure 4.2

Calgary Communities
Mental Disease and Disorders Risk



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Injuries, Poisonings, and Toxic Effects of Drugs

Figure 4.3 - The Injuries index values range from 0 to 5.04. The highest risk communities are not as contiguous as the previous categories, and occur from the inner city to the new suburbs. High values occur in a concentric patchwork pattern extending from the downtown to the established communities. High values occur for both the high as well as the low economic status communities.

Early Death

Figure 4.4 - The Early Death Risk index values range from 0 to 12.53. There is only one very high-risk community in the downtown core. Most high-risk communities occur in the south inner city, and in a belt of contiguous communities west of the Deerfoot Trail by the airport. The rest of the high-risk communities are scattered in the south and west and include some high economic status communities but are mostly low economic status communities.

Teenage Pregnancy

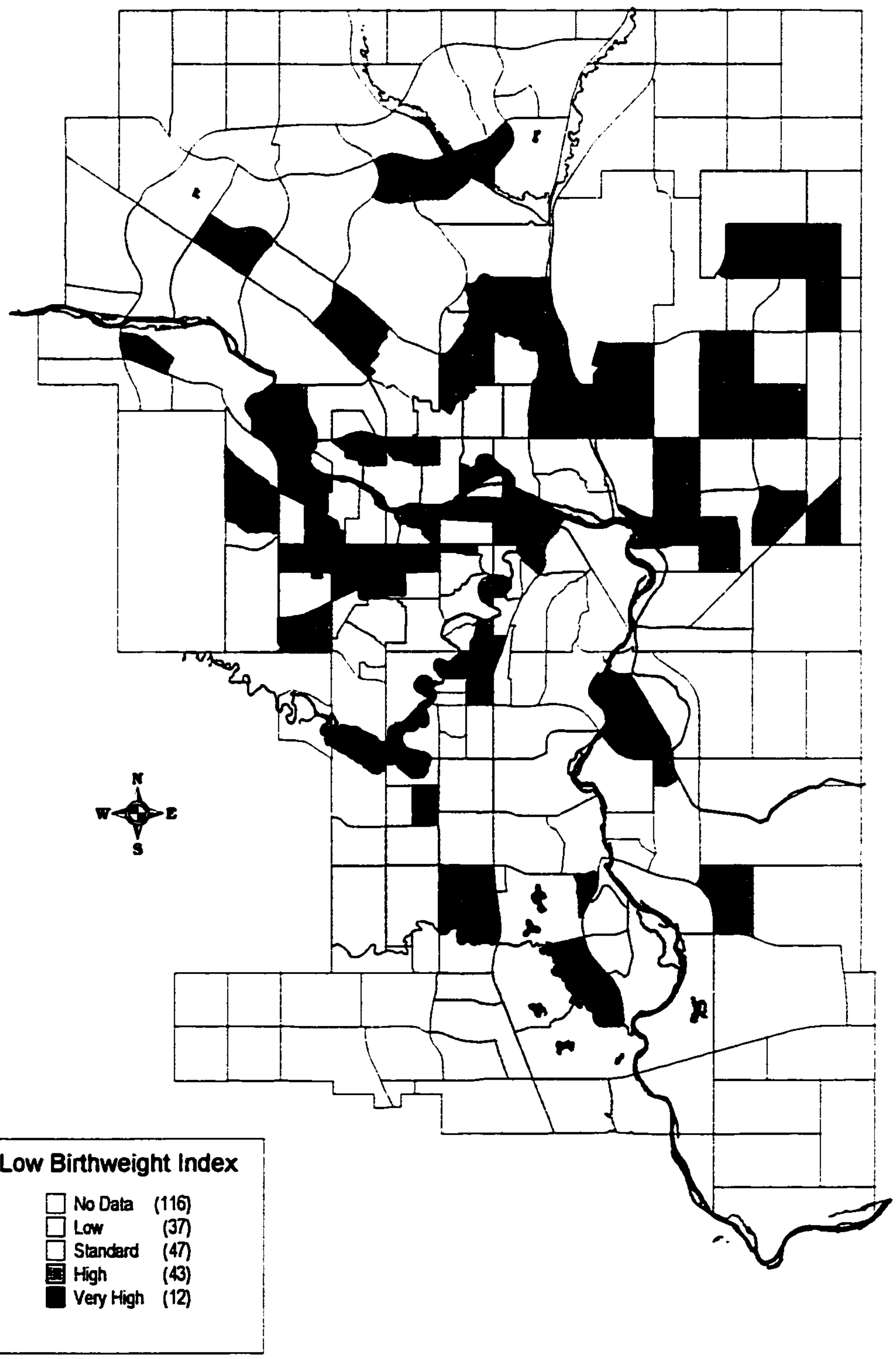
Figure 4.5 - Teenage Pregnancy Risk index values range from 0 to 7.78. The very high index values have a slight tendency to occur in the south and west of the city in or adjacent to industrial sectors. Otherwise high value communities exhibit little apparent pattern, include both high and low economic status communities, but not the highest economic ranked communities such as Upper Mount Royal and Britannia.

Low Birthweight

Figure 4.6 - The Low Birthweight Risk index values range from 0 to 3.96 and their spatial pattern is apparently highly randomly distributed. There are no obvious geographic patterns and this particular category does not appear to favour high or low economic status communities. In fact, of the two highest risk communities, Meadowlark Park is a low socio-economic status community while Lower Mount Royal is a high socio-economic status community.

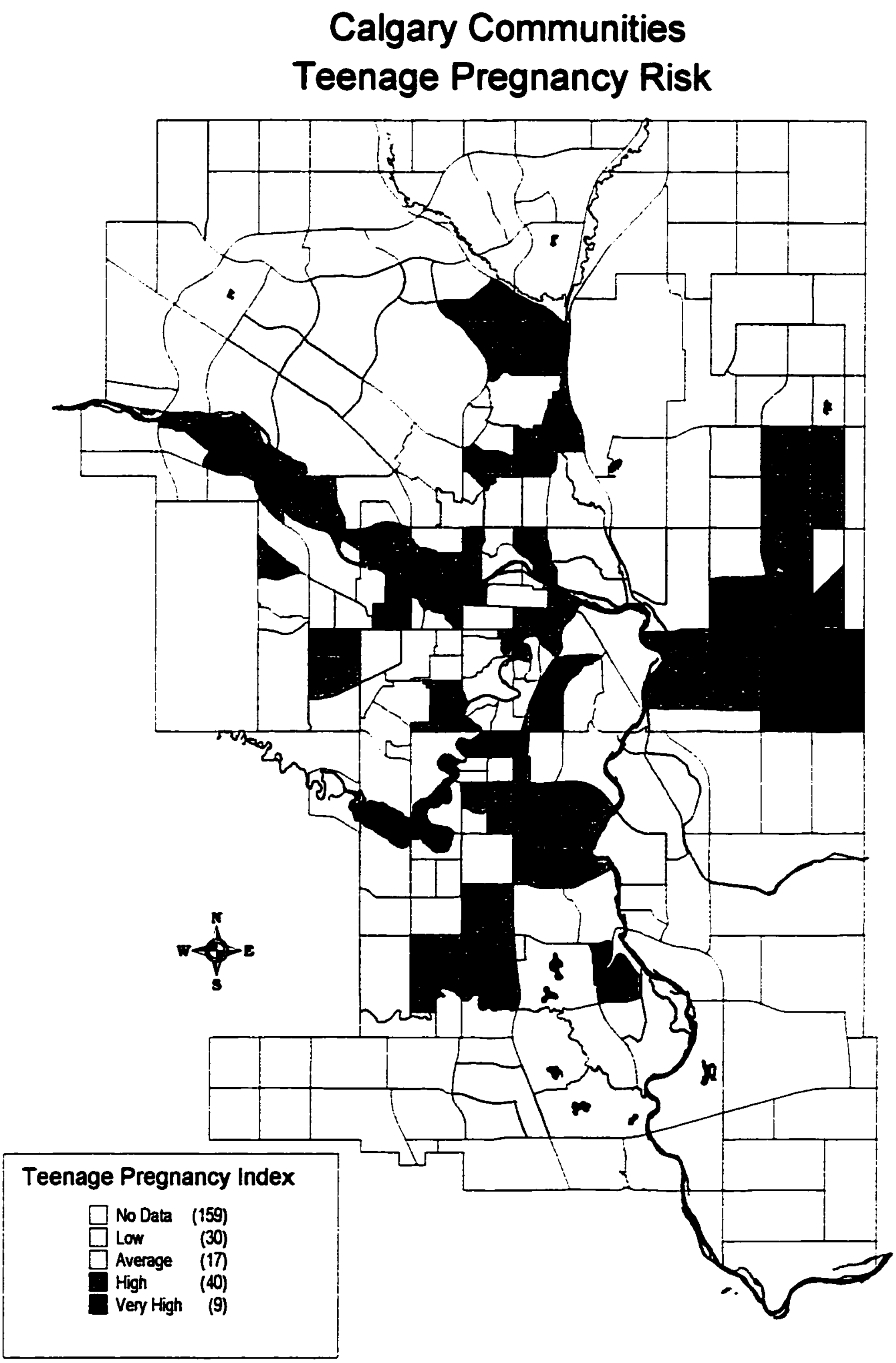
Figure 4.6

Calgary Communities
Low Birthweight Risk



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

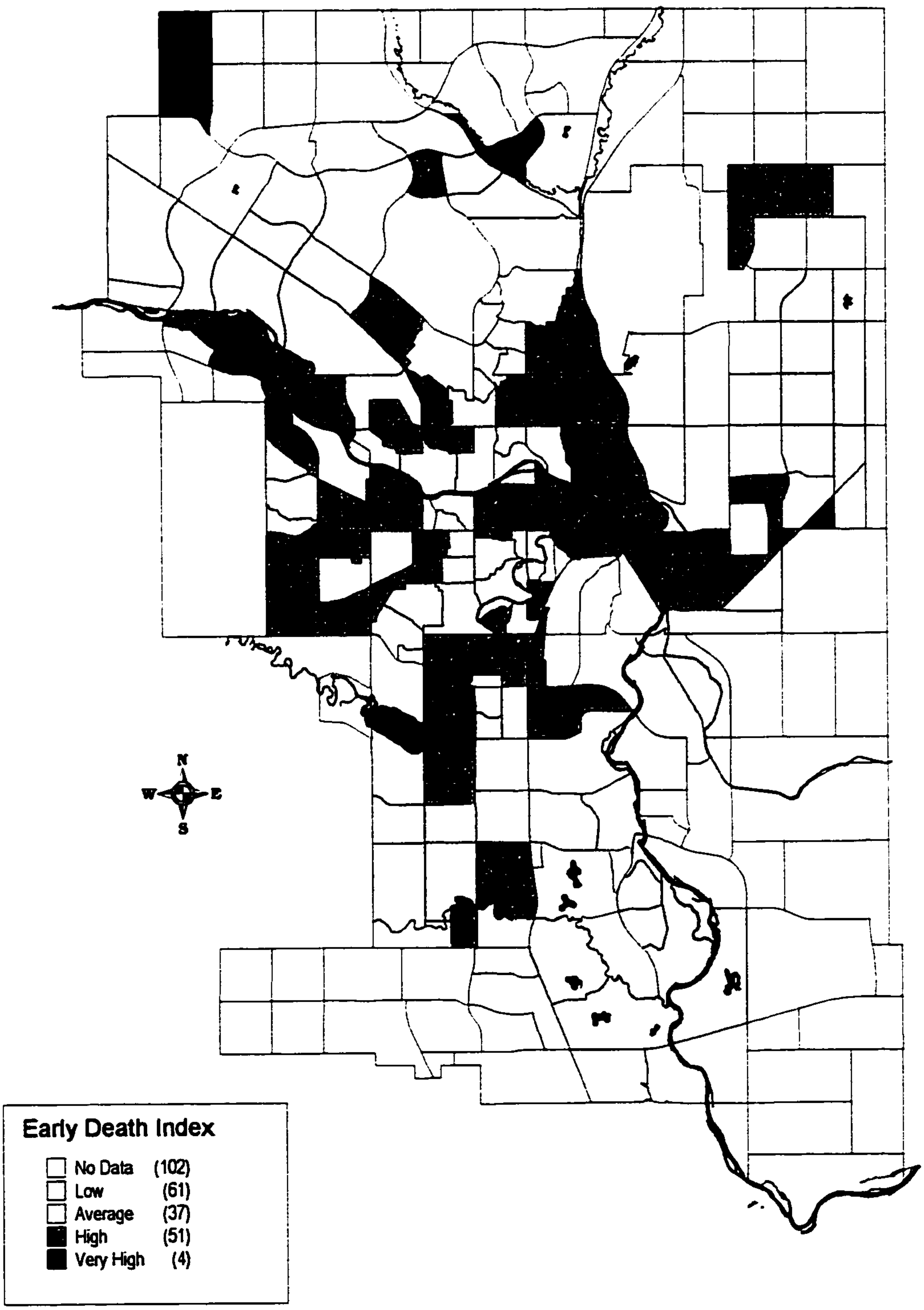
Figure 4.5



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Figure 4.4

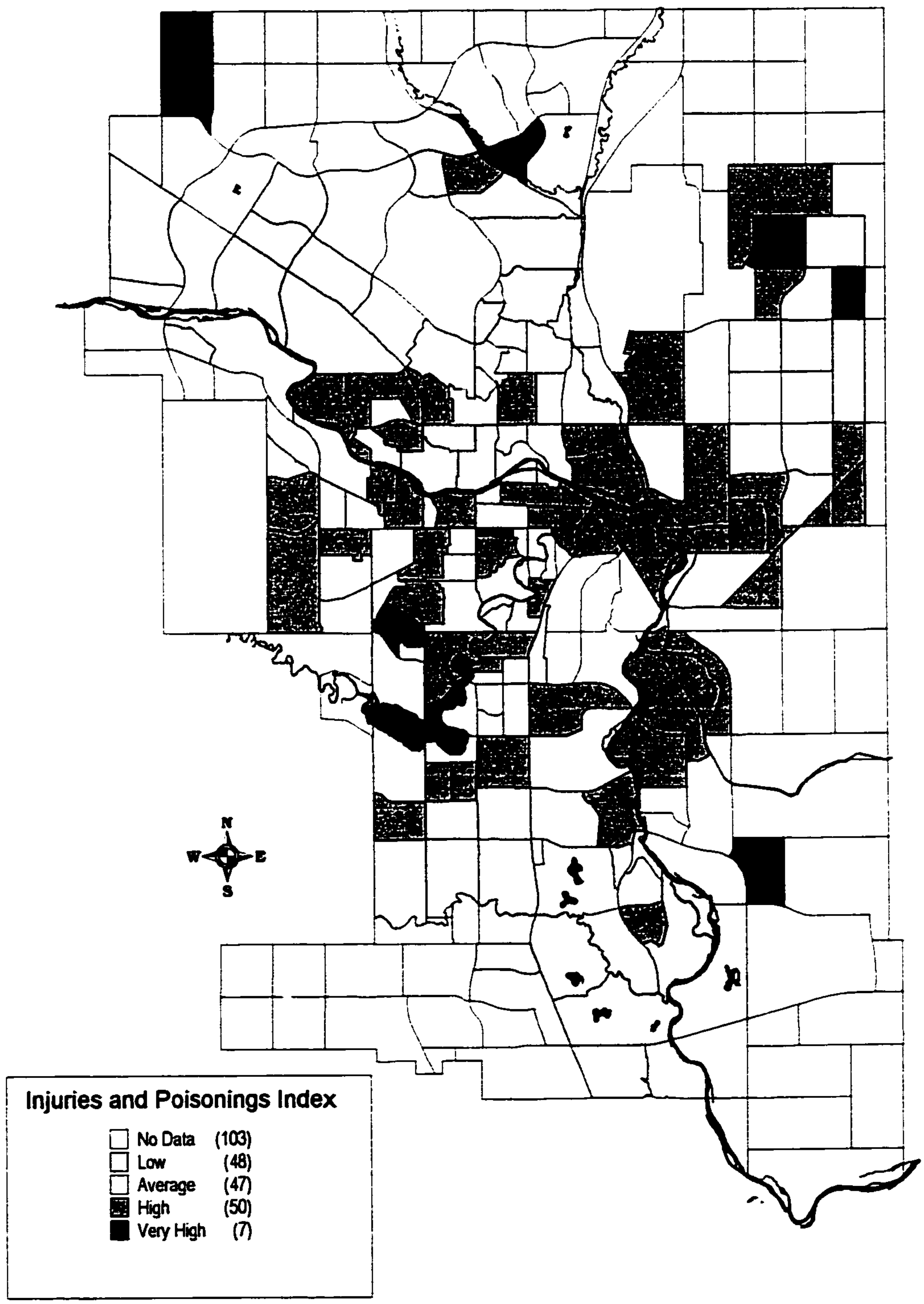
Calgary Communities
Early Death Risk



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Figure 4.3

Calgary Communities
Injuries and Poisonings Risk



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Spatial Distribution of Composite Health Risk

The Composite Health Risk index values were calculated by averaging the six individual health risk values for each community. The values for this health risk category range from 0 to 7.6.

The three highest indices occurred in the inner city community of Downtown east, an industrial suburb named Red Carpet in the east and a new suburb of Country Hills in the northwest. The map in Figure 4.7 shows that the high-risk communities tend to be the inner city communities west and east of the downtown. In the east and south these at-risk communities are adjacent to the industrial areas which dominate the east side of the city. Excluded from this high-risk category is the cluster of wealthier inner city suburbs such as Roxboro, Mount Royal, and Elbow Park, which are located immediately south of the commercial downtown sector.

The ranking system used for the health risk thematic maps is shown in Table 4.7.
A column is listed for each health risk category containing the following information;

- Range of index values for each rank (low, Average, High and Very High)
- Number of communities in each rank
- Percentage of total number of communities represented by each rank

4.4 Summary

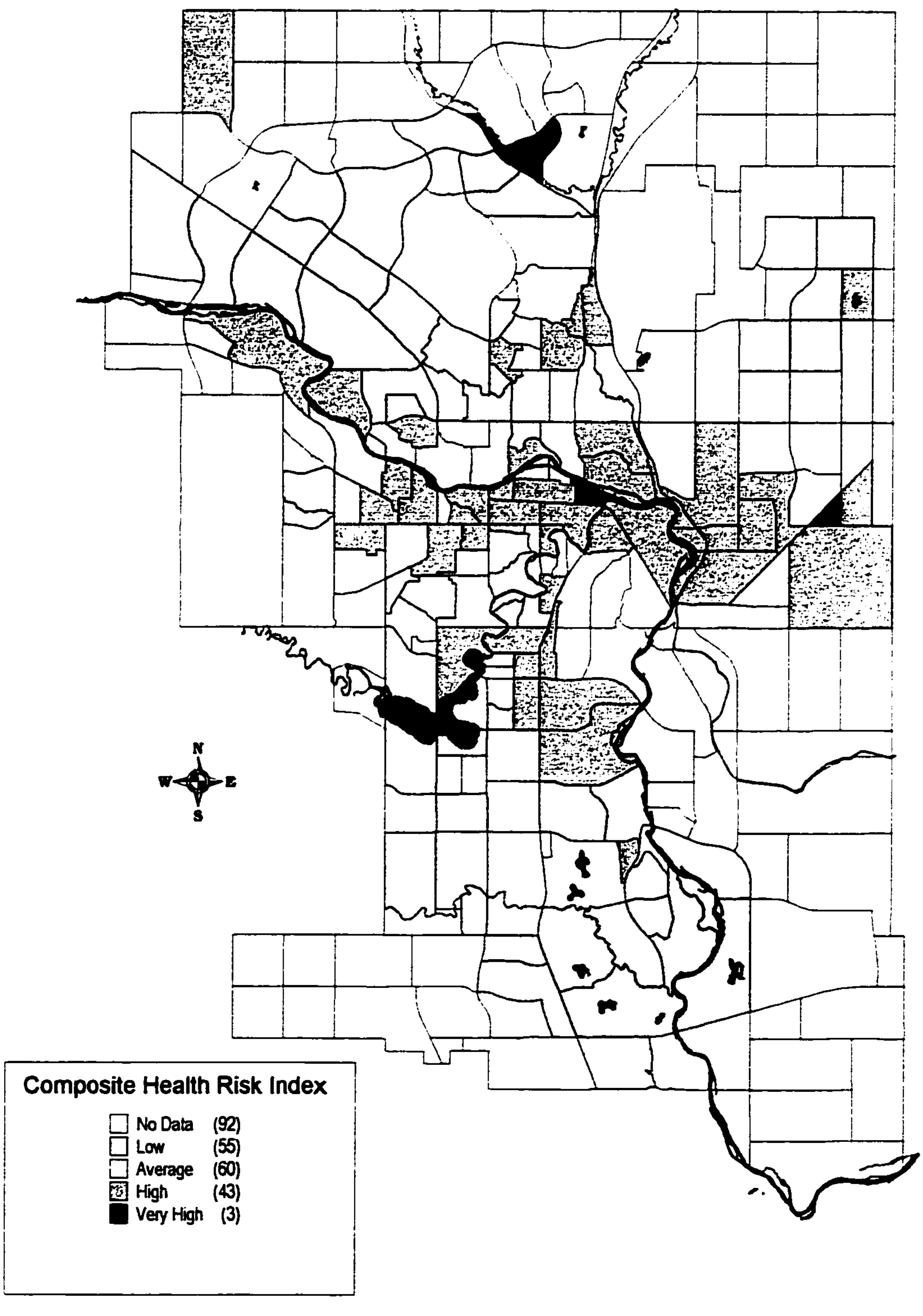
The downtown area contains many of the high health risk communities especially for four categories; Alcohol and Drug Abuse, Mental Disease and Disorders, Early Death and Injuries/Poisoning/Toxic Effects categories. The rest of these types of high-risk communities are scattered throughout the city in a patchwork pattern. High indices for these four groups coincide in a high proportion of communities which are in general associated with low income, low average dwelling value areas.

Country Hills in the northwest sector of the city is an anomaly because, while it enjoys a relatively high socio-economic standing as a fairly new Calgary suburb community, it has very high health risk indices for four of the six health risk categories. However, an analysis of Country Hills findings confirmed them to be spurious and they are discussed

Figure 4.7

Calgary Communities

Composite Health Risk Index



further in Chapter 6 and 7. The errors were due to a temporal mismatch in the datasets that could not provide accurate data for the massive population growth that has occurred in the interval between the census data (1991) and the end date of the CRHA dataset (April 31, 1996). The resulting under-estimate of total population resulted in an over-estimate of health risk for all categories for this community.

Contrasting with the pattern for these four health risk categories, are the Low Birthweight and Teen Pregnancy risk indices which appear to be unrelated to the other four health risk groups, and are difficult to associate with any particular income or social status group. High values for these two health risk groups appear in high and low income communities stretching from the inner city to the northern and southern outer city suburbs.

Most of the associations between low income McGlashan (1967) believes that geographers have much to offer in the way of geographical insights and evidence to medical hypothesis through the "associative occurrence" theme. The

Table 4.7

Range of Index Values for Each Health Risk Category

(253 Communities)

	Low Risk	number of Communities	% total Communities	Average Risk	number of Communities	% total Communities	No Data	% total Communities	High Risk	number of Communities	% total Communities	Very High Risk	number of Communities	% total Communities
Composite Health Risk	0 - 0.8	55	*(0.21)*	0.8 -1.2	60	*(0.23)*	92	*(0.41)*	1.2 - 3	43	*(0.16)*	3 - 7.55	3	*(0.01)*
Alcohol and Drug Abuse	0 - 0.8	43	*(0.16)*	0.8 -1.2	22	*(0.08)*	130	*(0.51)*	1.2 - 4	52	*(0.20)*	4 - 19.3	6	*(0.02)*
Mental Diseases	0 - 0.8	61	*(0.24)*	0.8 -1.2	44	*(0.17)*	93	*(0.36)*	1.2 - 3	48	*(0.18)*	3 - 9.02	7	*(0.02)*
Early Death	0 - 0.8	61	*(0.24)*	0.8 -1.2	37	*(0.14)*	100	*(0.39)*	1.2 - 4	51	*(0.20)*	4 - 12.6	4	*(0.01)*
Teen Pregnancy	0 - 0.8	28	*(0.11)*	0.8 -1.2	19	*(0.07)*	157	*(0.62)*	1.2 - 3	40	*(0.15)*	3 - 7.78	9	*(0.03)*
Low Birthweight	0 - 0.8	37	*(0.14)*	0.8 -1.2	47	*(0.14)*	114	*(0.45)*	1.2 - 2	43	*(0.16)*	2 - 3.96	12	*(0.04)*

5.0 ANALYSIS OF CENSUS RECORDS

A factor analysis is performed on the census dataset in this section. The procedure is intended to produce a series of variable subsets that identify the major population "dimensions" mentioned in the literature review. The results confirm that the independent variables that were selected to represent social status are appropriate for use in the final analysis, i.e., the multiple linear regression. A definition of each census variable is contained in the appendix.

A brief explanation of some of the terms used to describe the census dataset and subsets is provided and summarized in Table 5.0. *Census data* refers to data published in the Statistics Canada Geography 1991 Census database. The *Dimensions of Community* are urban population characteristics such as social status which enable the differentiation of communities from one another. *Socio-Economic Characteristics* are a subset of these community "dimensions" and include elements such as income, dwelling value and fertility. *Social Status Indicators* are specific socio-economic characteristics that are used to measure relative community social status within the GCR. The community values for each of the indicators are listed in the last table in Chapter 3.

Table 5.0

List of terms derived from the main Census record dataset

CATEGORY	DESCRIPTION
Data Source	Census Records
Data Categories	Dimensions of Community
Data Subset	Socio-Economic Characteristics
Data Derivatives	Social Status Indicators

5.1 Summary of Census Variables

Demographic variations are the main influence on community health patterns (Evans: 1994; CRHA: 1996) and Household Income and Average Dwelling Value, are the most useful measures of relative social status among communities. For instance, in communities of young residents, the influence of injuries and poisoning is more pronounced while in communities of older residents, there are more hospitalizations for chronic diseases (Miller et al: 1989).

Enumeration areas, (discussed in Section 3.4) are the basic unit to which the socio-economic indicator variables are related. However, to simplify the description of the socio-economic indicators in this section, average Dwelling Value, Household Income, ratios of Seniors, Adults and Infants are aggregated to 14 GCR municipal wards (see Figure 5.0) rather than to EAs, or communities.

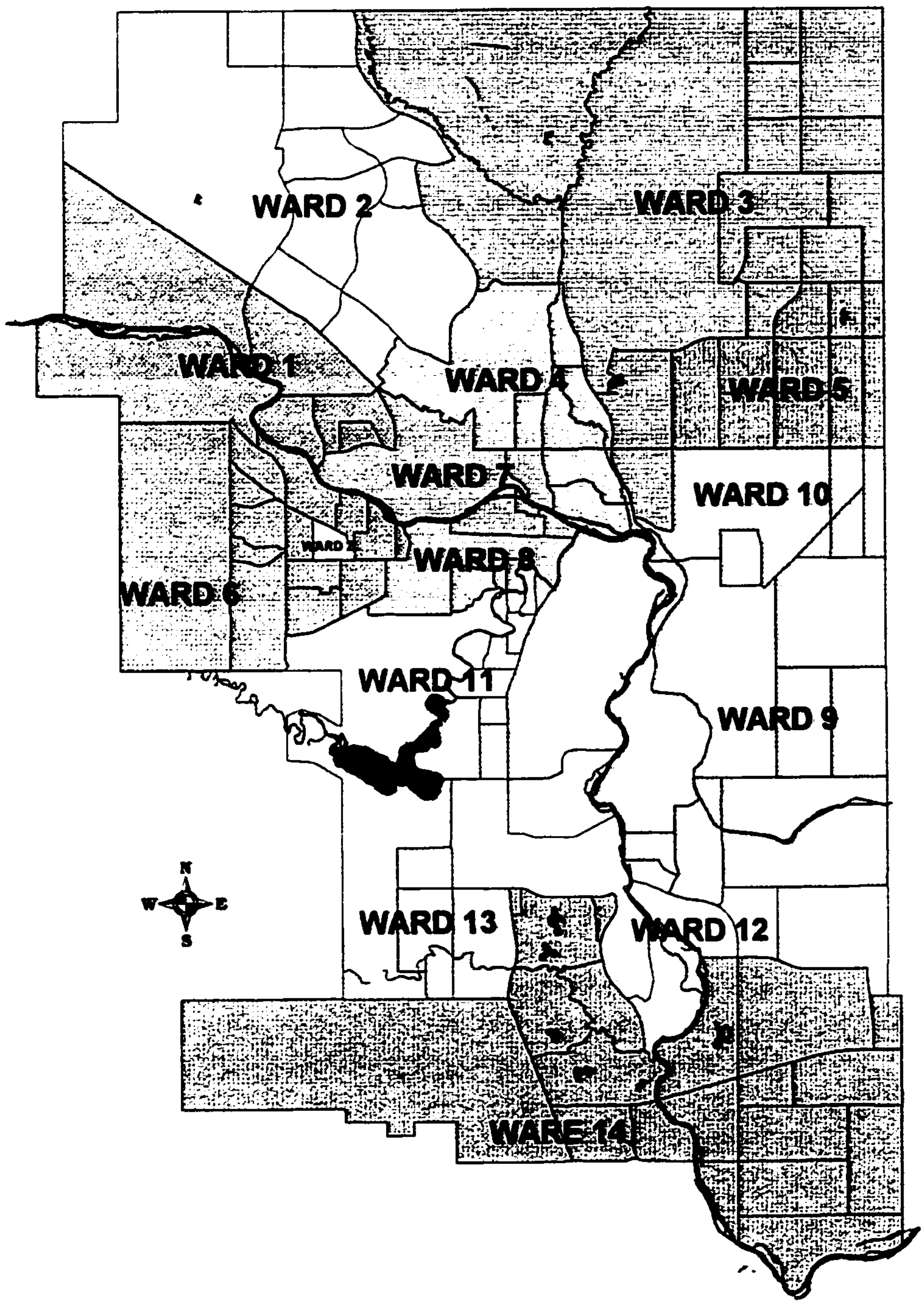
GCR Ward Profiles

Table 5.1 is a summary of community averages for two social status indicators: Household Income, and Dwelling Value for fourteen GCR wards. There is a wide range of values for each category and the highest values for household income and dwelling values are almost twice those of the lowest values. Average yearly household income ranges from $36,226 to $72,411 while average dwelling values range from $103,597 to $197,635 (see Figure 5.0).

Table 5.2 summarizes the ratios of three demographic groups, Seniors, Adults and Infants within the fourteen GCR wards. As the bar chart indicates, the proportion of adults is fairly stable among the wards and varies between 70-90% of ward populations; Seniors range from 4% to 10 % and infants 3% to 16%.

Figure 5.0

Calgary Communities by Ward



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Table 5.1
Household Income and Dwelling Value

Ward	H-Income	Dwel-Val
1	$57,385	$155,095
2	$65,498	$170,158
3	$51,393	$126,795
4	$43,101	$129,275
5	$49,122	$116,557
6	$56,293	$172,906
7	$41,911	$145,875
8	$36,226	$197,635
9	$41,289	$108,708
10	$44,028	$103,597
11	$61,867	$189,291
12	$55,907	$141,591
13	$68,691	$171,955
14	$72,411	$168,283

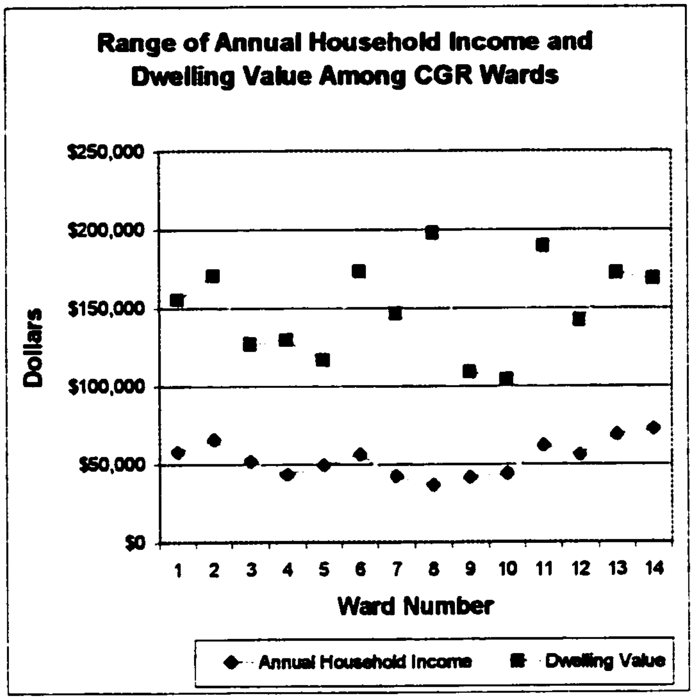
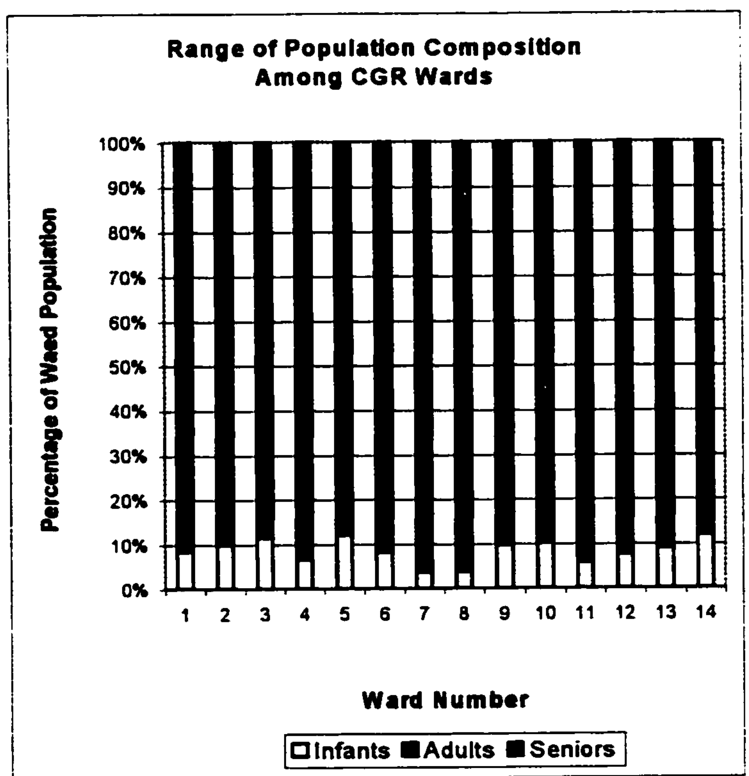


Table 5.2
Population Composition of Calgary Wards

Ward	Infants	Adults	Seniors
1	0.08	0.78	0.08
2	0.09	0.75	0.06
3	0.1	0.73	0.03
4	0.07	0.82	0.15
5	0.1	0.7	0.03
6	0.08	0.78	0.11
7	0.04	0.87	0.16
8	0.04	0.9	0.11
9	0.09	0.76	0.06
10	0.09	0.74	0.05
11	0.06	0.81	0.15
12	0.07	0.78	0.07
13	0.08	0.75	0.05
14	0.1	0.71	0.03



GCR Profile

Table 5.3 is a summary of the main census variables aggregated to the GCR level. The average values are the baseline (i.e., GCR average = 1.0) to which this study refers to for all community health and socio-economic status indices. Recall that in Chapter 3 community values were calculated as a standard ratio relative to the GCR by inserting the CGR averages as the denominator, and each community average as the numerator.

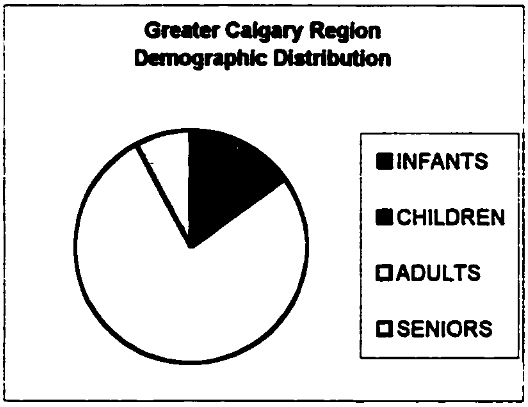
In 1991, the demographic composition in the GCR was approximately 8% infants, 8% seniors and 77% adults. Eighty percent of the residents claim English as their first language, while for less than 1%, it is an aboriginal dialect. By national standards, Calgary has a well-educated population with 42% having post secondary education and only 6% of adults have less than grade 9 education. The unemployment rate was a relatively moderate 8% in 1991.

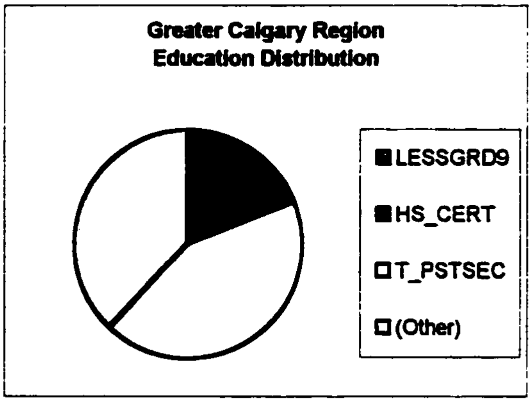
However, when considered in terms of social and economic status, a significant percentage of the urban population may be considered vulnerable in terms of housing and income. The cost of affordable housing, defined by Statistics Canada as 30% or less of the shelter cost to gross income ratio, was exceeded by 14% of home owners and 32% of tenants. Thirteen percent of families within the GCR were classified by Statistics Canada as "Low Income" families; and a substantial (11%) number of households with children at home were headed by single parents.

A recent research project on core housing needs of single parent families in Calgary concluded that single parent families are disproportionately vulnerable to high shelter-to-income cost, and that income and education are important explanatory variables for predicting that need (Burgess: 1997).

Table 5.3
GCR Summary of Demographic Composition, and Income and Dwelling Values

Age Group	**TOTPOP**	**640,757**	*Perc*		
1 to 4	INFANTS	52,090	8.13%		
4 to 15	CHILDREN	44,862	7.00%		
15 to 65	ADULTS	494,110	77.11%	AV-IND-INC	$24,698
65 +	SENIORS	49,695	7.76%		
24 to 65	MIDAGE	444,415	69.36%		
1st Language	ABORIGS	5,159	0.81%		
	ENGLISH	516,080	80.54%		
Families	CENSFAM	170,325			
	CHILDREN	206,683			
	LONEFPAR	18,880	11.08%		
	OVER5YR	583,930			
	MOVER5Y	340,160	58.25%		
Housing	SFAMDWELS	105,800		AV-DWEL-VAL	$127,441
	OVPYMORG	15,150	14.32%		
	RENTSFAM	40,675			
	OVPYRENT	13,015	32.00%		
Economic	ECNFAMLY	165,235		AV-FAM-INC	$48,946
	LWINCFAM	23,360	13.71%		
	PARTICIPATION	373,270	75.54%		
	UNEMPLOYED	40,848	8.27%		
	FAMILIES	170,300			
	HOUSHLDS	232,750		AV-HSHLD-INC	$45,134
Low Education	LESSGRD9	30,740	6.22%		
High School	HS_CERT	63,240	12.80%		
University	T_PSTSEC	211,970	42.90%		
	(Other)		38.08%		





5.2 Factor Analysis of Census Variables

Factor analysis is a statistical technique which is applied to a set of variables in order to produce cohesive variable subsets that are relatively independent of each other. These subsets may then be used to assess underlying themes that may not be otherwise evident. Mathematically, the factor analysis produces a summary of descriptive factors which highlights the associations among the variables and measures the contributions of the individual observable units to those variations via a factor score (Davies: 1975: 235). Since the number of factors is less than the number of variables, there is considerable parsimony in using the process (Tabachnick and Fidell: 1996: 635).

Factor analysis is useful for summarizing patterns of correlations among observed variables and for reducing the large number of variables to a smaller more manageable set of factors. Tabachnick and Fidell (1996) also recommend the procedure for developing an operational definition of an underlying process, or to test a theory about the nature of underlying processes. In this study, the factors extracted from the census data are the population "dimensions" that distinguish communities from each other.

The three main steps in the factor analysis are:

- Generation of a correlation matrix based on the raw census data, which in this study are the indices for each community variable;
- Extraction of the correlations from the matrix to produce a set of factors; and
- Rotation of the factors to simplify interpretation (Nie et al: 1970).

Correlation Matrix

The factor analysis, using the principal axis technique, was applied to the census datatset that consisted of 20 variables representing various descriptive population categories such as Demographics, Family Status, Housing, Employment, Income and Education. Table 5.4 is the lower triangle of the correlation matrix produced as the first step of the analysis. Sufficient correlation values over 0.3 qualify the matrix as a "factorable dataset" (Tabachnick and Fidell: 1996). The correlation coefficient (*r*) in each column of the diagonal matrix indicates the magnitude of the correlation between each pair of variables.

Table 5.4

Factor Analysis Correlation Matrix

	A_DWELVA	ABOR	ADULTS	ENGL	FAM_INC	FERTILTY	HOUS_INC	HSC_CERT	IND_INC	INFANTS	LESS_GR9	LONEPAR	LWINCFAM	MOVERS	OVP_MORG	OVP_RENT	PARTICIP	POST_SEC	SENIORS	UNEMPLOYD
A_DWELVA	1.00																			
ABOR	-0.27	1.00																		
ADULTS	0.11	0.19	1.00																	
ENGL	0.15	-0.18	0.26	1.00																
FAM_INC	0.80	-0.37	0.03	0.31	1.00															
FERTILTY	-0.06	-0.18	-0.83	-0.25	0.09	1.00														
HOUS_INC	0.70	-0.45	-0.20	0.27	0.94	0.32	1.00													
HSC_CERT	-0.29	0.04	-0.30	-0.17	-0.31	0.35	-0.17	1.00												
IND_INC	0.78	-0.40	-0.04	0.31	0.97	0.11	0.95	-0.28	1.00											
INFANTS	-0.25	-0.09	-0.77	-0.24	-0.17	0.68	0.04	0.36	-0.07	1.00										
LESS_GR9	-0.49	0.47	0.06	-0.47	-0.51	-0.07	-0.52	0.03	-0.54	-0.03	1.00									
LONEPAR	-0.43	0.46	0.11	-0.30	-0.54	-0.15	-0.61	0.03	-0.51	0.05	0.53	1.00								
LWINCFAM	-0.33	0.48	0.05	-0.48	-0.52	-0.14	-0.59	0.05	-0.52	0.11	0.59	0.78	1.00							
MOVERS	0.02	0.01	-0.20	-0.31	-0.20	0.01	-0.20	0.21	-0.14	0.41	-0.14	0.04	0.25	1.00						
OVP_MORG	-0.31	0.03	-0.41	-0.41	-0.34	0.36	-0.26	0.38	-0.32	0.54	0.12	0.10	0.20	0.53	1.00					
OVP_RENT	-0.35	0.10	-0.13	-0.15	-0.35	0.13	-0.31	0.10	-0.34	0.09	0.36	0.25	0.33	0.00	0.08	1.00				
PARTICIP	-0.07	0.02	-0.28	-0.13	-0.15	0.33	-0.06	0.37	-0.12	0.44	-0.33	-0.09	-0.06	0.56	0.32	0.01	1.00			
POST_SEC	0.65	-0.44	0.12	0.39	0.65	-0.16	0.60	-0.48	0.69	-0.22	-0.71	-0.59	-0.60	-0.04	-0.38	-0.35	-0.01	1.00		
SENIORS	0.10	0.02	0.38	0.25	0.11	-0.60	-0.05	-0.44	0.08	-0.58	0.23	0.08	0.02	-0.44	-0.41	-0.07	-0.79	0.14	1.00	
UNEMPLYD	-0.41	0.52	0.09	-0.23	-0.48	-0.14	-0.56	-0.02	-0.55	0.01	0.60	0.50	0.56	0.08	0.16	0.18	-0.10	-0.59	0.11	1.00

Initial Statistics

The second step of the factor analysis is a preliminary calculation of loading values for each factor produced from the correlation matrix. This step produced the initial statistics shown in Table 5.5.

Table 5.5

Initial Loading Values

Loading Matrix

Factor	Eigenvalue	Pct of Var	Cum Pct
1	6.83	34.20	4.20
2	4.31	21.50	5.70
3	1.69	8.50	4.10
4	1.43	7.20	1.30
5	0.95	4.70	6.00
6	0.89	4.50	0.50
7	0.78	3.90	4.40
8	0.63	3.10	7.60
9	0.60	3.00	0.50
10	0.42	2.10	2.70
11	0.39	1.90	4.60
12	0.30	1.50	6.10
13	0.20	1.00	7.10
14	0.17	0.90	7.90
15	0.14	0.70	8.60
16	0.12	0.60	9.20
17	0.08	0.40	9.70
18	0.04	0.20	9.80
19	0.02	0.10	9.90
20	0.01	0.10	0.00

The 20 rows of factors correspond to the total number of variables while their eigenvalues reflect their degree of variance explained by each factor. Factors with the largest eigenvalue explain the most variance. Factors with eigenvalues less than 1.0 are usually omitted from the solution. The first factor in the table may be viewed as providing the single best summary of the variation within the data. Thus, the linear combination of variables that represents factor 1 accounts for the highest percent (34.2) of the variance in the dataset. The second factor, which accounts for 21.5 percent of variance, is the second highest value. The second factor is derived so as to be orthogonal (unrelated) to the first. To be orthogonal to the first factor, the second one must account for that portion of the variance that is not accounted for by the first factor. Thus the second factor may be defined as the linear combination of variables that accounts for the most residual variance after the effects of the first factor are removed. Subsequent factors are defined similarly until all variables are exhausted. Because the goal of factor analysis is to sum a pattern of correlations with as few factors as possible, and because each eigenvalue corresponds to a different potential factor, only those with a value greater than 1 are retained. Therefore, out of the 20 variables with eigenvalues ranging from 6.83 to 0.01, only the first four values (6.83, 4.31,1.69,1.43) are transformed in the next step (Nie et al.: 1970; Tabachnick and Fidell: 1994).

Rotated Factor Matrix

The third step of the factor analysis is a transformation of the initial loading matrix to produce a rotated matrix of loading values measured in terms of the "factors" as shown in Table 5.6. Rotation is applied to the values in order to maximize high correlations and minimize low ones and thereby achieve a simpler and theoretically more meaningful factor pattern (Nie et al.: 1970: 212). The Varimax rotation method selected for this procedure transforms the values by maximizing the variance of the squared loadings in each column. The result is a table of loadings and correlations showing the strength of the relationship between each factor and each variable. Thus by reading the variable rows left to right one can assess their relative importance to each factor. For instance, AV_DWELVA has a loading value of .874 for Factor 1 and insignificant values for the other factors. Likewise, the only significant factor for LESS-GR9 (.73) is Factor 2. By reading every row in the same manner, the linear composition of each variable is described in terms of the four factors.

Complexity of Factors

The relative complexity of the variables is determined by looking at the loadings for each factor (Nie et al.: 1970). Variables with significant loadings (> 0.3) on only one factor have a factorial complexity of 1. Variables that load significantly on two factors have a

Table 5.6

Rotated Factor Loadings

Rotated Factor Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
A_DWELVA	0.874	-0.2	-0.1	0.03
ABOR	-0.22	0.58	-0.2	0.04
ADULTS	-0.01	0.04	-0.9	-0.1
ENGL	-0.02	-0.6	-0.3	-0.2
FAM_INC	0.861	-0.4	0.04	-0.2
FERTILTY	0.029	-0.1	0.93	0.09
HOUS_INC	0.778	-0.5	0.29	-0.2
HSC_CERT	-0.45	-0.1	0.4	0.32
IND_INC	0.864	-0.4	0.08	-0.1
INFANTS	-0.09	0.05	0.76	0.4
LESS_GR9	-0.37	0.73	0.09	-0.4
LONEPAR	-0.33	0.72	-0.1	-0
LWINCFAM	-0.21	0.86	-0	0.09
MOVERS	0.073	0.22	0.03	0.86
OVP_MORG	-0.22	0.23	0.43	0.51
OVP_RENT	-0.4	0.21	0.23	-0.2
PARTICIP	-0.12	-0.2	0.21	0.82
POST_SEC	0.628	-0.6	-0.3	0.04
SENIORS	0.096	0.12	-0.5	-0.7
UNEMPLYD	-0.34	0.67	-0.1	-0.1

factorial complexity of 2 and so on. The meaning of variables more complex than 1 is difficult to analyze because they measure more than one community "dimension". Although some of the variables in this rotated matrix table have significant loadings (>0.3), none of them have high loadings (> 0.5) for two or more factors, indicating that the data set values are reasonably simple to analyze.

Discussion of the Factor Loadings

Each factor used in the model addresses a group of related census variables. Factor 1, describes *Economic Status* and is the largest population dimension for the GCR communities. This dimension accounts for 34% of variability in the dataset, and features prominently in several noted population studies (Shevky and Bell: 1955; Moser and Scott: 1962). The distribution of scores in the column shows heavy positive loadings for A_DWELVA (.874), FAM_INC (.861), HOUS_INC (.778), IND_INC (.864), and POST-SEC (.63) meaning that the income, dwelling values, and university education are highly intercorrelated and define this dimension. Significant, but weaker, negative loadings appear for the low education, lone parent, overpayment of rent and unemployed variables. It is apparent that the standard measures of social and economic status such as income, education and residential address are the best indicators for the Economic Status dimension.

Factor 2 is the *Vulnerable Status* dimension and accounts for approximately 22% of variability. High positive loadings for LESS_GR9 (.73), LONEPAR (.72), LWINCFAM (.86) and ABOR (.58) indicate that low education, lone parents, low income families and aboriginal status are highly intercorrelated, and are the most important variables in this dimension. The variable POST-SEC which had a significant positive correlation to factor 1 has a significant *negative* correlation (0.6) to factor 2. The three income variables and university education have weaker, negative, loadings. The non-affluent population characteristics represented by aboriginal status, low education, and lone parent are the main influence on this dimension.

Factor 3, the *Family Status* dimension, accounts for 8.5% of the variability. Positive loadings are high for FERTILITY (.93), INFANTS (.76) and significant but weaker for OVP-MORG (.43) and HSC_CERT (.40). Negative loadings are high for ADULTS (-.90) and SENIORS (-.50). The Family Status dimension is defined by communities of young families with high fertility, infants and high school education indices which are characteristic of young middle class families. Although the dataset's three demographic categories determine this dimension, the variables Overpay Mortgages and High School certificate exert a strong secondary influence.

Factor 4, *Transient Workers*, accounts for 7.2% of the variability. According to Davies (1975), the Transient Worker dimension is rarely mentioned in factorial studies of urban characteristics, although it is a vital part of the complex society construct postulated by Shevky and Bell (1955). In this study, this dimension is more complex than the first three, because it contains variables that, although not high, are significant in more than one dimension. The high loading values are for MOVERS (.86), and PARTICIP (.82), and SENIORS (-.70), and there are also significant values for OVP-MORG (.51), LESS_GR9 (-.40), INFANTS (.40), and HSC-CERT (.32). This dimension is defined mostly by mobility and labour participation. However, its definition is more complicated because middle class, young family traits, which are prevalent in this dimension, are also evident in the previously mentioned Family Status dimension. The main differentiation between Factor 3 and 4 is that the shared traits are separated by education attainment which is lower in Factor 4, and mobility and participation which are lower in Factor 3.

5.3 Factor Analysis Results

This factor analysis reveals four main population dimensions that are sources of variation in the dataset i.e., Economic Status, Vulnerable Status, Family Status, and Transient Worker Status. These results concur with findings from similar western urban population studies in that economic status is the main discernible dimension in urban communities. In this study the Economic Status dimension accounts for over one third of the variability.

The Vulnerable status explains more than one fifth of the total variability. To a large extent, it accounts for the underclass populations in the lower Socio-economically ranked communities that are not accounted for in the Economic Status dimension. The Family Status and Transient Worker Status, which determine 8.5% and 7% respectively of the variability, seem to overlap in the characteristics which define the family cycle status. These two dimensions differ mainly in the level of education. In the Family Status dimension, the High School Certificate variable has the stronger correlation while in the Transient Worker Status, the Less than Grade 9 variable is more strongly correlated, which implies a hierarchical separation, based on education, of these two dimensions.

These findings agree with the description of an earlier study of Calgary's community character (Davies: 1975) even though different datasets were used and more than twenty years separate the two studies. Both analyses identify Economic, Family and Migrant Status as major community population dimensions. The main difference between the two studies is that the Davies analysis, using sixty census variables, ranked the first four dimensions as Family status, Economic status, (Migrant) Transient Worker status and Ethnicity dimensions while in this study using 20 variables, produced the Economic status, Vulnerable status, Family status, and the Migrant status.

There is also a difference in prominence of the dimensions identified by the two studies which is undoubtedly due mainly to differing sets of variables used in the factor analysis. However, it is tempting to speculate on the amount of variability that may be due to the changed economic environment. The two study periods both represent a "slice" in time when Calgary was experiencing a recovering economy. However, the later study may be influenced by the intense in-migration of young well-educated adults and an increasing economic gap between the social classes, which has occurred since the Davies study.

5.4 Spatial Distribution of Community "Dimensions"

The following is a brief discussion, supported by maps, of the areal distribution of the four community dimensions previously discussed. The rankings are in terms of standardized factor scores assigned to each community in a series of thematic maps (Figure 5.1, 5.2, 5.3, 5.4) which were created directly from the data.

Economic Status

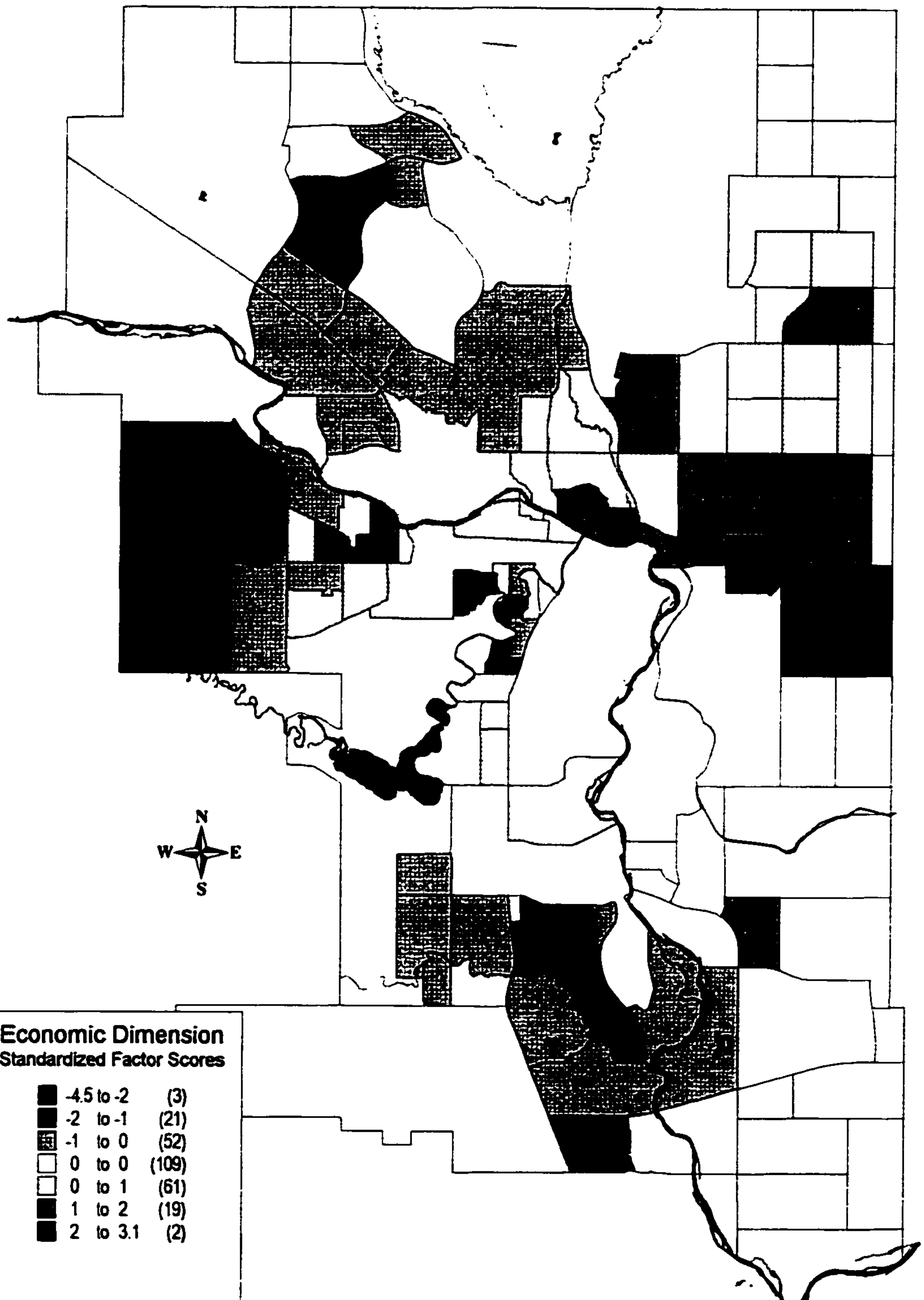
Figure 5.1 - This dimension is the most clearly differentiated and is characterized by a prominent north / south axis which creates east and west divisions in the city. The scores reflect the degree of advantage / disadvantage with respect to this economic status dimension, defined mainly by income and average dwelling value. The most prominent communities with negative standard deviation scores are the more prestigious communities in the west which occur in clusters extending from the inner city to new suburbs at the city's perimeter.

Positive factor scores are assigned to low income communities most prominently located in Calgary east on the city fringes mostly in and around the east industrial sectors especially south east of the airport.

Figure 5.1

Calgary Communities

Ranking by Economic Status



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Vulnerability Status

Figure 5.2 - This dimension is clearly differentiated but is characterized by a prominent concentric zonal pattern. The scores reflect the degree of community affinity with this dimension which is characterized by the low income, lone parents and low-income family status variables. The highest negative factor scores are assigned to communities in the inner and established suburbs, most prominently in the north and east, that correlate the least with this factor. The most vulnerable communities are in the new suburbs, near the edges of the city in all quadrants.

Family Status

Figure 5.3 - This dimension is less clearly differentiated than the first two (it describes 8.5% of the social status indicator variability) and may be described as having a sectoral pattern. The negative scores reflect the community trends mainly with respect to low fertility rates that occur more intensely in the inner city and inner suburbs particularly in the west and in new suburbs in the south.

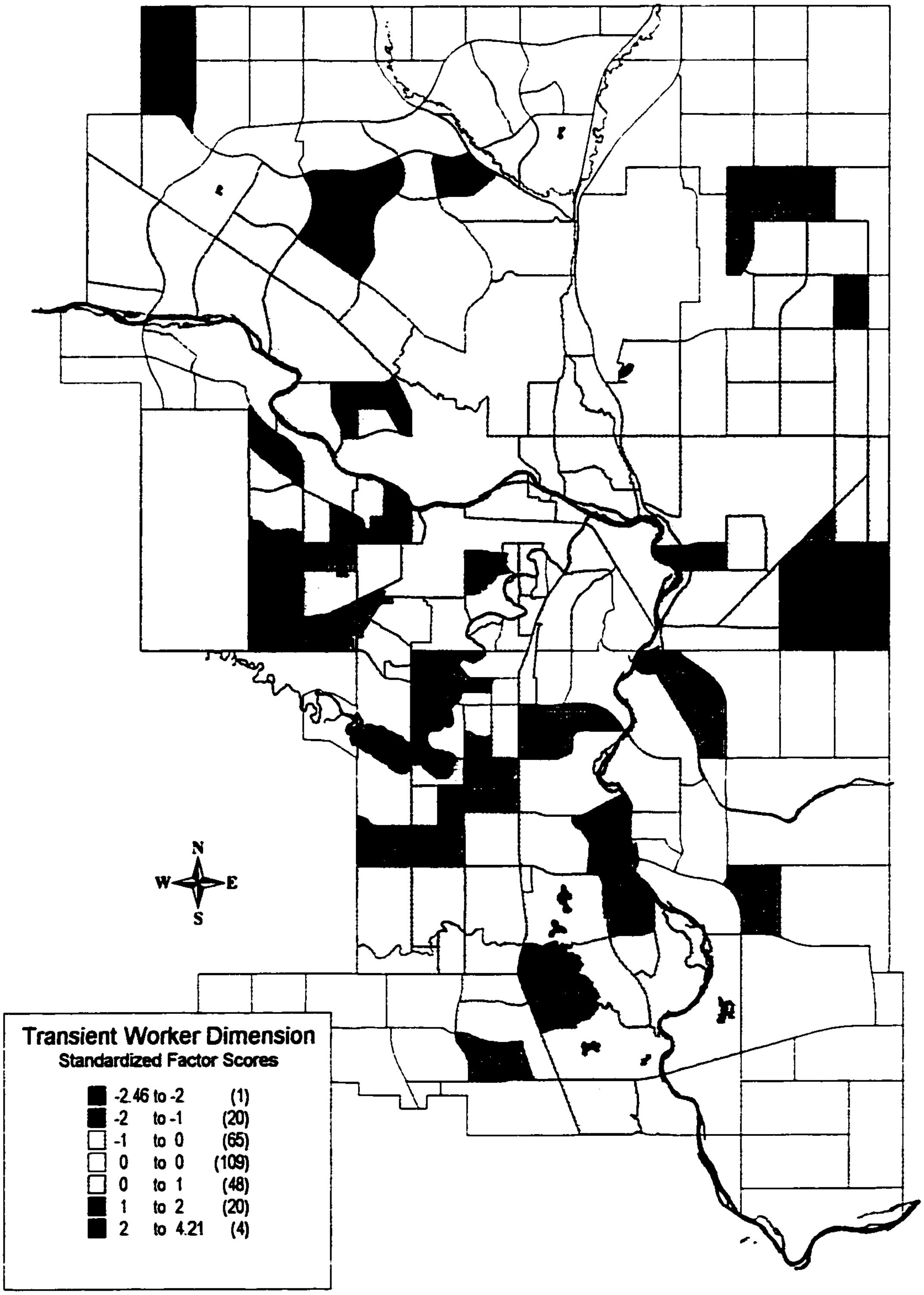
High positive scores are for communities in all quadrants of the city, but more intensely in a west / east band across the city.

Transient Worker Status

Figure 5.4 - This dimension is the most complex, but may be roughly described as characterizing the mobility and participation indices. It is also the least clearly differentiated (7.2% of variability), but may be described as occurring in a series of clusters. Negative factor scores are assigned to communities which tend to have more stable populations in terms of mobility and they occur more prominently in the south. Positive values occur in more transient communities that occur more prominently in the west and in the east.

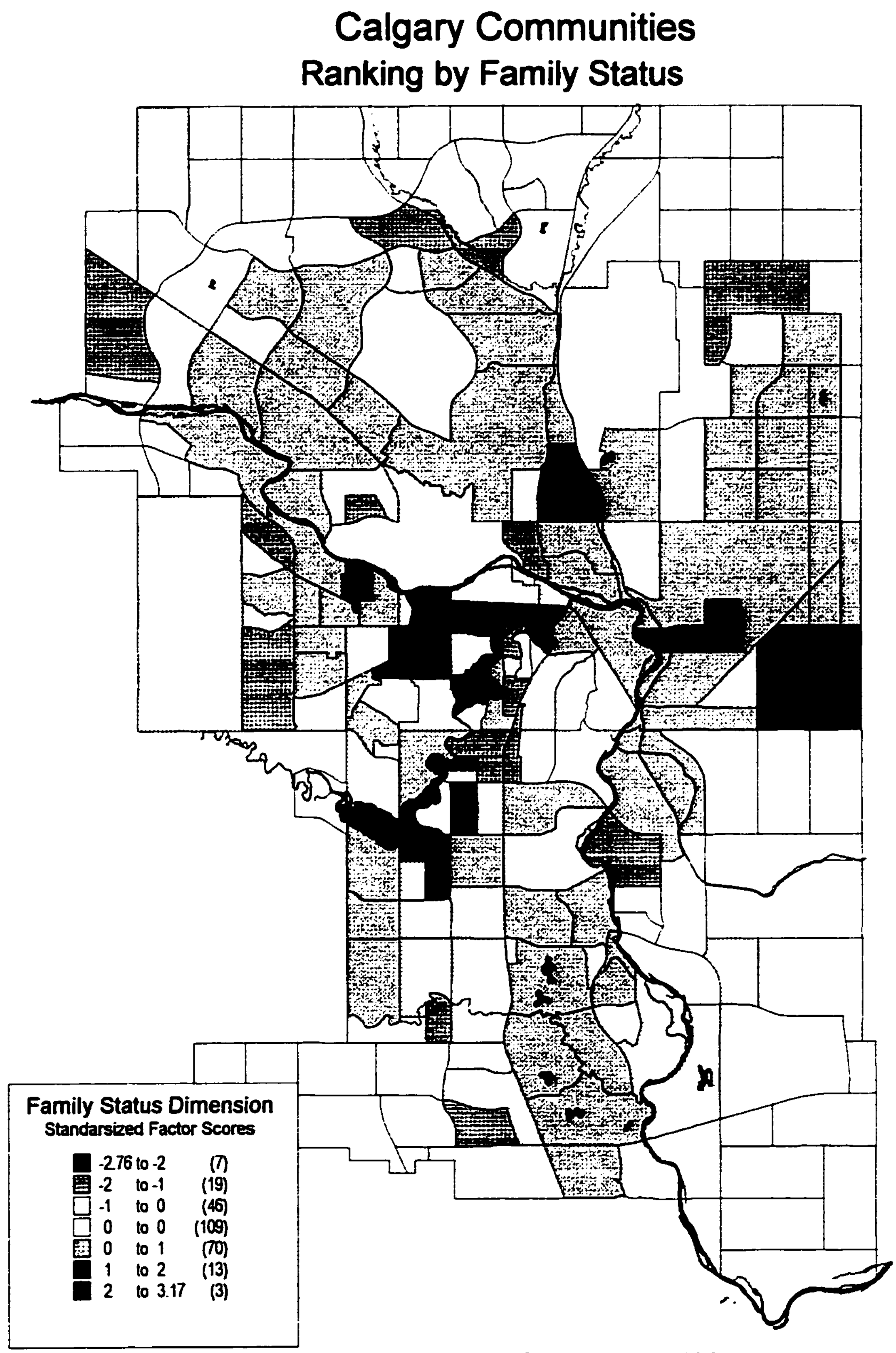
Figure 5.4

Calgary Communities
Ranking by Transient Worker Status



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

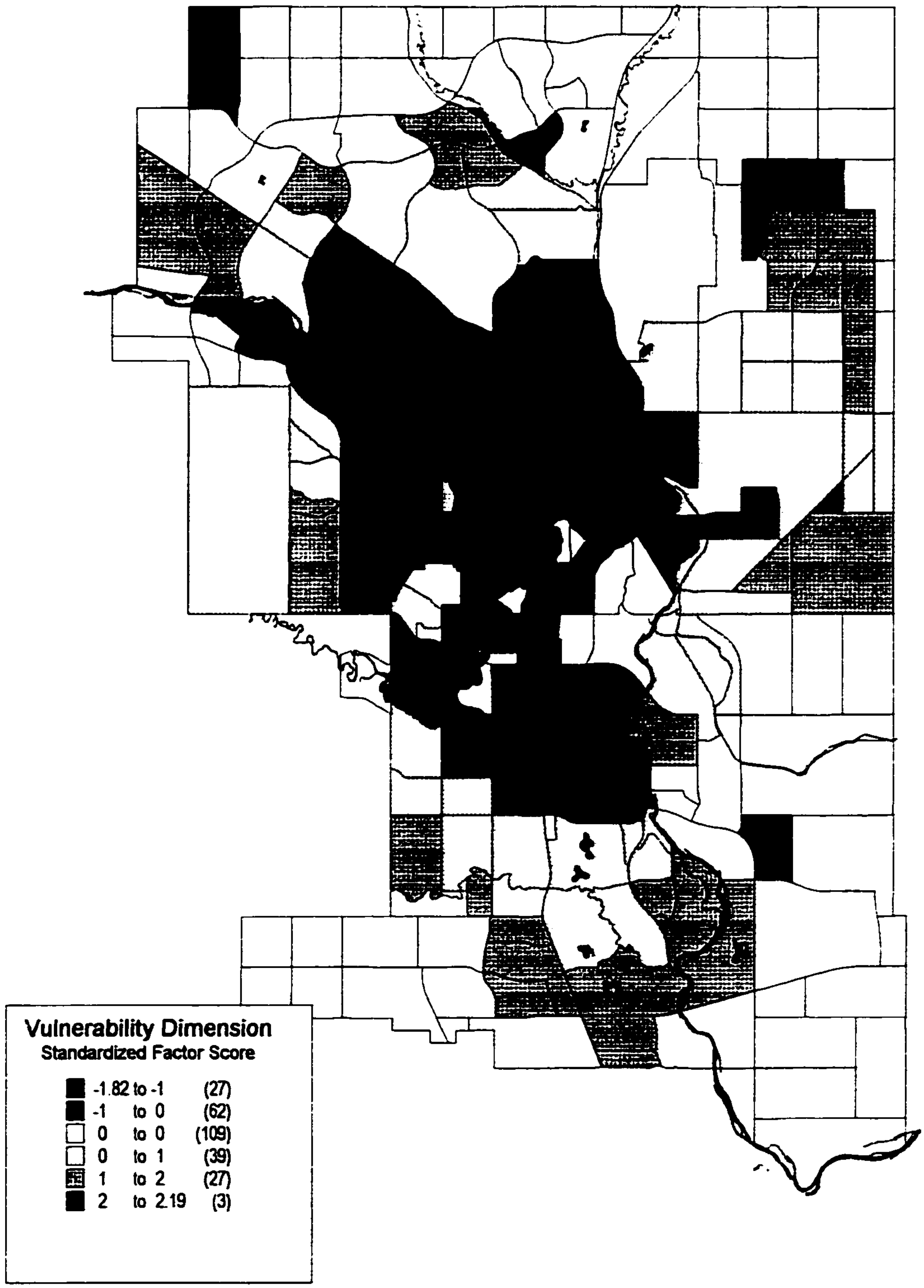
Figure 5.3



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

Figure 5.2

Calgary Communities
Ranking by Vulnerability Status



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

5.5 Summary

Social stratification by income and residence is a well-documented condition that prevails in most Western urban regions (Johnston: 1973). Most factorial analyses of North American cities generally conclude that three residential patterns prevail: a sectoral pattern for socio-economic status; a zonal pattern for family status; and a clustered pattern for ethnic groups (Berry and Rees: 1969). These residential patterns are not static but evolve unevenly over time. Schnore (1965) postulates a general model for transitions as part of the modernization process where in the beginning, the highest status populations are in the centre and the lowest status groups are on the periphery. In the intermediate stage, high and low status populations are both in the centre and the middle class are on the periphery. Finally, in the last stage, the lowest status populations are in the centre and the higher status populations are on the periphery.

Shnore's (1965) model would place Calgary somewhere between the intermediate and the final stages of city modernization. The highest income and dwelling values of Calgary's oldest, most established neighbourhoods, such as Mount Royal, and Calgary South, have established boundaries and low densities. This has resulted in the growth and spread of exclusive communities on the periphery of the city, such as Eagle Ridge in the west, which attract wealthier new residents who wish to live in communities of compatible social standing.

6.0 MULTIPLE REGRESSION ANALYSIS

This section focuses on the methods used to produce a predictive model of community health risk based on social status. The factor analysis of the census variables in the previous section distinguished some of the main population dimensions that differentiate communities from each other and the results indicated that economic, housing and education status are the main influences on variability within the dataset. The multiple linear regression in this section determines which of these dimensions have the most significant relationship with hospital utilization patterns and health risk within GCR communities. Health risk is defined in terms of the hospital-use categories discussed in Chapter 4, and social status is defined in terms of social, demographic, and economic indices that were analyzed in Chapter 5.

6.1 Regression Equation

The basic concept of a multiple regression is to produce a linear combination of Independent Variables (IV) which correlate as highly as possible with a Dependent Variable (DV) in order to produce a predictive equation. The results of regression can be applied in two ways; one is to estimate the DV value from known IV values in the prediction equation; the second is to assess the relationship of each IV with the DV by observing the strength and direction of the coefficient (*r*). A positive coefficient means, when other factors are equally weighted, that the IV and the DV have a directly proportional relationship (Nie et al.: 1970).

In this analysis, the census-derived social status indicators are the IVs and the diagnostic code-based health status indicators are the DVs. Both the strength and direction of the correlation of social status indicators to each health status indicator will be discussed as well as the predicted health risk for each of the final equations. The basic regression equation is the following:

<u>Equation: 1.0</u>

$$Y = a+b_1x_1+b_2x_2+\ldots b_nx_n$$

where *Y* is the predicted value of the DV, *a* is the intercept (the value of *Y* when all *x* values are zero), the *x*s are the IVs and the *b*s are the coefficients assigned to each of the IVs during the regression (Tabachnick and Fidell: 1996: 127).

In this analysis, 20 social status indicators are the IVs, which are used to predict each one of the six health status indicators (i.e., the DVs ALCL_DRG, MENTAL, ERLYL_DTH, INJURY, TEEN_PRG, L_BWGHT) separately. The last regression inserts the composite health risk (HLTH_RSK), a dependent variable which is an aggregate of the six individual health risk categories

Stepwise Method

Of the three main strategies that can be used in multiple regression, Standard multiple regression, Sequential regression, and Statistical (Tabachnick and Fidell: 1996: 150), the latter was selected to produce the subset of variables that were used as predictors of health risk. Because it does not rely on any prior interpretation of variables, Tabachnick and Fidell consider Statistical Regression a *"controversial procedure"* (1996). Even minor differences in the computed statistics can have a profound effect on the apparent importance of an IV. However, this analytic procedure is desirable because of its flexibility and for the fact that it is considered the surest path to the best prediction equation (Tabachnick and Fidell: 1996: 150).

The statistical regression method used for this analysis has two main purposes. The first is to develop a subset of IVs that is useful in predicting the DV and the other is to eliminate IVs that do not provide additional predictive value to the IV set already in the equation (Norusis: 1993: 334). In a stepwise statistical method, the equation begins with all or none of the independent variables and the entry or elimination of variables into the equation is based solely on predetermined statistical criteria using one of three strategies, forward, backward or stepwise. The forward procedure begins with no independent variables and then *adds* them one at time. The backward method begins with all of the independent variables in the equation and *removes* them one at a time. Addition and removal criteria are based on the *F*-value of the next variable tested and the partial-correlation coefficient determines which variable is the next one to be added or dropped. The stepwise selection is a compromise between the forward and backward selection strategies where the equation starts off empty and variables are added one at a time if they meet the statistical criteria, but are deleted if they no longer contribute significantly to the regression (Tabachnick and Fidell: 150).

Selection of the "optimal" number of variables avoids unreliable estimates that could arise with too many inter-correlated IVs or exclusion of potentially important variables (Norusis: 1993: 334). For a stepwise regression where DVs are not normally distributed and transformations are not undertaken, Tabachnick and Fidell recommend a minimum 40 to 1, cases-to-IV ratio, otherwise "*...stepwise regression can produce a solution that does not generalize beyond the sample*" (Tabachnick and Fidell: 1996: 133). Since there are 164 communities or "cases", using this guideline would limit the number of allowable variables to only four. However, these limitations do not apply in this case because of two conditions. One is that the solution sought is not based on a sample population, but rather on the entire GCR population; and the other is that the emphasis of the solution sought need not apply beyond these GCR communities.

6.2 Multiple Regression Results

Output for a regression contains three main sections: a simple correlation matrix, a summary of the regression steps as the variable enters the regression equation, and a statistical summary of the total prediction equation. The simple correlation in the matrix is the Pearson Correlation Coefficient, the r value which indicates the strength of the linear association (Norusis: 1993: 292). A perfectly linear relationship has an r value of plus or minus 1, for a direct or indirect relationship respectively, and the equation would pass through all points. Alternatively where there is no relationship, r has a value of 0. When assessing the relative individual importance of each census variable (IV) to health risk (DV), the larger the simple correlation coefficient, the stronger the linear association of that particular IV with the DV.

To produce the regression equation, the dependent variables (health status indices) were inserted into a regression one at time to assess their "predictability" based on the social status indicators. A total of seven regressions were performed; one for each individual hospital use category and one for a composite health risk index that was created by averaging the six hospital use indices.

Each regression's output for the multiple regression began with a correlation matrix. Only the first analysis on the composite health risk index is shown in this chapter. For the six others, the matrix values are discussed but not shown. All seven of the regression discussions include an output table showing the sequence of the variables as they enter the equation; and a summary of the final equation.

Composite Health Risk Index

The Composite Health Risk indicator is an average of the six hospital-use indices and is intended to describe overall health risk for each community. The matrix values in Table 6.0 show the highest simple correlation to the Composite Health Risk index; HOUSE_INC (-.44), UNEMPLYD (.42), LWINCFAM(.38), IND-INC(-.38), FERTILTY(-.35), FAM_INC(-.34), ABORIG(.30), POST_SEC(-.30), MOVERS(.27), LESS_GR9(.25), A_DWELVAL(-.23), LONE_PAR(.21), and OVP_MORG(.21). The positive simple correlation values imply that as these indices increase so does community health risk. Alternatively, as the three income variables, and Fertility, Dwelling Value and Post-secondary education increases, the community health risk decreases. The census variables with a positive correlation to the composite health risk index are similar to those composing the Disadvantaged and Mobility Status dimensions that were highlighted in the factor analysis. The variables with negative correlations to the composite health risk index coincide with the Economic and Family Status dimensions.

The strength and direction of the matrix correlation values support the notion that higher social and economic status, identified by high indices for income, housing value and university education, are directly correlated to higher health status. Conversely, the economically and socially disadvantaged in community populations, those categorized as low-income families, lone female parents, and the poorly educated endure lower health status.

The next output, shown in the top half of Table 6.1, shows the nine regression steps that were taken to select the final variables. The changing correlation coefficient (*Multi R*) for each step shows the contribution of each variable as it enters the equation. The last

Table 6.0
Correlation Matrix for Composite Health Risk

	Comp_RISK	ABORIGIN	ADULTS	DWL_VALU	ELDR_DEP	ENGLISH	FAM_INC	FERTILTY	HOUS_INC	HS_CERT	IND_INC
COMP_RISK	1.00	-0.04	0.26	-0.24	0.01	0.02	-0.30	-0.47	-0.37	-0.08	-0.30
	.	0.29	0.00	0.00	0.48	0.41	0.00	0.00	0.00	0.15	0.00
ABORIGIN	-0.04	1.00	0.00	-0.10	0.00	-0.12	0.00	0.06	-0.02	0.14	-0.05
	0.29	.	0.48	0.10	0.49	0.06	0.50	0.22	0.42	0.03	0.27
ADULTS	0.26	0.00	1.00	0.02	0.05	0.03	0.00	-0.80	-0.27	-0.22	-0.12
	0.00	0.48	.	0.42	0.26	0.33	0.49	0.00	0.00	0.00	0.06
DWL_VALU	-0.24	-0.10	0.02	1.00	0.06	-0.01	0.73	0.03	0.73	-0.30	0.76
	0.00	0.10	0.42	.	0.23	0.44	0.00	0.36	0.00	0.00	0.00
ELDR_DEP	0.01	0.00	0.05	0.06	1.00	0.03	0.05	0.02	0.03	0.00	0.02
	0.48	0.49	0.26	0.23	.	0.33	0.25	0.42	0.38	0.50	0.41
ENGLISH	0.02	-0.12	0.03	-0.01	0.03	1.00	-0.05	-0.01	-0.03	-0.09	-0.05
	0.41	0.06	0.33	0.44	0.33	.	0.27	0.46	0.38	0.13	0.26
FAM_INC	-0.30	0.00	0.00	0.73	0.05	-0.05	1.00	0.11	0.89	-0.29	0.86
	0.00	0.50	0.49	0.00	0.25	0.27	.	0.09	0.00	0.00	0.00
FERTILTY	-0.47	0.06	-0.80	0.03	0.02	-0.01	0.11	1.00	0.31	0.25	0.12
	0.00	0.22	0.00	0.36	0.42	0.46	0.09	.	0.00	0.00	0.06
HOUS_INC	-0.37	-0.02	-0.27	0.73	0.03	-0.03	0.89	0.31	1.00	-0.25	0.92
	0.00	0.42	0.00	0.00	0.38	0.38	0.00	0.00	.	0.00	0.00
HS_CERT	-0.08	0.14	-0.22	-0.30	0.00	-0.09	-0.29	0.25	-0.25	1.00	-0.27
	0.15	0.03	0.00	0.00	0.50	0.13	0.00	0.00	0.00	.	0.00
IND_INC	-0.30	-0.05	-0.12	0.76	0.02	-0.05	0.86	0.12	0.92	-0.27	1.00
	0.00	0.27	0.06	0.00	0.41	0.26	0.00	0.06	0.00	0.00	.
INFANTS	-0.28	-0.03	-0.66	-0.22	0.05	-0.03	-0.14	0.67	-0.01	0.21	-0.11
	0.00	0.37	0.00	0.00	0.28	0.37	0.04	0.00	0.43	0.00	0.08
LESS_GR9	0.51	0.14	0.15	-0.42	-0.02	0.05	-0.39	-0.23	-0.39	-0.09	-0.38
	0.00	0.04	0.02	0.00	0.41	0.26	0.00	0.00	0.00	0.14	0.00
LONE_PAR	0.11	-0.10	0.10	-0.33	0.07	0.14	-0.45	-0.06	-0.49	-0.16	-0.42
	0.07	0.09	0.09	0.00	0.20	0.04	0.00	0.24	0.00	0.02	0.00
LWINCFAM	0.28	-0.01	0.05	-0.28	0.03	0.04	-0.48	-0.13	-0.49	0.05	-0.33
	0.00	0.44	0.28	0.00	0.34	0.30	0.00	0.05	0.00	0.26	0.00
MOVERS	0.03	-0.12	0.04	0.17	0.08	0.06	0.10	-0.03	0.14	0.02	0.23
	0.33	0.07	0.32	0.02	0.15	0.24	0.10	0.34	0.04	0.42	0.00
OVP_MORG	0.05	0.01	-0.34	-0.15	0.03	-0.08	-0.28	0.34	-0.19	0.36	-0.16
	0.27	0.45	0.00	0.03	0.35	0.16	0.00	0.00	0.01	0.00	0.02
OVP_RENT	0.21	0.13	-0.07	-0.37	0.07	-0.01	-0.35	0.06	-0.34	0.15	-0.32
	0.00	0.05	0.19	0.00	0.18	0.46	0.00	0.21	0.00	0.02	0.00
PARTICIP	-0.31	0.08	-0.25	0.02	0.06	-0.15	-0.07	0.31	-0.02	0.50	0.02
	0.00	0.16	0.00	0.38	0.21	0.02	0.17	0.00	0.42	0.00	0.38
POST_SEC	-0.30	-0.16	0.09	0.68	0.01	-0.09	0.62	-0.08	0.61	-0.38	0.71
	0.00	0.02	0.14	0.00	0.48	0.13	0.00	0.16	0.00	0.00	0.00
SENIORS	0.37	-0.03	0.28	0.07	-0.10	0.01	0.08	-0.57	0.04	-0.40	0.06
	0.00	0.33	0.00	0.18	0.10	0.43	0.14	0.00	0.30	0.00	0.22
UNEMPLYD	0.20	-0.08	0.07	-0.34	0.15	0.10	-0.22	-0.05	-0.30	-0.24	-0.37
	0.01	0.16	0.18	0.00	0.03	0.09	0.00	0.26	0.00	0.00	0.00

Table 6.0 (Cont'd)
Correlation Matrix for Composite Health Risk

INFANTS	LESS_GR9	LONE_PAR	LWINCFAM	MOVERS	OVP_MORG	OVP_RENT	PARTICIP	POST_SEC	SENIORS	UNEMPLYD	
-0.28	0.51	0.11	0.28	0.03	0.05	0.21	-0.31	-0.30	0.37	0.20	COMP_RISK
0.00	0.00	0.07	0.00	0.33	0.27	0.00	0.00	0.00	0.00	0.01	
-0.03	0.14	-0.10	-0.01	-0.12	0.01	0.13	0.08	-0.16	-0.03	-0.08	ABORIGIN
0.37	0.04	0.09	0.44	0.07	0.45	0.05	0.16	0.02	0.33	0.16	
-0.66	0.15	0.10	0.05	0.04	-0.34	-0.07	-0.25	0.09	0.28	0.07	ADULTS
0.00	0.02	0.09	0.28	0.32	0.00	0.19	0.00	0.14	0.00	0.18	
-0.22	-0.42	-0.33	-0.28	0.17	-0.15	-0.37	0.02	0.68	0.07	-0.34	DWL_VALU
0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.38	0.00	0.18	0.00	
0.05	-0.02	0.07	0.03	0.08	0.03	0.07	0.06	0.01	-0.10	0.15	ELDR_DEP
0.28	0.41	0.20	0.34	0.15	0.35	0.18	0.21	0.48	0.10	0.03	
-0.03	0.05	0.14	0.04	0.06	-0.08	-0.01	-0.15	-0.09	0.01	0.10	ENGLISH
0.37	0.26	0.04	0.30	0.24	0.16	0.46	0.02	0.13	0.43	0.09	
-0.14	-0.39	-0.45	-0.48	0.10	-0.28	-0.35	-0.07	0.62	0.08	-0.22	FAM_INC
0.04	0.00	0.00	0.00	0.10	0.00	0.00	0.17	0.00	0.14	0.00	
0.67	-0.23	-0.06	-0.13	-0.03	0.34	0.06	0.31	-0.08	-0.57	-0.05	FERTILTY
0.00	0.00	0.24	0.05	0.34	0.00	0.21	0.00	0.16	0.00	0.26	
-0.01	-0.39	-0.49	-0.49	0.14	-0.19	-0.34	-0.02	0.61	0.04	-0.30	HOUS_INC
0.43	0.00	0.00	0.00	0.04	0.01	0.00	0.42	0.00	0.30	0.00	
0.21	-0.09	-0.16	0.05	0.02	0.36	0.15	0.50	-0.38	-0.40	-0.24	HS_CERT
0.00	0.14	0.02	0.26	0.42	0.00	0.02	0.00	0.00	0.00	0.00	
-0.11	-0.38	-0.42	-0.33	0.23	-0.16	-0.32	0.02	0.71	0.06	-0.37	IND_INC
0.08	0.00	0.00	0.00	0.00	0.02	0.00	0.38	0.00	0.22	0.00	
1.00	-0.17	0.24	0.07	-0.12	0.45	-0.02	0.36	-0.14	-0.60	0.29	INFANTS
.	0.02	0.00	0.18	0.06	0.00	0.41	0.00	0.04	0.00	0.00	
-0.17	1.00	0.25	0.51	0.01	-0.03	0.35	-0.50	-0.56	0.39	0.24	LESS_GR9
0.02	.	0.00	0.00	0.44	0.35	0.00	0.00	0.00	0.00	0.00	
0.24	0.25	1.00	0.60	-0.09	0.05	0.11	-0.12	-0.41	-0.06	0.56	LONE_PAR
0.00	0.00	.	0.00	0.13	0.28	0.09	0.06	0.00	0.20	0.00	
0.07	0.51	0.60	1.00	0.03	0.22	0.34	-0.06	-0.45	0.00	0.13	LWINCFAM
0.18	0.00	0.00	.	0.35	0.00	0.00	0.23	0.00	0.50	0.05	
-0.12	0.01	-0.09	0.03	1.00	0.00	-0.06	0.01	0.22	0.00	-0.03	MOVERS
0.06	0.44	0.13	0.35	.	0.50	0.24	0.44	0.00	0.49	0.37	
0.45	-0.03	0.05	0.22	0.00	1.00	0.06	0.37	-0.16	-0.43	-0.05	OVP_MORG
0.00	0.35	0.28	0.00	0.50	.	0.22	0.00	0.02	0.00	0.25	
-0.02	0.35	0.11	0.34	-0.06	0.06	1.00	-0.06	-0.34	-0.01	-0.01	OVP_RENT
0.41	0.00	0.09	0.00	0.24	0.22	.	0.22	0.00	0.45	0.44	
0.36	-0.50	-0.12	-0.06	0.01	0.37	-0.06	1.00	0.13	-0.73	-0.18	PARTICIP
0.00	0.00	0.06	0.23	0.44	0.00	0.22	.	0.05	0.00	0.01	
-0.14	-0.56	-0.41	-0.45	0.22	-0.16	-0.34	0.13	1.00	0.00	-0.27	POST_SEC
0.04	0.00	0.00	0.00	0.00	0.02	0.00	0.05	.	0.48	0.00	
-0.60	0.39	-0.06	0.00	0.00	-0.43	-0.01	-0.73	0.00	1.00	0.01	SENIORS
0.00	0.00	0.20	0.50	0.49	0.00	0.45	0.00	0.48	.	0.48	
0.29	0.24	0.56	0.13	-0.03	-0.05	-0.01	-0.18	-0.27	0.01	1.00	UNEMPLYD
0.00	0.00	0.00	0.05	0.37	0.25	0.44	0.01	0.00	0.48	.	

value (67%) in this column shows a strong linear relationship of the variables to the composite health risk index. The squared correlation coefficient in the *Rsq* column is a measure of the proportion of variability in the dependent variable set that is accounted for by the regression. The final *Rsq* value is 0.45 indicating that 45% of the variability in the dataset is predictable from the 5 independent variables which remain in the equation.

Table 6.1

Multiple Regression with Census Variables and Composite Health Risk

Dependent Variable Comp H Risk

Step	*MultR*	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	0.4356	0.1897	35.3560	0.00	In:	HOUS_INC	-0.4356
2	0.4907	0.2408	23.7860	0.00	In:	FERTILTY	-0.2388
3	0.5487	0.3011	21.3930	0.00	In:	OVP_MORG	0.2898
4	0.5925	0.3510	20.0130	0.00	In:	UNEMPLYD	0.2694
5	0.5892	0.3472	26.4140	0.00	Out:	HOUS_INC	
6	0.6191	0.3833	23.0000	0.00	In:	ADULTS	-0.3505
7	0.6408	0.4107	20.4880	0.00	In:	INFANTS	-0.2832
8	0.6582	0.4333	18.6030	0.00	In:	SENIORS	-0.2381
9	0.6709	0.4501	16.9520	0.00	In:	POST_SEC	-0.1777

Variables Left In Equation	*B*	*SE B*	*95% Confdnce*	*Intrvl B*	*Beta*
ADULTS	-3.8261	0.7770	-5.3619	-2.2904	-0.7616
FERTILTY	-1.8137	0.2760	-2.3592	-1.2681	-0.9293
INFANTS	-0.5883	0.1623	-0.9092	-0.2675	-0.4360
OVP_MORG	0.2274	0.0694	0.0902	0.3645	0.2592
POST_SEC	-0.3735	0.1775	-0.7244	-0.0226	-0.1777
SENIORS	-0.1476	0.0581	-0.2624	-0.0328	-0.2482
UNEMPLYD	0.3475	0.1140	0.1222	0.5728	0.2463
(Constant)	7.1689	1.2060	4.7853	9.5526	

The bottom half of the table shows that the final regression equation retains the variables for Fertility, Overpay Mortgage, Unemployed, Adults, Infants, Seniors, and Post-Secondary education which together, account for about 45% of the variability in the dataset. Using the values in the "Variables Left in Equation" column, the final regression equation for the composite health risk index is:

$Y = a+b_1x_1+b_2x_2+\dots b_nx_n$

COMPOSITE HEALTH RISK

=7.2(Constant) -3.83(ADULTS) -1.81(FERTILTY) -.59(INFANTS) +.23(OVP_MORG) -.38(POST_SEC) -.15(SENIORS) +.35(UNEMPLYD)

Alcohol and Drug Abuse

The simple correlation coefficients calculated as a first step (not shown) in the SPSS stepwise regression analysis indicate that the highest individual correlation to the Alcohol and Drug Use index is FERTILTY (-.36) ABOR (.34), HOUSE_INC (-.33) and ADULTS (.30). As the indices for Aboriginal and Adults increases, so does the index for Alcohol and Drug-Abuse while the Fertility and Household income indices have the opposite effect.

Table 6.2

Multiple Regression with Census Variables and Alcohol and Drug Use

Dependent Variable ALC_DRG

Step	*MultR*	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	0.3645	0.1328	22.9760	0.00	In:	FERTILTY	-0.3645
2	0.4598	0.2114	19.9720	0.00	In:	ABOR	0.2847
3	0.4970	0.2470	16.1800	0.00	In:	OVP_MORG	0.2031

Variables Left In Equation	*B*	*SE B*	*95% Confdnce*	*Intrvl B*	*Beta*
ABOR	0.2426	0.0662	0.1118	0.3733	0.2667
FERTILTY	-1.5088	0.3007	-2.1030	-0.9146	-0.3913
OVP_MORG	0.3517	0.1330	0.0888	0.6146	0.2031
(Constant)	1.8436	0.2883	1.2740	2.4133	

Once the effects of multicollinearity among the census variables are removed, the final regression equation shown in Table 6.2 includes Aboriginal, Fertility and Overpay mortgage variables. Together, this group accounts for about 25% of the variation in the Alcohol and Drug Use health status indicator and may be summarized by the following equation:

$Y = a+b_1x_1+b_2x_2+...b_nx_n$

ALCOHOL AND DRUG USE

= 1.84(Constant) + 0.24(ABOR) - 1.50(FERTILTY) + 0.35 (OVP_MORG)

Mental Diseases and Disorders

The highest simple correlations to the Mental Diseases and Disorders index are ADULTS (-.43), FERTILTY (-.34), LWINCFAM (.23) and MOVERS (.23) meaning that as the Movers and Low Income Family indices increases so does the Mental Disease index, while the Adults and Fertility indices have the opposite effect. As shown in Table 6.3, after the effects of multicollinearity among the census variables are removed the final regression equation retains the variables Fertility, Adults, Movers, Infants, and Post-secondary education which collectively, account for about 25% of the variability in the Mental Diseases and Disorders index.

The final regression equation for Mental Diseases and Disorders is expressed as:

$Y = a+b_1x_1+b_2x_2+...b_nx_n$

MENTAL DISEASES AND DISORDERS

= 6.5(Constant) -3.6(ADULTS) -1.43(FERTILTY) -0.72(INFANTS) + 0.77 (MOVERS) -0.5(POST_SEC)

Table 6.3

Multiple Regression with Census Variables and Mental Diseases and Disorders

Dependent Variable MENTAL

Step	*MultR*	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	0.3349	0.1121	18.8180	0.00	In:	FERTILTY	-0.3349
2	0.4109	0.1688	15.0290	0.00	In:	ADULTS	-0.4321
3	0.4427	0.1959	11.9410	0.00	In:	MOVERS	0.1753
4	0.4808	0.2312	10.9750	0.00	In:	INFANTS	-0.3336
5	0.5095	0.2596	10.1690	0.00	In:	POST_SEC	-0.1746

Variables Left In Equation	*B*	*SE B*	*95% Confdnce*	*Intrvl B*	*Beta*
ADULTS	-3.5662	1.0429	-5.627420	-1.5050	-0.5187
FERTILTY	-1.4317	0.3724	-2.1678	-0.6956	-0.5378
INFANTS	-0.7173	0.2377	-1.1871	-0.2476	-0.3900
MOVERS	0.7706	0.2302	0.3157	1.2255	0.2866
POST_SEC	-0.5096	0.2159	-0.9363	-0.0828	-0.1746
(Constant)	6.5139	1.4726	3.6035	9.4243	

Early Death

The highest simple correlation coefficients to the Early Death Index belong to SENIORS (.23) and FERTILTY (-.23) meaning that as the seniors index increases, the Early Death index increases, while the fertility index has the opposite effect.

When the effects of multicollinearity among the census variables are removed (see Table 6.4) the equation retains the variables for Adults, Infants, Fertility, and Overpay Mortgage which account for about 22% of the variability in the Early Death index which may be estimated with the following equation:

$Y = a+b_1x_1+b_2x_2+\ldots b_nx_n$

EARLY DEATH

= 10.23(Constant) -6.37(ADULTS) -2.27(FERTILTY) -1.08(INFANTS) +0.5 (OVP_MORG)

Table 6.4

Multiple Regression with Census Variables and Early Death

Dependent Variable ERLY_DTH

Step	MultR	Rsq	F(Eqn)	SigF		Variable	BetaIn
1	0.2347	0.0551	8.7440	0.00	In:	FERTILTY	-0.2347
2	0.3593	0.1291	11.0470	0.00	In:	ADULTS	-0.4937
3	0.3997	0.1598	9.3820	0.00	In:	ENGL	-0.1816
4	0.4358	0.1899	8.6170	0.00	In:	INFANTS	-0.2747
5	0.4804	0.2308	8.7610	0.00	In:	OVP_MORG	0.2557
6	0.4691	0.2201	10.3690	0.00	Out:	ENGL	

Variables left In Equation	B	SE B	95% Confdnce	Intrvl B	Beta
ADULTS	-6.3652	1.4565	-9.243508	-3.4869	-0.6687
FERTILTY	-2.2691	0.4920	-3.241494	-1.2968	-0.6129
INFANTS	-1.0842	0.3186	-1.7138	-0.4545	-0.4237
OVP_MORG	0.5003	0.1438	0.2160	0.7845	0.3008
(Constant)	10.2297	1.9438	6.388277	14.0712	

Injuries, Poisonings, and Toxic Effects of Drugs

The highest simple correlation to the Injuries, Poisonings, and Toxic Effects of Drugs index are UNEMPLYD (.33), MOVERS (.30), OVP_MORG (.26), LWINCFAM (.24), and ABOR (.23) which means that as those indices increase, so does this particular health risk index.

Only two variables are retained in the final regression equation once the effects of multicollinearity among the census variables are removed; the Movers and Unemployed indices, shown in Table 6.5, which together account for about 18% of the variability.

Table 6.5

Multiple Regression with Census Variables and Injuries, Poison, and Toxic Effects

Dependent Variable INJURE

Step	*MultR*	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	0.3339	0.1115	17.8200	0.00	In:	UNEMPLYD	0.3339
2	0.4347	0.1890	16.4270	0.00	In:	MOVERS	0.2787

Variables left In Equation	*B*	*SE B*	*95% Confdnce*	*Intrvl B*	*Beta*
MOVERS	0.7854	0.2140	0.3624	1.2085	0.2787
UNEMPLYD	0.6773	0.1612	0.3585	0.9960	0.3190
(Constant)	-0.3163	0.2744	-0.8589	0.2262	

The final equation is expressed as:

$Y = a+b_1x_1+b_2x_2+\ldots b_nx_n$

INJURY POISONINGS AND TOXIC EFFECTS OF DRUGS

= -0.32(Constant)+0.79(MOVERS)+0.68(UNEMPLYD)

Teenage Pregnancies

The highest simple correlation to the Teen Pregnancy index are DWEL_VALU (-40), POST_SEC (-.40), UNEMPLYD (.37), LONE_PAR (.36), the income variables (all are over .32), and LESS_GR9 (.26) meaning that as Unemployment, Lone parent, and the low education indices increase so does the index for Teen Pregnancy while Dwelling value and Post-secondary education have the opposite effect. Table 6.6 shows that once the effects of multicollinearity among the census variables are removed the final regression equation retains only two variables; LWINCFAM and DWEL_VALU which together, account for about 24% of the variability in Teen Pregnancies risk.

Table 6.6

Multiple Regression with Census Variables and Teen Pregnancies

Dependent Variable TEEN_PRG							
Step	*MultR*	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	0.4006	0.1605	28.6730	0.00	In:	A_DWELVA	-0.4006
2	0.4888	0.2389	23.3880	0.00	In:	LWINCFAM	0.2965
Variables left In Equation	*B*	*SE B*	*95% Confdnce*		*Intrvl B*	*Beta*	
A_DWELVA	-0.9758	0.2434	-1.4568		-0.4949	-0.3033	
LWINCFAM	0.5217	0.1331	0.2586		0.7847	0.2965	
(Constant)	1.4317	0.3357	0.7682		2.0951		

The final regression equation is expressed as:

$Y = a+b_1x_1+b_2x_2+\ldots b_nx_n$

TEEN_PREGNANCY

=.1.4(Constant). -.98(DWL_VALU) +.52(LWINCFAM)

Low Birthweight Newborns

ABOR is the only significant simple correlation (.22) to the Low Birthweight Newborns index, meaning that its value increases with an increase in the Aboriginal index.

It is the only variable retained in the final equation (see Table 6.7) and explains only .04% of the variability in the dataset:

$Y = a+b_1x_1+b_2x_2+\ldots b_nx_n$

LOW BIRTHWEIGHT

= 0.87(Constant) +.13(ABOR)

Table 6.7

Multiple Regression with Census Variables and Low Birthweight Newborns

Dependent Variable LBW

Step	MultR	Rsq	F(Eqn)	SigF		Variable	BetaIn
1	0.2230	0.0497	7.8530	0.01	In:	ABOR	0.2230

Variables left In Equation	B	SE B	95% Confdnce	Intrvl B	Beta
ABOR	0.1353	0.0483	0.0399	0.2306	0.2230
(Constant)	0.8667	0.0737	0.7211	1.0122	

6.3 Summary of Beta Values for Each Health Risk Category

Table 6.8 is a summary of the correlation values for each of the variables retained in the final regression equation for each of the health categories. Census variables with positive values are those whose index values increase as the health risk indices increase, while the negative values are those that are inversely related to the health risk indices.

Table 6.8

Summary of Beta Weights for Composite Health Risk

	Comp H Risk	Alcohol Drug	Mental Disease	Early Death	Injury Poison	Teen Preg	Low Bwght
POSITIVE INFLUENCES							
UNEMPLYD	0.2463				0.3190		
OVP_MORG	0.2592	0.2031		0.3008			
ABORIG		0.2667					0.2230
MOVERS			0.2866		0.2787		
LWINCFAM						0.2965	
NEGATIVE INFLUENCES							
ADULTS	-0.7616		-0.5187	-0.6687			
FERTILTY	-0.9293	-0.3913	-0.5378	-0.6129			
INFANTS	-0.4360		-0.3900	-0.4237			
POST_SEC	-0.1777		-0.1746				
SENIORS	-0.2482						
A_DWELVA						-0.3033	

6.4 Mapping Residuals for Composite Health Risk

Cases, or communities, which fit poorly to the regression equation are "outliers" and represent the difference between the predicted and the observed health risk values for each community. When measured in standard deviations, assessment of residual values is useful since it shows the degree to which communities' health risk varies from the regression model.

Mapped residuals provide a convenient means to identify the communities that fit poorly with the predictive model. A "Residuals Map" is a graphical performance measurement of the regression equation because it shows the magnitude and location of the variations which make the linear correspondence of the variable less than perfect (Robinson et al: 1968: 295).

The relative magnitudes of residuals are easier to judge when they are divided by estimates of their standard deviations (Norusis: 1993: 325). The residuals are expressed in standard deviation units above or below the mean. Positive residuals indicate that the observed health risk index value is higher than the value predicted by the model. Mapped residuals of the composite health risk equation in Figure 6.0 illustrate the standardized residual values (shown in the legend) which are skewed to the negative side.

Discussion of "Outlier" Communities

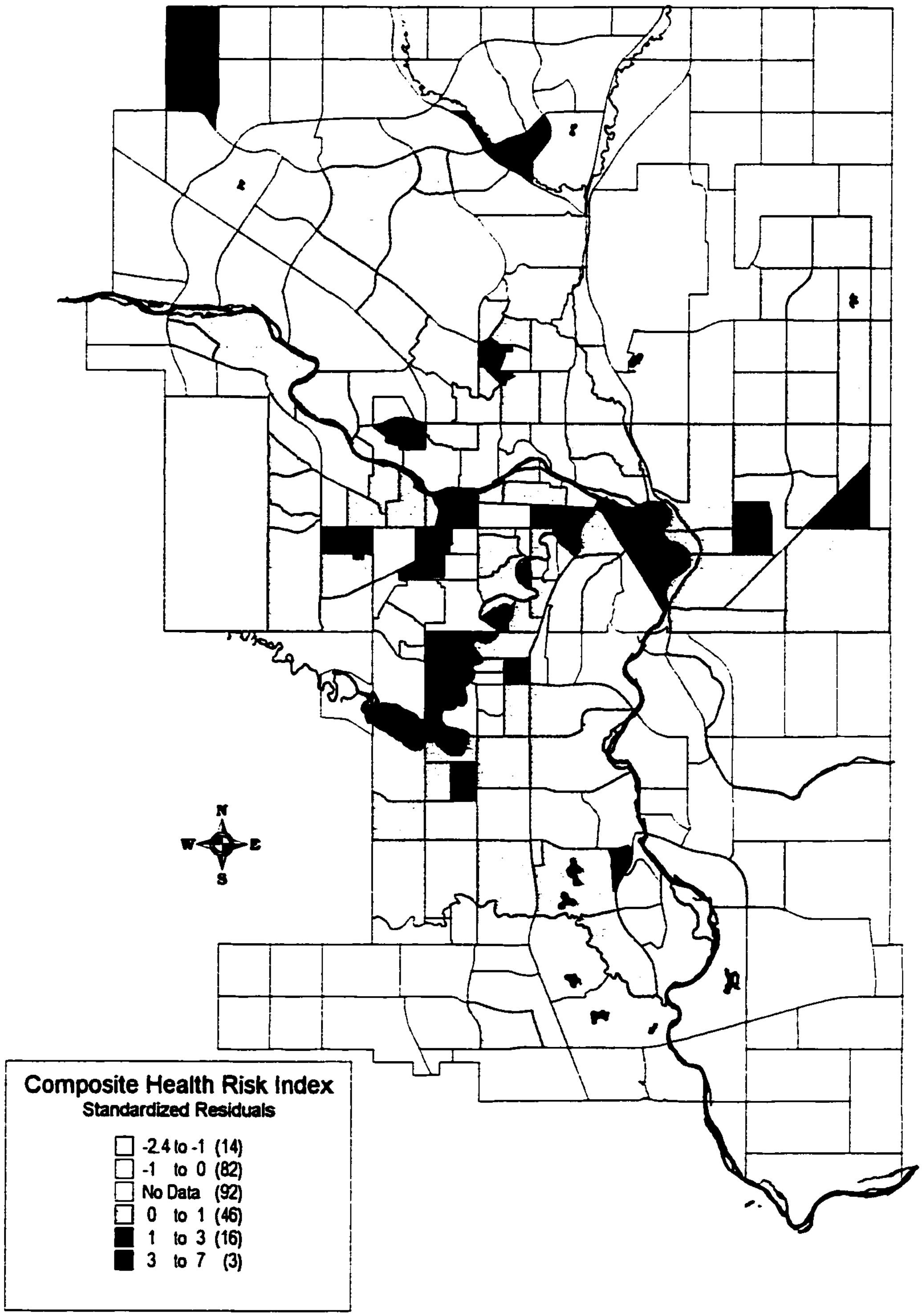
The following is a description of the communities with the highest residual values. Each is examined spatially and discussed in terms of the associated socio-economic characteristics that may explain its inability to fit the model.

Extreme Positive Residuals

The most extreme underprediction of health risk, residuals > 3 standard deviations, occurs in 3 suburb communities; Country Hills which had a 6.58 residual, is in the north; Red Carpet, which has a 3.06 residual, is in the east; and Glendale, with a 3.07 residual, is in the west. Country Hills, with the highest residual, featured prominently in the thematic maps, discussed in Chapter 5, of the health status categories due to extremely high indices for most of the health risk categories.

Figure 6.0

Calgary Communities Overprediction and Underprediction of Composite Health Risk Index



Boundary File Source: City of Calgary, Budget and Planning, Dec. 1996

From the available data an intuitive assessment would conclude, as the model did, that Country Hills should have much lower composite health risk index value than 4.38. This NW community is unremarkable in many ways; it is a young family neighbourhood of new homeowners with few seniors. Income and education levels are average and there are few of the "disadvantaged" classes such as Low-Income and Lone Parent families. In spite of these advantages, the community has very high health risk indices in four categories; Early Death (9.39), Alcohol and Drug Abuse (5.69), Injuries (5.04), and Mental Diseases (4.96).

Red Carpet, a trailer park, is also a young family suburb community of new homeowners. In contrast to Country Hills though, it has a high proportion of Low Income / Low Education residents, very low dwelling values and high unemployment. Intuitively, a high health risk index would be expected in this community but not, apparently a value of 3.06 to which Teen Pregnancy (7.78) and Early Death (4.07) are the major contributors.

Glendale has an observed health risk of 2.05, which is higher than the model predicted. Besides having twice the average proportion of seniors and a low-income index, this community has few of the Disadvantaged populations that would increase the model's health risk prediction. Recall that in the Teen Pregnancy regression, the final equation retained (negative) dwelling value and low income family status to account for 24% of the variability. It is possible that the 5.05 index for Teen Pregnancy, itself an anomaly and not well predicted by the model, could not be accounted for based on the remaining variables.

Extreme Negative Residuals

Overprediction by more than -2 standard deviations, occurs for two communities; Greenwood / Greenbriar, a new suburb in the northwest, has a -2.4 residual and Houndsfield Heights / Briar Hill and Houndsfield Heights, an inner city centre Calgary neighbourhood has a -2.06 residual.

Greenwood / Greenbriar has a 1.09 health risk index. Its average dwelling value is one quarter the average suggesting that it is a trailer park. Other than having a moderately high senior ratio, and three quarters of the average income, there is nothing noteworthy for this community except for the low composite health risk index caused by a zero value in 3 of the 6 hospital use categories.

Houndsfield Heights / Briar Hill on the other hand, which has a .69 health risk index is unusual because of its high (5.38) seniors index. This is due to the location of a large seniors' home in the community, whose services would likely also attract seniors to the housing in the neighbourhood. It has a higher than average income and few of the Disadvantaged variables. Health risk values are slightly high for non-maternal related health risks (Alcohol, Injuries, Mental and Early Death).

6.5 Summary

There are two main trends evident in the results of the seven regressions. One is that the Disadvantaged dimension variables, such as Low Income and Lone Parent Families, Overpay Mortgage, and Less than Grade 9 education, are reliable predictors of high health risk for most of the health risk categories. The other trend is that the Economic dimension variables such as Income, Average Dwelling Value and Post Secondary education are reliable predictors of low health risk.

The results of this Calgary region study confirm the findings of numerous population health studies (Roos et al: 1996; Evans: 1994), both in Canada and internationally, which associate poverty, unemployment, low education and numerous related indicators of low socio-economic status, to lower standards of health caused by higher risks for a multitude of health risk categories.

Explanation for Extreme Residuals

Tabachnick and Fidell (1966: 139) define outliers as those with standardized residuals in excess of +/- 3.3. The three communities with positive residuals in excess of 3 were discussed in addition to two which had negative residuals greater than 2. The underprediction occurred in communities with higher than expected composite health risk due to individual health risk categories that, by themselves, were difficult to predict from the social status indicators. These anomalous values in turn inflate the composite health risk index, which is not predictable from the equation.

The underpredictions occurred in communities that had a higher than expected composite health risk index. The three highest values tended to be for communities located in or adjacent to new suburbs near the edges of the city. This suggests that the counts for this health risk category, used to calculate the health risk index, may be based on outdated, smaller population counts than current ones. Calculations based on populations that have grown since the last census would result in an underprediction of health risk for that community.

Another, less likely explanation is that a rapid demographic and socio-economic transition, since the census used in this study was taken, changed the community's overall social status and was accompanied by higher health risks. Since community profiles are relatively stable over long periods of time (Johnston: 1973), social and economic transitions of this magnitude are unlikely within a five-year time frame.

The most plausible explanation is the 4-year temporal difference in the datasets. The 1991 Statistics Canada Census data is five years older than the 1995-96 hospital records and may not accurately reflect contemporary population counts particularly for the newer suburbs on the fringes of the city.

The overpredictions occurred in communities which have a lower than expected composite health risk which are due to either null values, or low values for one or more of the six health categories. The reasons for this are unclear, since it implies that some communities do not obtain hospital services for some of these diagnostic categories within the CRHA. This is plausible for high-income community residents who have the option of obtaining private local health care, or traveling elsewhere for treatment. For diagnostic categories such as Alcohol and Drug Use, Mental Diseases and Depression, and Teenage Pregnancy, it is reasonable to assume that wealthy patients would prefer to discreetly avoid the perceived stigma of such treatments. However, Houndsfield Heights / Briar Hill is not a particularly high-income community but it does have a high ratio of seniors. The low residuals for Greenwood / Greenbriar, is more curious because it is a low-income community with a high rate of seniors and Aboriginals. The reason why there should be null or low values for all the health risk categories except Low birthweight is difficult to explain. Either patients are not seeking treatment within the CRHA or are not seeking treatment at all.

A more comprehensive understanding of both residual groups would be possible with supporting studies, more current social and demographic data and a better knowledge of the local community conditions.

7.0 DISCUSSION AND CONCLUSIONS

The main research objective of this study was to assess the utility of geography census variables for a population-based assessment of CRHA patient health risk by answering the following three questions:

1) Is there a statistically significant correlation between health risk and socio-economic characteristics in the GCR populations?;
2) If there is a significant correlation, which communities are the most at-risk?; and
3) What are the particular population characteristics of the high-need, high health risk communities identified by the model?

The study was based on the results of a geographic and statistical analysis of 164 Greater Calgary Region (GCR) communities. High-risk communities for six medical diagnostic categories were identified and spatially analyzed through the use of principles similar to those used to develop the Manitoba "Population Health Information System" (PHIS). Because the PHIS was designed to track the health status and hospital use of individual residents of Manitoba's health regions rather than the performance of clinical care provider, it also recognizes impoverishment as an important factor of poor health (MCPHE: 1994).

The findings of this thesis suggest that, like Manitoba populations, the health of the GCR population is significantly influenced by social status. This study has identified a number of Calgary communities with elevated risk in several health categories and related the socio-economic trends to high-need, high health risk populations.

7.1 Main Findings

This study's conclusions are restricted to those that can be demonstrated by statistical correlations of the selected health risk and social status categories and does not propose to provide explanations for causality of the associations. However, by highlighting some of the statistically demonstrable characteristics of specific health categories, patterns were identified that can serve as a first approximation for a more detailed analysis at a later time. The answer to the three main questions posed as the main objectives of the study are as follows:

1) *Is there a statistically significant correlation between health risk and socio-economic characteristics in the GCR populations?;*

Yes, there is. The factor analysis on the census variables, discussed in Chapter 5, created a socio-economic and demographic profile for each GCR community. The linear regressions, discussed in Chapter 6 showed that unemployment, unaffordable housing, Aboriginal populations, mobility and Low Income Families ratios within the communities were associated with higher community health risks.

The variability accounted for by retained variables in the regression equations ranged from 4% for Low Birthweight Newborns to 26% for Mental Diseases and Disorders. The predictability of Low Birthweight was complicated by the fact that Aboriginal status was the only variable retained in the regression equation, even though this population group comprises less than 7% of the GCR population. Other health risk studies that specifically targeted larger populations of low birthweight newborns have attained more statistically valid results. A health risk model for the City of New York, based on a temporal study of changes in low birthweight, found a strong, positive correlation with poverty, drug use, unemployment and lower education levels (Tempalski: 1997: 35).

2) *If there is a significant correlation, which communities are the most at-risk?*

At-risk communities for each of the health categories were identified. The non-maternal related health risk categories; Alcohol and Drug Abuse, Mental Diseases and Disorders, Early Death, and Injuries / Poisonings / Toxic Effects of Drugs tended to occur more intensely and contiguously in the inner city and inner suburbs and their distribution density diminished with distance from the city centre. Established suburbs had lower risks for these categories and the new suburbs, particularly in the far north and far south, had low (or no) risk.

For the maternal-related health risks, Teenage Pregnancy, and Low Birthweight, the geographic pattern of high-risk communities tended to be less contiguous (particularly for Low Birthweight). Moreover the at-risk communities tended to be spread out in all quadrants from the inner city to the established and new suburbs near the limits of Calgary.

3) *What are the particular population characteristics of the high-need, high health risk communities identified by the model?*

The population characteristics of the high needs, high health risk communities were identified. Although the actual ratios varied for each of the categories, higher community health risks were associated with high incidences of:

- low income families
- aboriginals
- unemployment
- mobility
- high housing cost to income ratios (ovp – mort)

Alternately, low health risk communities tended to have higher ratios of;

- high income
- high dwelling values
- young families (infants)
- post secondary education
- English as first language.

7.2 Discussion

A common interpretation of the correlation between socio-economic status and health is that the poor tend to lack the material requirements of good health such as proper nutrition, adequate housing or safe secure home and work environment. However, this assumption is not supported by empirical study that suggests that the main cause of poor health is not impoverishment itself (Evans: 1994: 12). Results vary between countries, but in the U.K. where even the lowest ranking British civil servant could not be considered poor, a steep health and mortality gradient exists. It manifests itself in a premature mortality rate three times higher for the low civil servant ranks than for the high ranks (Marmot et al: 1978: 248).

Part of the answer to the link between social rank and health risk may lie with individual response or adaptation to environmental stimulus. This is supported by studies that show that the benefits of a "good" supportive, nurturing social environment can offset the disadvantages of an "unhealthy" beginning in life. The Kausi Longitudinal study (Werner and Smith: 1982; Werner: 1989) focuses on the long-term health effects of early adversity on child development. Findings suggest that babies who are disadvantaged early in life by factors such as poverty or unstable homes have a good chance of recovering if they are placed in a "good" environment (measured by family stability and socio-economic status). With an emphasis on psychological stimulation and nutritional supplements, early intervention can even offset a disadvantageous *genetic* inheritance. Infants born to mentally handicapped mothers have shown remarkable intellectual improvements when intervention provided them with extra mental stimulation (Grantham-McGregor et al: 1991).

7.3 Value of the Study

The main value of this study is that it provides an example of a simple methodology that can be applied by a non-medically trained researcher to make a valid, scientific population health assessment. Using existing administrative data, the desktop version of the two main analysis tools, SPSS for the statistical analysis and MapInfo GIS for the geographic analysis and mapping, were sufficient to enable analysis that produced thought-provoking results. Also the study illustrates how geographic research methodology applied to population health research can identify important ecological themes of health risk and provide a starting point to explain the broader implications of the health determinants.

A secondary and unintentional result of the findings is the confirmation that the CRHA appears to provide a proportional amount of services to those communities with the highest needs. While further work is required to relate indicators of health service need to hospital use, the CRHA acute care hospital system, when described at the community level, appears to work equitably and responds effectively to different levels of need. With a few exceptions, the communities with the highest use of hospital care are also the ones with the highest socio-economic risk and appear to be adequately served by the CRHA.

However, the findings indicate large variations in the needs-driven use of acute care hospital resources that raise important policy questions. Clearly, the system provides a high level of care to residents of disadvantaged communities. Given the strong association between socio-economic risk factors, health status and use of hospital resources, significant issues emerge as to whether investment in high use of acute care services represents the most effective approach for improving health or whether alternative solutions are likely to produce greater benefits (MCHPE: 1995).

7.4 Limitations of the Research

The purpose of associative analysis in this study is to introduce a degree of statistical understanding of the relationships between the incidence of specific health risk categories and social factors. In using simple correlations and multivariate statistical methods of analysis, the results of the equations and the correlation coefficients, coefficients of determination and regressions imply an associative relationship in the dependent variable which is usually a ratio measure of incidence of disease or mortality. This methodology inherently imposes its own limitations in addition to some of those that are based on data quality.

Methodological Considerations

Bennet (1991: 344) cautions against the dependence in medical geography on the 'associative occurrence theme' and conclusions based only on statistical relationships between aggregated datasets because they do not provide explanations of causality. Conclusions in medical geography are "*...only supported empirically and probabilistically, and are fraught with the danger of the ecological fallacy. This is often criticized as being a flimsy basis for predicting, whereas a fully causal explanation which may be made in medicine or medical science is forever beyond the reach of medical geography.*" Mayer (1992) concurs by cautioning researchers against the use of standardized, statistical programs as indiscriminate data filters; and both authors object to 'fishing' for associations because *"relationships based solely on correlation are not necessarily meaningful even if found to occur repeatedly"* (Stimson: 1983).

Ultimately though *"... the basis for judging is pragmatic, using pragmatic here in the philosophical sense, of choosing between premises by evaluating their consequences"* (Stimson: 342). As an example of pragmatism in medical geography, Bennet asks the reader to consider the inductive reasoning applied by Dr. Snow to produce his dot map of cholera occurrences in London. At the time the cause of cholera was unknown, but he surmised that the outbreak was related to use of the Broad Street water pump. *"The point is, is that pragmatically, the authorities removed the pump handle and cholera subsided"* (Stimson: 343).

Data Quality

The limitations imposed by the use of the hospital records and the census data for the datasets, may be summarized as problems of incompatibility in areal, scale, temporal units, and the accuracy of the data itself.

Areal Units

The unique capabilities of GIS to re-aggregate data based on geographic relationships is one of its most useful features. However, the GIS data manipulations for this study are accompanied by some degradation in areal accuracy with respect to the precise location of patients. The postal code centroid markers used to identify the theoretical location of hospital patients actually represent a postal walk that is, in reality, a bounded area. When performing a point-in-polygon overlay, the real (invisible) postal code boundaries do not coincide with the community boundaries. Since these postal walks are not community exclusive, there is a relatively small opportunity for error in locating patients assigned to one community who could actually reside in an adjacent one.

Scale Units

Stimson (1983) warns researchers of insufficiently disaggregated data scales to identify areas of concentration. In this study the 1991 census data was available at the EA geography level, which in the GCR has sufficient population concentrations for a valid analysis. Unfortunately, insufficient hospital data at this level resulted in too many empty cells in the hospital-use columns. The solution used in this study was to aggregate the hospital data to larger community levels, and in so doing lose some details on spatial attributes. One possible solution for similar research in the future, but which was not an option for this study, would be to use at least 3 or 4 years of hospital data to ensure enough values in the health categories for a more robust model. This would provide the added benefit of reducing the number of outliers caused by random temporal variations in the individual occurrences within each of the health risk categories.

Temporal References

When searching for causative factors in associative studies, data should be compatible in time and space to avoid spurious relationships (Stimson: 344). The census data used in this study captures the social conditions existing on a single day in 1991. In contrast, the hospital data is a profile of one full year of hospital utilization that occurs four to five years later during March 31, 1995- April 1, 1996.

This four to five-year gap between the 1991 census data and the 1995-96 hospital data caused some anomalous values. The city of Calgary has experienced significant growth in the five year span between 1991 and 1995, particularly in the subdivisions on the periphery of the urban areas. The health data records the hospital stays for residents of these communities who were not residents there during the 1991 census. Country Hills is a good example of a community whose population grew significantly in the interval between the two datasets which resulted in a high observed health risk because of its basis on larger, current populations.

Hospital Data Accuracy

The reliance on hospital data to describe health status is based on several assumptions that may not be warranted. The assumption that data is representative of all patients, regardless of social rank and that diagnosis and treatment is accurate and unbiased, may not necessarily be true.

Representativeness of Hospital Data

Hospital data may be inherently biased towards patients who seek hospital care rather than clinical care or other options for their ailments. In this respect, the low status populations may be over-represented in the hospital data because they have fewer options. Alternatively, high social status groups may be under-represented because they have more health care options outside the mainstream acute care system. Use of private care, by more wealthy populations, that is outside the hospital system or outside the region would result in a decrease from the true values of the high status groups within the health risk categories. Additionally some health risk categories, with high social stigma attached to it such as Alcohol and Drug Abuse, would be severely biased.

Also, length of hospital stays may not be evenly distributed across all social groups. It has already been established in the literature review that there may be biases towards longer stays for some social groups, particularly those with poor social support networks. For instance single people and the elderly may have longer stays in hospital because they are perceived to have fewer social supports to rely on during convalescence (Butler and Morgan: 1977). This would contribute to an over-representation of these groups in the analysis.

Diagnostic Data

The accuracy of diagnostic categories is difficult to verify, particularly for a non-medical specialist. Admission to a hospital facility is classified with a primary MDC or ADRG code that may not allude to other equally important diagnostic information. This problem is compounded by patterns of medical practice and administration that vary widely from one physician or hospital to another. According to Roos and Roos (1994: 246), hospital admission is affected by "politics driven expansion of acute care" which may result in some unnecessary treatments. This could cause an over-representation of some ADRG codes and raise the index value for the associated health risk category.

The problem of a mobile population can further complicate a diagnosis, especially when assessing the social factors correlated to specific distributions of health risk. For example, a person who contracts a disease while in one occupation or while residing in one community may be diagnosed at a much later time, long after they have moved to another occupation or another community. The health risk and social status indicators would then exhibit statistical correlations that are not characteristic of current conditions.

Finally, this study, like most others which correlates disparate datasets that cannot be linked via individual identification criteria (i.e., full name or street address), is weakened by the ecological fallacy. In this study, there is no way to obtain the necessary personal information to create a social status profile for each of the 1995-96 CRHA inpatient records. Therefore, it is impossible to confirm how well the hospital patients in the health risk categories being analyzed actually fit the composite socio-economic characteristics of their communities.

7.5 Further Research

Canadian population health studies that focus on community characteristics and health risk have much to gain from similar, previous studies. In the case of this particular research, the findings of the MCPHE study of Manitoba population health were a major influence on the methodology developed for the study of GCR residents' health risk. Future health related studies and needs assessments of Calgary populations could add value to this research if they are able to overcome some of the limitations discussed herein in addition to the observations which follow.

For future studies on a population-based model using census variables, a smaller number of independent variables is possible with no loss of information. Some of the variables could be reduced by more extensive use of the factor analysis to reduce the dataset prior to the regression while others such as age categories could be combined into a single variable. For instance, instead of having two separate columns for infants and seniors, a single age-dependency ratio could be used to describe the proportion of both age cohorts in the communities.

Improving the model's predictive power could be achieved by incorporating enough health status data to enable a statistically valid analysis at the smallest census geography level. For the GCR study, the existence of a longer duration data set would also have improved the statistical rigour of the findings, particularly for less prevalent MDCs. Additionally, application of the 1996 mid-term census data, not available for this study, would have resulted in an improved temporal correlation of the data.

More importantly, a sophisticated population health model should use several types of health indicator data. A future population health information system for the CRHA could include health status measures such as infant mortality rates, cause-specific mortality rates and other Vital Statistics data to create a much larger health care use database. Also, other types of health care utilization such as hospital day use, physician visits, and private health clinic visits would broaden the selection of health risk categories available for analysis.

Less conventional health determinant indicators such as specific crime statistics (i.e., domestic violence), health surveys (which measure alcohol consumption, tobacco use and exercise), housing conditions, population density, or relative location of industrial sites to residents, could also be used in a broader analysis.

7.6 Further Policy Implications of the Thesis

The techniques outlined in this research stand to benefit community populations and other groups who lack the political and economic will to ensure that their health needs are met. Strategies to implement the methodologies outlined in this thesis could be used to build a Population Health Information system for the CRHA which would provide the basis of health policy decisions and would inform the allocation of health care resources. This would provide two main benefits:

1 It would highlight high-risk communities and population groups and target them for more in-depth health needs analysis, risk assessment and community based solutions.

2 It would form the basis for establishing health policy and principles for the provision of equitable health services.

Policy development is the means by which problem identification, technical solutions, and societal values join to set a course of action. Used judiciously, the knowledge base tempers the excesses of partisan politics and encourages equitable decisions (University of Washington website: 1997) Information gathered from assessment activities are useful for developing local and provincial health policies which reflect local organizational and community values.

7.7 Summary

The usefulness of using census data variables as indicators of health risk has been demonstrated by this GCR based study and confirms the methodology and findings of other Canadian population health research organizations such as the MCPHE. The CRHA already recognizes that poverty is a significant influence on health risk, although there are few health programs that specifically target the poor from a socio-economic perspective. This is not a criticism of the CRHA for there are risks in well-intentioned public policies aimed at alleviating only the harshest health impacts of poverty. In fact, the findings of this study clearly point to the directly overlapping jurisdictions of health and social services (both provincial and federal) ministries as well as related responsibilities in areas such as taxation, housing and education. Allocation of scarce resources to the visible health *effects* of poverty must not be diverted from the search for the root socio-economic causes of poor health. The health of a community is a matter of fact. However, to the extent that it can be forecasted by the enumeration of socio-economic predictors, community health can be improved by pre-emptive strategy.

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APPENDIX A

A Description of the Census-Derived Socio-Economic Characteristics

The following list of census-derived variables are categorized by major themes and include the full variable name as well as its label.

Cultural Characteristics

English first language (ENGLISH)

The proportion of the total population for whom English was the first language learned and which is still understood

Aboriginal first language (ABORIG)

The proportion of the total population for whom a native language was the first language learned and still understood

Demographic Characteristics

Seniors (SENIORS)

Population over 65 years old

Infants (INFANTS)

Population under 4 years old

Adults (ADULTS)

Population 15-65 years old

Elderly dependency ratio (ELDER_DEP)

The population ratio of Seniors / Adults

Social Characteristics

Fertility (FERTILTY)

The ratio of live births for all women 15 years and over

Lone Parent (LONE_PAR)

The ratio of single female parents among a subset of households with children under 15 years old

Mobility (MOVERS)

In-migration in the last five years as a proportion of the total population. Calculated by using the population over 5 years old in the "movers" group of residents who have changed dwellings since the last census 5 years ago

Housing Characteristics

Dwelling Value (DWEL_VALU)

Average value of all owner occupied, non-farm, non-reserve, single detached dwellings

Overpay Mortgage (OVP_MORG)

Percent of owner-occupied households spending more than 30 % of household income on housing costs including utilities, taxes for municipal services, mortgage payments and property taxes

Overpay Rent (OVP_RENT)

Percent of owner-occupied households spending more than 30 % of household income on gross rent including utility costs and cash rent

Low Income Economic Family (LW-INC-F)

Economic families are composed of persons related by blood, marriage or adoption living in the same dwelling

Employment Characteristics

Activity is for the population 15 years and over. Employed and the unemployed together make up the labour force.

Unemployment Rate (UI_RATE)

The unemployment/population ratio shows the employed as a percentage of the population

Participation Rate (PARTI_RATE)

The participation rate shows the labour force as a percentage of the population

Income Characteristics

Average income from all sources, employment, government transfer payments, investments and other sources

Individual Income (IND_INCM)

Average income for all income earners over the age of 15

Family Income (FAM_INCM)

Census families are husband and wife or common law partners, with or without never-married offspring at home. Includes all never-married blood, step or adopted children who live in the dwelling. The value is calculated from the sum of the total family income in a geographic area, divided by the number of census families in the area.

Household Income (HOS_INCM)

Households encompass all persons living together in a single dwelling whether they are related or not. The value is calculated from the sum of the total household income in a geographic area, divided by the number of households in the area.

Education Characteristics

Year of schooling for persons 15 years and over, at two levels secondary schools and university.

Less than Grade 9 (LESS_GR9)

The count of household residents reporting no certificates of any kind; high school, trades, other non-university or university

High School Certificate (HSC_CERT)

The count of household residents reporting a high school certificate as their highest academic attainment

Post Secondary Education (POST_SEC)

The count of household residents reporting a university degree (bachelor, masters or doctorate)

IMAGE EVALUATION
TEST TARGET (QA-3)

150mm

6"

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