Allocating Funds for Healthcare in Manitoba Regional Health Authorities: A First Step–Population-Based Funding

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The Manitoba Centre for Health Policy

The Manitoba Centre for Health Policy (MCHP) is located within the Department of Community Health Sciences, Faculty of Medicine, University of Manitoba. The mission of MCHP is to provide accurate and timely information to healthcare decision-makers, analysts and providers, so they can offer services which are effective and efficient in maintaining and improving the health of Manitobans. Our researchers rely upon the unique Population Health Research Data Repository (Repository) to describe and explain patterns of care and profiles of illness, and to explore other factors that influence health, including income, education, employment and social status. This Repository is unique in terms of its comprehensiveness, degree of integration, and orientation around an anonymized population registry.

Members of MCHP consult extensively with government officials, healthcare administrators, and clinicians to develop a research agenda that is topical and relevant. This strength, along with its rigorous academic standards, enables MCHP to contribute to the health policy process. MCHP undertakes several major research projects, such as this one, every year under contract to Manitoba Health. In addition, our researchers secure external funding by competing for research grants. We are widely published and internationally recognized. Further, our researchers collaborate with a number of highly respected scientists from Canada, the United States and Europe.

We thank the University of Manitoba, Faculty of Medicine, and Health Research Ethics Board for their review of this project. MCHP complies with all legislative acts and regulations governing the protection and use of sensitive information. We implement strict policies and procedures to protect the privacy and security of anonymized data used to produce this report and we keep the provincial Health Information Privacy Committee informed of all work undertaken for Manitoba Health.

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Executive Summary

If there were no disparities in health status between the populations living in Manitoba Regional Health Authorities (RHAs), a simple per capita distribution of healthcare funds would be appropriate; that is, a certain number of dollars would be assigned to each person and regional funding would be calculated simply on the basis of the number of people living in the region. We could even adjust the funding allocation between regional populations to take into account demographic differences that are known to affect health service utilization such as age and male/female distribution. However, this assumes that the people living in every region have equal need for health services, and that funding is only a function of population size and the age-sex makeup of that population. Yet we know that even after controlling for age and sex, the people living in some regions are less healthy than those living in others (Brownell et al., 2003; Fransoo et al., 2005; Martens et al., 2003; Roos et al., 2001)—hence the need to move beyond basing health service funding simply on age, sex and population size.

This report describes a first step in an overall funding allocation methodology for Manitoba Regional Health Authorities. It shows a proportional allocation of funds among RHAs that reflects important characteristics of the population living in each RHA. This funding is for selected health services. These services are: inpatient hospital care and day surgery, personal care homes, and home care. The second (and final) step necessary to establish overall funding for RHAs includes two components: allocating funds for population-based services that are not included in this report (community and mental health services, emergency response and transportation, and hospital-based ambulatory care including outpatient clinics and emergency departments); and allocating funds for non-population-based services—those services that are located in regions but are funded on a geographic or policy basis.

Manitoba Health asked the Manitoba Centre for Health Policy to consider how funds for healthcare would be allocated to Manitoba Regional Health Authorities if the characteristics that are expected to influence need for health services were taken into account. The specific objectives of the project were:

1. To initiate a process that would involve key decision-makers in developing the funding allocation methodology

2. To develop a methodology that would describe the proportion of funds that would be allocated to each Regional Health Authority for inpatient hospital and day surgery care, personal care homes, and home care, if the characteristics of the population were taken into account

3. To describe some of the implementation issues that would need to be considered if the methodology is adopted

There are two key messages in this report—we can describe how funds would be allocated on a proportional basis, but not how many dollars should be allocated to each region, and, in Manitoba, population-based funding allocation is only one component of the overall funding allocation process.

Developing a Population-Based Funding Allocation Methodology – The Process

At the outset of this work, it was decided that the process of developing the methodology would be critical to its success. Therefore, a Working Group composed of representatives from the executive level of Manitoba Regional Health Authorities, representatives from Manitoba Health, and other interested parties were involved in developing a truly "made in Manitoba" funding allocation methodology. The working group for this project was crucial for considering the core issues, including: identifying factors expected to affect need for and use of health services, reviewing and accepting a general approach to funding allocation, and reviewing results and providing important insights that resulted in further refinement of the methodology. The work of this group was supplemented through meetings with the Manitoba Health Senior Executives Committee, which is composed of the Chief Executive Officers of all RHAs and senior Manitoba Health staff, who assisted the research team by raising relevant issues and concerns.

The process of developing the methodology started with reviewing the funding allocation approaches that have been adopted in Canada, and elsewhere around the world. From there, we moved to identifying the types of characteristics or factors that could be expected to influence an individual's need for or use of health services. The list of 30 items included demographic, behavioural, morbidity and mortality, and other indicators. The next step was to think about how these items could be used to develop a funding allocation methodology. Statistical modelling enables the inclusion of a wide variety of factors in examining their effect on health service costs—this was the approach that was adopted.

Using modelling, we were able to identify those characteristics that, on a province-wide basis, were best able to predict health service costs. For inpatient hospital and day surgery care these factors were: age, sex, having co-morbidities, socioeconomic status, dying during the year, distance from community of residence to a major hospital, being a newborn, being a newborn with weight-related risk factors, having a chronic disease, and being hospitalized during the year for an injury. For personal care home ("nursing home") use: age, sex, having co-morbidities, socioeconomic status, dying during the year and marital status were most highly associated with PCH use. Age, sex, having co-morbidities, socioeconomic status, dying during the year, marital status, having a chronic disease, and having a hospital stay during the year were most predictive of home care use.

While we started with 30 possible variables, there were a number of characteristics, particularly behavioural characteristics, that could not be included due to lack of data. Body mass index (BMI) and smoking behaviour, for example, are considered to be important indicators of potential need for healthcare. However, individual-level data are not available and community-level data (e.g., the proportion of the population that has a BMI of 25 or greater, an indicator of being overweight) are incomplete (particularly in northern RHAs) as national health surveys that collect these types of data are not conducted in First Nations communities.

One of the important findings of this work was that community-level socioeconomic status is a better predictor of health services utilization than any of the other community characteristics that were considered: aboriginal population, older population, population density, infant mortality rate, etc. This is valuable information because it indicates that although aboriginal status and infant mortality rates (for example) may be important in determining health services use, socioeconomic status is able to explain more variability in utilization than the other factors.

Data Sources

Data for this study were drawn from the administrative data contained in the Population Health Research Data Repository housed at MCHP. All data used for this study are anonymized. In addition, aggregate census data from Statistics Canada were used for some analyses.

Results

The results of this work are presented in two ways: a user-based approach and a population-based approach. The user-based approach produces estimates based only on those individuals who have used health services in the past, but increases or decreases their utilization to make it similar to Manitobans with similar characteristics. If an individual uses more services than others with similar characteristics, the allocation for that person would be reduced. Conversely, if a person uses fewer services than others with similar characteristics, the allocation would be increased. The population-based approach assumes that there are some individuals who have not used health services, but because of their characteristics, would have been expected to use the services. We do not know why some people do not use health services—access to services (e.g., supply, geography and provider practice patterns), and social norms of health service utilization are possible explanations, as are utilization of healthcare services that are not captured in the data held at MCHP, including, for example, federal personal care homes and alternative or traditional healthcare.

We further look at the user-based approach and the population-based approach according to where people receive their services. We show the regional allocation assuming that each region is self-sufficient and residents receive all of their health services within their home region. Clearly this would have tremendous operational implications—it assumes that every region would have the capacity (particularly for inpatient hospital care and day surgery) to meet all of the needs of residents. We recognize that this is likely not feasible (nor in some cases desirable)[1]. The alternative approach (i.e., where some services are received outside of the home RHA) adopts recent patterns of movement between regions to estimate how, in reality, funding would need to be allocated between regions.

The population-based approach with some services received outside of the region of residence could be considered a target for population-based funding allocation.

Methodology Implementation

The decision to adopt a population-based funding allocation methodology is a policy decision— yet no single approach can be expected to respond fully to a matter as complex as health services funding allocation. It is therefore necessary to acknowledge that population-based funding allocation is a starting point for policy development. It indicates how funds would be allocated if only the characteristics of the population were considered. There are many other factors that will need to be considered before the methodology can be operational, specifically other geographic or policy-driven features (e.g., the location of programs that serve multiple regions) as well as the other components of RHA-funded health services for which data are not available to permit modelling (i.e., hospital-based ambulatory care, community and mental health services, and emergency response and transportation).

It may be helpful to consider a hypothetical example of how this methodology could be implemented, given the additional work that will be needed to make it fully functional. The total funding available for RHA-delivered health services can be envisioned as a combination of population-based, geography/policy-based, unmodelled, and community services (including initiatives to promote good and prevent poor health). This report has only considered the population-based allocation—the actual allocation to a region would be:

Population-based funding + Geographic/Policy-based funding + Unmodelled funding + Community services funding

For this hypothetical example, assume that $3 billion is allocated for RHAs to provide all of the services for which they are responsible. Then, assume that $300 million is identified as being the amount of geographic/policy-based funding, $300 million is the amount for unmodelled services (hospital-based ambulatory care, mental health services and emergency response and transportation), and that 10% of total expenditures ($300 million) is committed to community services including health promotion and illness prevention. This would mean that $2.1 billion would be the amount that would be allocated strictly according to population characteristics. For Assiniboine

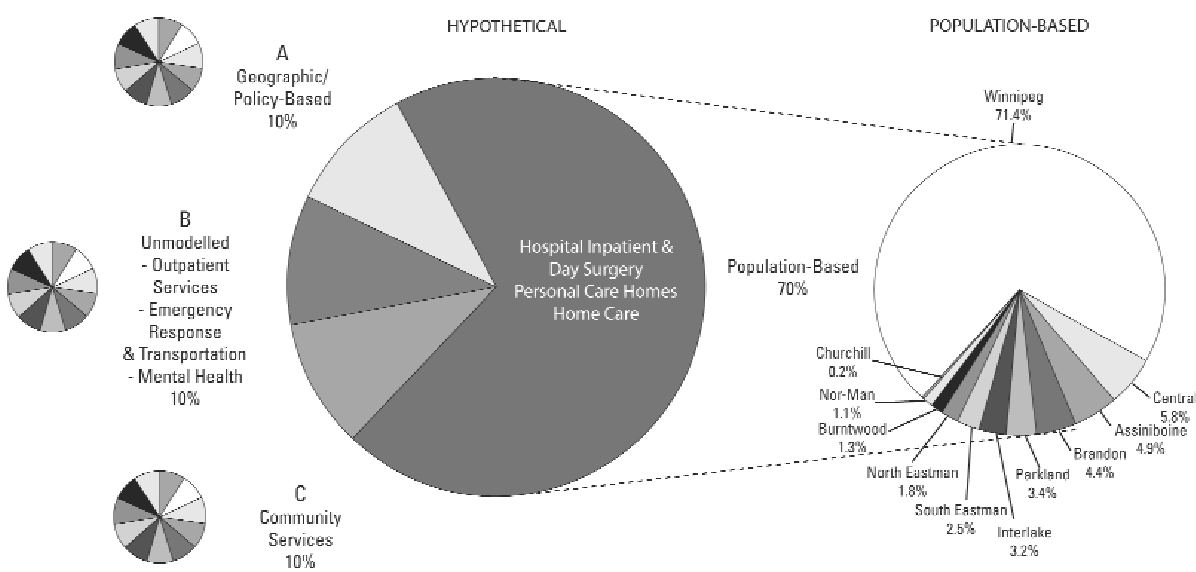
[1] This approach would also be appropriate if regions purchased services for their residents from other regions. This would produce a heavy administrative burden.

RHA (this region was selected only because it is first in the alphabetical list of regions), this would mean that they would receive the following allocation according to one of the scenarios that are described:

Population-based funding	\$2.1 billion x 4.88% = \$102,480,000
+ Geographic/Policy-based funding	\$A
+ Unmodelled funding	\$B
+ Community services funding	\$C
= Total Funding	\$102,480,000 + \$A + \$B + \$C

Total funding for Assiniboine RHA would be the total of the four funding categories—the population-based proportion is taken from this report, the unmodelled funding will need to be based on historical and/or other funding allocation mechanisms negotiated between RHAs and Manitoba Health, the geographic/policy-based funding will need to be explicitly identified, and community services funding will need to be considered in the context of the health status of the population (the Community Health Assessments and other MCHP reports can inform this process). Figure 1 provides a graphic example of these four funding allocation components. The pie chart on the right is the population-based allocation—the allocations for the other components would need to be developed if the approach described here is accepted.

Figure 1. Allocation of Funding to Regional Health Authorities



From the beginning, we were clear about what this work would not do—it would not describe how much funding should be allocated to health services. Rather, what is described is how funding would be proportionally allocated to regions for selected services if the characteristics of the people in the region were considered. As a result, the number of dollars that would be distributed to each region under this methodology is not described here, rather we show "how to slice the pie"—the size of the pie is a decision that is made through the government decision-making process.

In considering any funding allocation methodology, it is necessary to understand that "things change." We have proposed a starting point for funding allocation that is based on recent demographic characteristics and utilization patterns. Over time the make-up of populations in regions will change, as will how we use health services (due to changing practice patterns and/or technology). While the methodology that is described here can be expected to remain stable over time, the data it uses should be updated on a regular basis.

Finally, it is important to recognize that healthcare is only one of the factors that affect the health of the population. The methodology that is presented here proposes the way in which funds would be allocated for healthcare if the characteristics of the population were considered. MCHP has done considerable work in describing the health status of populations (Brownell et al., 2003; Fransoo et al., 2005; Lix et al., 2005; Martens et al., 2003; Martens et al., 2004; Roos et al., 2001) and this information can be used to further inform the policy development process. While it is important and necessary to have health services available when they are needed, it is equally important to continue to work towards improving the health of Manitobans through illness prevention activities and health promotion.

1.0 INTRODUCTION

Regional Health Authorities (RHAs) in Manitoba are responsible for providing most health services to residents of the province. In 2004/05, RHAs received over $2.3 billion in funding to provide hospital care, home care, personal care home services, community and mental health services, and emergency response and transport (Manitoba Health and Healthy Living, 2006).

Research conducted by the Manitoba Centre for Health Policy (MCHP) has shown that the health status of people living in different areas of the province varies, with the population living in some regions being healthier (on average) and other populations being less healthy (Brownell et al., 2003; Fransoo et al., 2005; Martens et al., 2003; Roos et al., 2001). One would expect that a less healthy population would require more health services than a healthy one. But this is not necessarily how the healthcare system has evolved. There are hospitals in the province that have low occupancy or provide long-term care (rather than acute care), and there may be locations where individuals are admitted to a personal care home (PCH) when home care would be as effective and more efficient. Because of this, Manitoba Health asked MCHP to investigate whether it would be possible to develop a funding allocation methodology that would take into account the relative need for health services by the populations of RHAs. The purpose of this report is to describe the process of developing such a methodology, and to present the findings that result from applying the methodology.

While this research makes an important contribution to policy development in Manitoba, it is important to recognize what this methodology does not do—it does not recommend how much should be spent on health services to meet the needs of Manitobans. Rather, it describes how health service dollars would be allocated among regions if the characteristics of the population were used as the basis of allocation. Further, this methodology can be seen as a starting point for an overall approach to RHA funding. It describes an allocation for services that are population-based and for which data for modelling are available. An overall approach must also include funding for services that were not modelled, as well as services that are not based on the characteristics of people living in a region (i.e., geographically and policy-based funding).

1.1 BACKGROUND

1.1.1 Funding Allocation Methods

The allocation of funds by a central government to smaller operational units is a common policy function in a publicly-funded healthcare systems. The need to allocate funds for services on a geographical basis is not unique to health—many other government functions involve this process, for example federal transfer payments to provinces, and provincial education department transfers to school divisions. In health systems where services are publicly-funded (as is the case in Canada and many other countries in the world), four approaches have been adopted for making such an allocation: historical experience combined with budgeting and planning, capitation, risk adjustment and modelling.

A purely historical approach assumes that the existing pattern of funding is appropriate, and changes in funding levels would change only in response to the availability of funds or other policy-based decisions. Typically (although not always), a planning and budgeting process is implemented to justify funding levels, and to build accountability into the system.

Capitation is a general term that refers to a per capita funding allocation for health services. Both risk adjustment and modelling could be considered forms of capitation as they too allocate funds according to population size, but for the purposes of this discussion we will distinguish between the three allocation methods by looking at the mechanisms that are used for assigning per capita values. In the current context, a pure capitation approach simply assigns a fixed per capita amount that will be paid to providers (in this case, RHAs) for health services. The same amount would be assigned to each resident, and the size of the allocation would simply be a function of the size of the population. This approach fails to recognize that not all populations are the same—there are many characteristics that would be expected to affect utilization of health services. The two key characteristics affecting health service utilization are age and sex, with populations with a higher proportion of females using, on average, more health services, and populations with a larger proportion of older people also using, on average, more health services. Other factors may also affect need for health services, such as socioeconomic status (SES). Low SES associated with poor health and greater healthcare need. Both British Columbia and Alberta have developed capitation approaches that recognize that age, sex and socioeconomic status influence health service utilization (Alberta Health and Wellness, 2005; British Columbia Ministry of Health Services, 2002). Their funding allocation method is based on assigning a capitated amount to each of a large number of age-sex-SES categories, and then providing funds to regions based on the number of people in each of these categories.

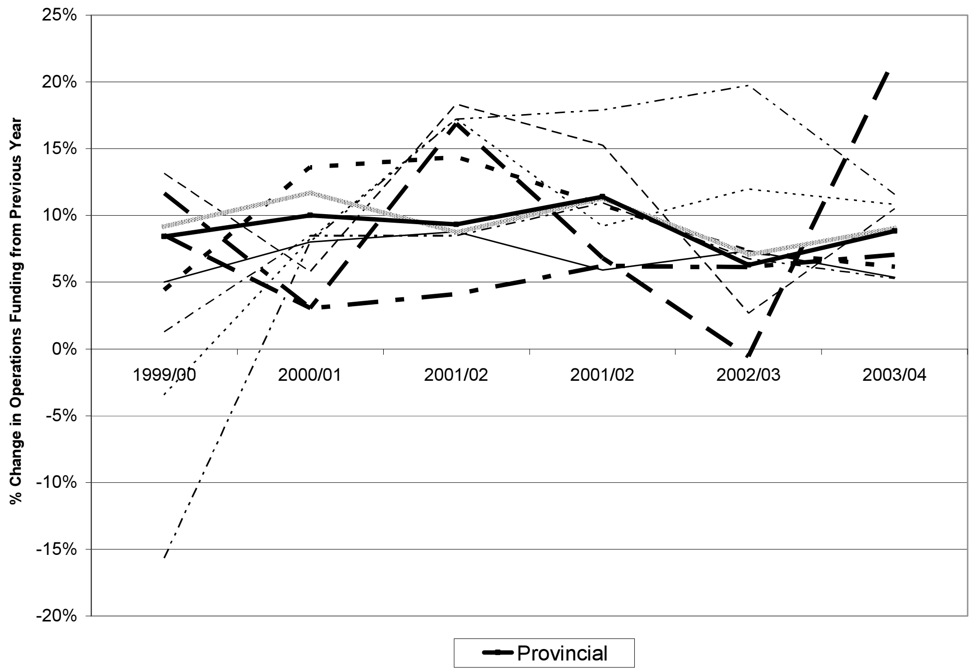
Not everyone in the same age-sex-SES category uses the same amount of health services. A risk adjustment approach takes into account the level of health services used by individuals, and predicts future health services utilization based on past utilization. This approach is used extensively by the insurance industry in the USA for setting healthcare premiums, and is typically applied to establish differential premiums for employee groups and/or geographic areas. Diagnoses, treatments and personal characteristics are used to predict the cost of health services. Unfortunately, this approach is based entirely on past utilization, and would therefore underestimate need in those areas that have been underserved in the past to the point where some people who should have been treated may have done without adequate health services. Another disadvantage of this approach is that it introduces a perverse incentive to maintain high levels of utilization, regardless of the need for services.

Like capitation and risk adjustment, modelling uses past utilization as a means of estimating future healthcare expenditures. However, the statistical approaches used in modelling permit both the testing of a large number of possible variables that may predict utilization, and a weighting of these variables to allow more precise estimates of future cost for individuals. There are two major stages in modelling—the model specification and the development of estimates. The specification stage involves the testing of theoretically relevant variables to see if they actually predict differences in utilization. Once the variables that will be used in the model are selected (i.e., the characteristics that are both theoretically relevant and have been found to predict the outcome), weights for each of the variables are developed. These weights may then be used to assign expected expenditures to individuals in a population, taking into account their personal and community characteristics. This approach allows us to estimate expected need for services even in those regions that have not had adequate services in the past.

1.1.2 Manitoba's Current Methods

Like many other jurisdictions, funding for health services is primarily allocated to Manitoba's eleven RHAs on an historical basis. Prior to 1997, when the RHAs were created, the province provided funds directly to acute and long-term care facilities, and to health programs that were offered throughout the province. Since regionalization, funds have been allocated to regions, and regions have responsibility for delivering many health services. A regional planning process has been implemented whereby regions develop plans and budgets which are reviewed by the province. Regions typically include, as part of the budget justification, information on the characteristics of the population of the region, and how these characteristics may be expected to drive need for health services. In spite of this planning process it is extremely difficult to adopt an evidence-informed decision-making process to differentially allocate funds when there is demonstrable need for health services in all regions. Figure 2 shows the annual change in operational funding for acute care, long-term care and home care services (Manitoba Health, 2000; Manitoba Health, 2001; Manitoba Health, 2002; Manitoba Health, 2003; Manitoba Health, 2004; Manitoba Health, 2005). Each line represents one of the Manitoba regions, with the thick line showing provincial expenditures. This figure is not intended to make comparisons between regions but rather to show the variability that has occurred in operational funding to regions in the recent past. Little systematic reallocation of funds from one region to another can be seen, and changes in funding have resulted from implementation of new programs (which are presumably created by policy decisions in response to demonstrated need and/or political influences), or changes in accounting practices.

Figure 2. Annual Per Cent Change in Funding to Regional Health Authorities, 1998/99 to 2003/04



Source: Manitoba Centre for Health Policy, 2007

1.2 WHAT IS "POPULATION-BASED FUNDING ALLOCATION" FOR MANITOBA RHAS AND WHY WOULD WE WANT IT?

1.2.1 Principles

MCHP was asked by Manitoba Health to answer the question "How would funding be allocated if it were based upon the [characteristics[2]] of the population?" Therefore, the principle upon which our work is based is that populations that are less healthy would receive a proportionally greater allocation than would a population that is considered "healthier." This is often referred to as "equity." Much is written about equity, and from a variety of disciplinary perspectives. For our work, we have adopted a definition offered by Culyer (2001): "Equity in health care requires that patients who are alike in relevant respects be treated in like fashion and that patients who are unlike in relevant respects be treated in appropriately unlike fashion." This can be contrasted with "equality" where everyone receives the same treatment (or funding), regardless of their characteristics. Culyer describes two types of equity—horizontal equity and vertical equity. Providing similar funding to like people is horizontal equity. Vertical equity involves providing different funding to people with different characteristics, in proportion to the size of the differences. According to Culyer, "supposing that 'need' is selected as the only relevant factor, then the two principles would imply that like

[2] In its original specification of this report, Manitoba Health used the word "need" rather than "characteristics." For reasons discussed below, this term has been changed.

needs should receive like attention and resources (horizontal equity) and that greater needs should receive greater attention and resources (vertical equity)."

1.2.2 Some Thoughts on "Need"

Manitoba Health had originally asked MCHP to develop a "needs-based" funding allocation methodology. One of the key issues in developing a needs-based approach is defining the concept of "need." Figuratively, one can think of true need in this way:

True need = Current use – Excess use + Unmet need

The obvious challenge in determining "true need" is measuring two of the components that contribute to it. We know about current use—the Population Health Research Data Repository (the "Repository") held at MCHP contains anonymized records of most encounters that Manitobans have with the healthcare system. However, we know that we see variability in utilization that cannot be explained by differences in individual characteristics. Two individuals with identical personal characteristics may have very different health service utilization patterns. A variety of factors could contribute to this, including access to services (e.g., supply, geography and provider practice patterns), and social norms of health service utilization. It is entirely possible that some people are receiving more healthcare than they truly need—this would be considered "excess use." Similarly, it is entirely possible that some people are receiving less care than they truly need—this is "unmet need." Further complicating this is that the "right" amount of care for individuals cannot be defined, making it impossible to judge if someone is getting too much care or not enough.

Based on what we know about variation in utilization, we assume that excess use and unmet need may be present in the province. But we also recognize that government policy determines the funds that are available for health services, and that, on a province-wide basis, the funding level reflects what we, as a society, have determined to be "appropriate" use. Rather than attempting to determine whether policy-makers have made the correct decision about the total level of funding, which will, after all, be decided through the political process, we have focussed on how the available funding could be distributed among regions if population characteristics were the major determinant. If some populations are receiving less healthcare than the average, after adjusting for their characteristics, they should be getting more. If some are receiving more than average, they should get less. Consequently, we have chosen not to refer to this work as "needs-based" and instead use the term "population-based" in recognition of the fact that we do not operationalize the concept of "need" in this work.

1.2.3 What Is Population-Based Funding Allocation and How Does It Differ From Needs-Based Funding Allocation?

A population-based funding allocation approach takes into account characteristics known to affect health service utilization as a basis for determining the proportional level of funding for each region. Population-based methods are widely used for funding allocation—in Canada, British Columbia (British Columbia Ministry of Health Services, 2002) and Alberta (Alberta Health and Wellness, 2005) approach allocation in this way; it is used in the UK (FID Resource Allocation, 2003), Sweden (Andersson et al., 2000) and many other countries (Rice and Smith, 2001). Each setting utilizes a somewhat different approach, but all are designed to attempt to achieve equity in funding allocation. While the term "needs-based" is sometimes incorporated into the title or description of the methodology (for example British Columbia refers to their approach as a "Population Needs Based Funding Allocation Methodology" (British Columbia Ministry of Health Services, 2002)), no jurisdiction has been able to overcome the issues of defining need that were described above in order to implement a truly needs-based approach to funding.

The approach that has been adopted here is a reasonable alternative to needs-based funding—it utilizes what we know about individuals and their communities, and reallocates funds so that similar individuals receive the same amount of funding.

1.3 ISSUES IN DEVELOPING A POPULATION-BASED FUNDING ALLOCATION METHODOLOGY

1.3.1 Alternative Approaches Can Be Used

When this work was initiated, it was recognized that there are a wide variety of approaches to funding allocation that are in place in Canada and around the world. Four approaches have been described here, but there may be others. The issue of concern is that the method that is selected will affect the end result. Recognizing that any particular reallocation process will involve some regions receiving increased funding while others will see their share reduced, this was a significant concern for the investigators on this project. As will be described later in this report, a Working Group composed of representatives of Manitoba RHAs and Manitoba Health was intimately involved in selecting the approach that would be taken. While alternative methods could have been used, we believe that the approach that has been adopted is among the most rigorous and fair of any in the world. Indeed, alternative methods that were considered (in particular age-sex-SES-based capitation) were not found to be as precise in estimating health services use.

However, no single approach can be expected to respond fully to a matter as complex as health services funding allocation. It is therefore necessary to acknowledge that population-based funding allocation is a starting point for policy development. It indicates how funds would be allocated if only the characteristics of the population were considered. Later in this report we will describe several limitations of the methodology that will need to be addressed through alternative means.

1.4 SUMMARY

In this section we have provided an introduction to why population-based funding is important for Manitobans and is a relevant policy approach for consideration by Manitoba Health. We have established the principles that were adopted in developing the methodology, and have introduced some of the issues that needed to be considered before setting out to actually begin working on the methodology.

2.0 METHODS

For the reasons described in the previous section, we are proposing that a "modelling" approach be adopted for population-based funding allocation for health services in Manitoba. The following sections provide a brief description of modelling, and discuss the process that was used in developing the allocations that are described later. Additional details on the methods are found in the Appendix A.

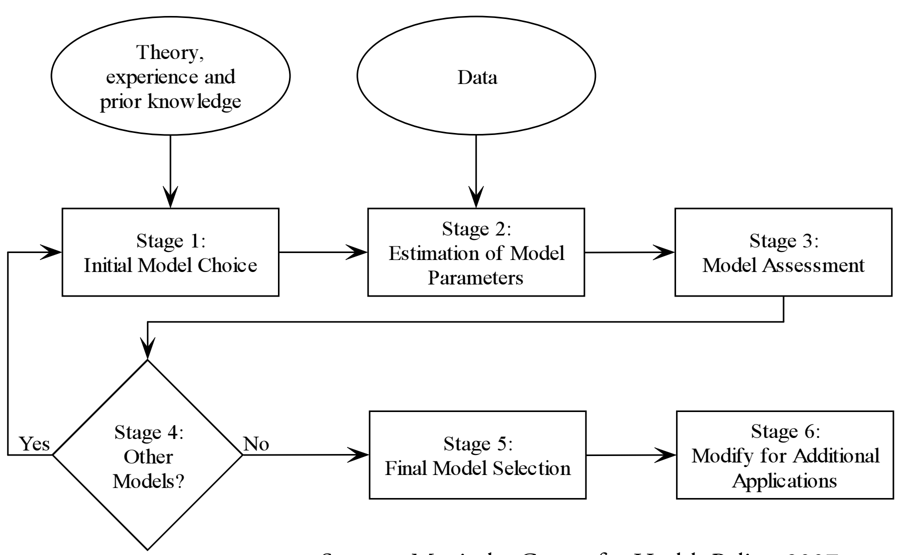
2.1 WHAT IS MODELLING AND HOW DOES IT WORK?

In developing this population-based funding allocation methodology we have used statistical techniques called "modelling." While the process of developing models is complex, the general principles are those of accuracy and parsimony. That is, a good model will accurately predict an outcome (in our case healthcare costs) using as few predictor variables as possible.

A mathematical model is a simplified description of the behaviour of a system based on theory, the knowledge and experience of the modeller, and historical data. The system is usually described by a set of variables and a set of equations that establish relationships between the variables. Techniques for mathematical modelling include regression analysis, decision theory, and simulation models to mention a few.

Mathematical modelling is a process and can be illustrated with the following diagram:

Figure 3. The Modelling Process



Source: Manitoba Centre for Health Policy, 2007

Stage 1: Based upon existing theory, the nature of available data and the modeller's prior knowledge and experience of the system, an initial model or models are selected. For example, based on what we know about costs of hospital care, we would expect to use a special type of distribution for modelling (a lognormal or gamma distribution) to capture the skewed nature of the data that results from a large number of people having relatively low costs and a small number of people having very high costs. A model is made up of a dependent variable and one or more predictor or independent variables/covariates. It is usually preferable to use as much *a priori* information as possible to make the model more accurate. The more experienced the modeller is, the easier it is to build a model that accurately describes the historical data.

Stage 2: At this stage, the available data are used to estimate the model parameters that may represent the unknown population quantities such as the means and variances. Methods of parameter estimation include maximum likelihood, moments matching, and percentile matching, among others.

Stage 3: The adequacy of the model developed in stage 2 is assessed to ensure that model is a good fit to the data. This is done by the use of statistical tests such as the chi-squared goodness-of-fit test, the proportion of variance explained test, the likelihood ratio tests, and a host of other tests.

Stage 4: If stage 3 reveals that the current working model is inadequate, other possible models are considered and stages 1 to 3 are repeated. Otherwise, if this stage reveals that the existing model is adequate, then the process moves to the next stage.

Stage 5: A final model is selected at this stage. This is done by comparing all models considered in stages 1 through 4 using statistical tests (formal and informal). The principle of parsimony should also be taken into account at this stage. This principle states that unless there is a very good reason to do otherwise, a more parsimonious model (model with smaller number of parameters) should be selected. A parameter may be removed from a model for two reasons: it is not associated with the outcome, or, it is associated but other parameters have better explanatory power. All other models that were considered but not ultimately selected are retained for sensitivity analyses.

Stage 6: One of the objectives of building a mathematical model could be to use such a model or models for prediction or projection. At this stage, the selected model may be adapted for such applications[3].

[3] In this particular project, we have not utilized Step 6, but the results of the preceding steps could be used as a basis for future research.

The above six stages will need to be repeated in order to improve the model if new data become available or if the environment changes.

2.2 How We Developed our Models

The models used in this work were developed in an iterative manner, as is described above. The advice of a Working Group was solicited at the initial model choice stage, and the research team worked through the additional stages until the final models were selected.

2.2.1 The Working Group Process

MCHP typically invites a number of individuals from beyond the MCHP research team to be part of a "Working Group" for a project. The role of the Working Group is to provide advice, guidance and "real-world" insight to investigators. For this project, the Working Group was an integral part of the process of developing the funding allocation methodology.

The Working Group was composed of five Executive Officers of Manitoba RHAs, five individuals from Manitoba Health, one person from Manitoba Education, Citizenship and Youth, one person from Manitoba Family Services and Housing, and one person from the Centre for Aboriginal Health Research. Although not all members attended all meetings, each member had an opportunity to participate in the process of developing the methodology.

The process of developing the methodology was as follows:

1. Review funding allocation methodologies currently being used within other jurisdictions in Canada and internationally.
2. Develop a list of factors that would be expected to affect the need for or use of health services.
3. Establish priorities within the list.
4. Develop statistical models for each of the health services with a goal to maximize the ability of the model to describe health service expenditure/utilization of individuals, while minimizing data requirements.
5. Using these models, specify the expected proportional use of provincial health services resources by each of the eleven RHAs. The expected proportional use will be a function of the size of the population, and the characteristics of the individuals and communities in each region.

The Working Group was involved at each of the stages of the process: they reviewed methodologies in place elsewhere; they became familiar with the principles of modelling and accepted the approach as an appropriate means of developing the methodology; they developed, in collaboration with the MCHP research team, a list of variables to be considered in the models; they reviewed the results of the models, and provided extensive guidance and insight into issues that arose during the analysis stages. They also contributed to recognizing the limitations of the methodology, and suggesting alternative means of addressing the limitations. Over the course of the project, the Working Group met five times.

For this project, the investigators also relied on the advice of the Health Senior Executives, a committee that is composed of the Chief Executive Officers of all RHAs, senior Manitoba Health staff and a representative of the umbrella group, the Regional Health Authorities of Manitoba. At three meetings with the group, the methodology and results were presented, and feedback was solicited. This feedback was subsequently considered by the investigators and made important contributions to the completed methodology.

From the outset of this project, the investigators were committed to developing a methodology that was transparent and acceptable to those who may have a role in implementing it. Through the involvement of these groups, we endeavoured both to make use of their expertise and to develop a collaborative relationship that would result in a methodology that is useful for Manitoba RHAs.

2.2.2 Identifying Independent Variables/Covariates

One of the first tasks undertaken by the Working Group was identifying those factors or characteristics that would be expected to affect need for or use of health services. This involved a "brainstorming" exercise where we started by reviewing the factors that have been considered by others to be associated with health services utilization, and then developing a list of those factors that may cause some Manitobans to need more health services than others. The list included personal characteristics (e.g., age, sex), individual health characteristics (e.g., presence of a chronic condition), individual social determinants of health (e.g., education, employment), community characteristics (e.g., air quality), and community health characteristics (e.g., premature mortality rate). In Table 1 we have classified these thirty characteristics as demographic, behavioural, morbidity and mortality, and other.

It is important to note that because this was a brainstorming exercise, there are several factors that are correlated (e.g., premature mortality rate and life expectancy), or that are redundant (e.g., both diabetes and chronic conditions are included in the list—diabetes is one type of chronic condition). Once the complete list was developed, the Working Group then identified the "Top 5" factors that were expected to drive the need for health services. These were: age, sex, socioeconomic status, chronic health conditions, and Aboriginal status.

Table 1: Factors expected to influence the need for or use of health services, as identified by the project working group

Demographics	Behavioural Characteristics	Morbidity and Mortality	Other
• Age • Sex • Education • Birth rate • Employment • Socioeconomic status[1] • Aboriginal status • Social allowance status • Genetic predisposition Geography/remoteness • Living in a First Nations community[2]	• Smoking • Physical activity • Seat belt use • Diet	• Premature mortality rate[3] • Injury • Life expectancy • Infant mortality • At-risk birth weight • Mental health • Chronic conditions • Cancer • Diabetes • Hypertension • Sexually transmitted diseases	• Self-rated health • Disability • Environment (e.g., air and water quality) • Housing

[1] In this report, socioeconomic status is measured using the Socio-Economic Factor Index (SEFI) (see Glossary)
[2] This includes both Aboriginal and non-Aboriginal people living in First Nations Communities
[3] The rate of death before the age of 75

Source: Manitoba Centre for Health Policy, 2007

The Top 5 factors became the initial model that was tested. Subsequent models were developed using both factors that were identified by the Working Group and additional items that were proposed by the investigators (e.g., marital status was a personal characteristic that was not proposed by the Working Group but the investigators considered it a potentially important predictor of home care utilization).

One of the important limitations of the models is lack of data that can be used to measure certain characteristics. For example, we know that genetics can have an important influence on health status, and air and water quality can clearly affect health, but data are not available to permit these characteristics to be used in modelling. We also do not have individual level data for many of the characteristics. A reliable indicator of individual Aboriginal status was not available for this study, and individual behavioural and socioeconomic status characteristics are not available. As a result, for several characteristics, community level measures were tested. For Aboriginal status, Statistics Canada data were used to determine the proportion of individuals who reported Aboriginal descent or status. Likewise, a community measure of socioeconomic status was used. Behavioural characteristics (e.g., smoking, seat belt use) were considered to be very important contributors to need for health services. The only source of these data is national surveys such as the National Population Health Survey and the Canadian Community Health Survey. While these surveys include questions relevant to measuring population-based characteristics (e.g., proportion of the population with a body mass index of 25 or greater), they are not administered in First Nations communities. The investigators, in consultation with the Working Group, therefore decided that these data could not be used, given the acknowledged importance of considering the health status of Aboriginal people in Manitoba. Using the rates developed from available data would be misleading for RHAs that include large proportions of people living in First Nations communities. For example, nearly 50% of the population of Burntwood lives in a First Nation community.

A large number of variables were tested for each of the models. Table 2 shows all of the variables that were considered for inclusion in the models. The variables that were ultimately included in the final models are indicated by a dot. Those that were tested but were not part of the final model are indicated with a T (for "tested"). Details on the definitions of these variables are included in the Glossary.

Table 2: Predictor variables considered for each model

	Hospital Inpatient Care		Personal Care Home		Home Care	
	Individual	Community	Individual	Community	Individual	Community
Demographic Characteristics						
Aboriginal – percent of the population of aboriginal origin		T				
Aboriginal – percent of the population self-identified as aboriginal		T				
Age	•		•		•	
Age – proportion of the population age 65+		T				T
Age – proportion of the population age 75+		T				T
Distance to a major hospital	•					
Marital status			•		•	
Newborn	•					
Population density		T				
Population size		T				
Socioeconomic Status (SEFI)		•		•		•
Sex	•		•		•	
Morbidity/Mortality Characteristics						
At risk newborn	•	T				
Chronic disease	•				•	
Comorbidities	•		•		•	
Death	•		•		•	
Home care recipient in fiscal year	T					
Admitted to hospital in fiscal year					T	
Discharged from hospital in fiscal year					T	T
Hospital days in fiscal year					•	
Infant mortality rate		T				
Injury hospitalization	•	T				
Personal Care Home resident in fiscal year	T					
Panelled for Personal Care Home in fiscal year	T					
Potential years of life lost (PYLL)		T				
Premature mortality rate (PMR)		T*				

* Using premature mortality rate rather than the indicator of socioeconomic status (SEFI) produces similar results.

Source: Manitoba Centre for Health Policy, 2007

For the final models, the above independent variables were entered in the models as:

- Age (continuous variable)
- Sex (binary variable – Male/Female)
- Chronic disease (binary variable – Yes/No)
- Newborn separation abstract (binary variable – Yes/No)
- Comorbidity (continuous variable)
- Injury hospitalization (binary variable – Yes/No)
- At risk newborn (binary variable – Yes/No)
- Socioeconomic status (continuous variable)
- Distance to hospital (categorical variable)
- Marital status (binary variable – Married/Not Married)
- Death in the fiscal year (binary variable – Yes/No)
- Hospital days (continuous variable)

2.2.3 Identifying Dependent Variables

The goal of this research is to describe a methodology that may be used to allocate funds for health services. Therefore, healthcare cost is the outcome of interest. For inpatient and day surgery cases, we are able to assign costs to individuals by utilizing case-mix costing methods[4]. But for care received in a PCH, we have no measure of actual cost although we do know the level of care a person is receiving (each person who resides in a PCH is assigned to one of four levels of care representing the amount of nursing care they require based on their needs). These levels of care can be used to calculate "weighted days of care" that approximate the relative cost of care. For home care, data are not available to determine either the intensity or specific duration of care. We know the length of time a person is a registered recipient of home care, but we do not know the type of services that are being received (e.g., homemaker services, rehabilitation, nursing care), or the frequency of the services for an individual. As a result, the measure of home care service utilization that was adopted was the number of days a person has an open case file during a fiscal year.

We had hoped to include community and mental health services, emergency response and transportation, and hospital-based outpatient services (e.g., day clinics, emergency departments) in this analysis, but no data on the individuals receiving these services, or the costs associated with the services they receive, are collected on a province-wide basis. Roos (1999) has described two key aspects of a population-based data system as:

[4] For a description of case-mix costing see Finlayson et al., 1999 or Jacobs et al., 1999 (Finlayson et al., 1999; Jacobs et al., 1999). Note that when an individual is hospitalized in a region other than their own and then returns to a hospital in their home region to recuperate or for rehabilitation, the cost for each hospital stay is reported within the region in which the person is hospitalized.

1) A complete population-wide enumeration of encounters (of service delivery) is essential. A core set of data elements must be collected using the same definitions, province-wide.
2) Each encounter must identify the individual to whom service is provided and be linkable to the individual's area of residence. This ensures the service data can be tied to a specific population in order that counts of those receiving services as well as those not receiving services can be identified.

Population-based data are not available for community and mental health services, emergency response and transportation and hospital-based outpatient services and we are therefore unable to model utilization of these components of the healthcare system.

The dependent variables used in the modelling are summarized in Table 3. These values were determined for each individual who used these services during the three-year period from April 1, 2001 through March 31, 2004, regardless of where in Manitoba they received the service. The annual cost of hospital care, annual weighted days of PCH residence and/or days of an open home care file were summed across this three-year period to provide the dependent variable(s) for each person. Details on the definitions of these variables are included in the Glossary.

Table 3: Dependent variables

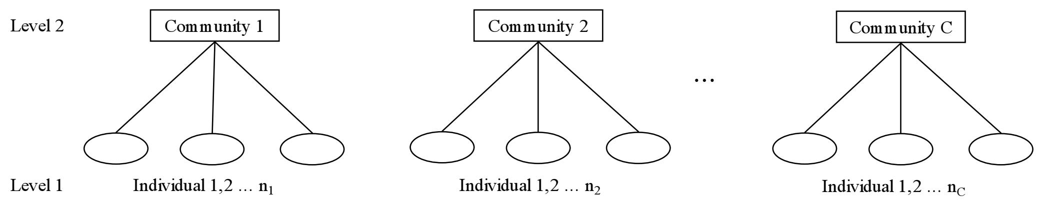
Model	Dependent Variable
Inpatient hospital care/day surgery	Annual cost (assigned through case-mix costing)
Personal care home	Days in the fiscal year, weighted by level of care
Home care	Days in the fiscal year with an open case file

Source: Manitoba Centre for Health Policy, 2007

2.3 UNIT OF ANALYSIS AND TIME FRAME

The individual and community characteristics expected to affect health service utilization that are described above naturally lend themselves to a two-level hierarchy of data structures that can be shown as:

Figure 4. Hierarchical Data Structure



Source: Manitoba Centre for Health Policy, 2007

Where Level 1 is the individual and Level 2 is the communities in which individuals live and the characteristics of those communities.

Thus, the unit of analysis used in this study is individuals nested within community areas. By individuals we mean each Manitoba resident, that is, each person who was residing in Manitoba and who used one of the services (inpatient hospital care, day surgery, home care, PCH) during the study period. "Communities" in this study are the 25 Winnipeg neighbourhood resource networks and the 51 non-Winnipeg districts. In the language of multi-level analysis, Level 1 represents individuals and Level 2 the community areas (see figure above).

The time period for this study spans from April 1, 2001 to March 31, 2004.

2.4 Modelling Inpatient and Day Surgery Hospital Costs of Care, Days of Home Care, and Weighted Days of PCH Care

Hierarchical generalized linear models (HGLM) are used to model hierarchical data structures in which the distribution of the dependent variables is not normal (Raudenbush and Bryk, 2002; Snijders and Bosker, 1999). HGLM is an extension of hierarchical linear models (HLM). One of the advantages of the techniques of both HLM and HGLM over the traditional ordinary least squares method is that they allow for the simultaneous modelling of both the individual and community level variables.

A special case of HGLM known as the random intercept models was used in modelling the costs incurred by individuals for inpatient care and day surgery, the total number of days of open home care file, and the total weighted days of care for PCH. By using the random intercept model, we only allowed the Level 2 (community) intercept to vary. In other words, instead of allowing all individuals to have the same mean cost (for example) irrespective of which community they live, we allow their means to differ from community to community.

The gamma distribution was used in modelling inpatient and day surgery costs of individuals. This enabled us to obtain the predicted values in their untransformed scale and thereby avoid the drawbacks inherent in modelling the log-transformed cost (Blough and Ramsey, 2000; Briggs and Gray, 1998; Manning and Mullahy, 2001). The number of days of open home care cases and the weighted days of care for PCH are modelled as count data. Count data are best modelled using the negative binomial distribution in order to avoid the over-dispersion (i.e., variance being greater than the mean) that would result from the use of the Poisson distribution. The PCH model only includes residents who are age 70 and over as the majority of the population in PCHs is in this age group.

The Level 1 variables in the final model for the cost of inpatient care and day surgeries are: age, sex, chronic disease, death record, newborn separation abstract, comorbidity, injury hospitalization, at risk newborn and distance to hospital. For the PCH model, the Level 1 variables are: age, sex, marital status, death record and comorbidity. Home care model has the following Level 1 variables: age, sex, death record, chronic disease, hospital days, marital status and comorbidity (see Table 2).

The only Level 2 variable included in all the models is socioeconomic status which was measured using the Socio-Economic Factor Index (SEFI). Premature mortality (PMR) which is another Level 2 variable was also tested in a separate model because it is highly correlated with SEFI. The results of models with SEFI and PMR are very similar. The other Level 2 variables (see Table 2) that were tested but not used were not included in the models because their proportion of variation explained was lower than SEFI or PMR.[5]

All final models were assessed for goodness of fit using techniques described more fully in Appendix A.1.

2.5 CALCULATING PROPORTIONAL DISTRIBUTION OF FUNDING

After the modelling was completed, two adjustments were made to recognize the realities of health service utilization that cannot be reflected through the modelling approach that was adopted. Further information on these adjustments is provided in Appendix A.2.

Hospitals are widely distributed throughout the province, but all services cannot be provided in all facilities. For example, many surgical procedures are performed only in larger hospitals, and the only tertiary care facilities are located in Winnipeg. Consequently, if a person needs a service that is

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[5] The determination of the proportional reduction in variance was done by modelling the natural logarithm of costs using SAS® PROC MIXED.

not available in their home region, they will need to receive the service in another region. However, the funding allocation methodology considers the characteristics of residents of each region, and attributes funds to the RHA based on those characteristics.

Specifically, adjustments were made to recognize that not all hospital services are received in a resident's home region. One way of dealing with this fact would be to put in place accounting systems allowing regions to transfer funds to pay for "their" residents when care is received outside the home RHA. This, however, would be both costly and time-consuming. Instead, we adjusted regional allocations to reflect where individuals have historically received care.

To adjust for the reality of people receiving hospital services in regions other than their home region, we utilized three years of historical data to determine the patterns of movement between regions. Using these data, the proportion of total inpatient and day surgery costs that were incurred by residents of one region in another region were "moved" from the home region to the region in which the service was actually received. The net result of this was that the modelled allocation for many regions went down, while for other regions it went up. Table 4 shows how expenditures were allocated between regions. For example, of all of the inpatient and day surgery costs incurred by residents of Assiniboine RHA, 54.1% of them were in Assiniboine RHA hospitals, 24.5% were in Brandon Hospital, 0.01% were in Burntwood, and 18.4% were in Winnipeg facilities. So an amount equivalent to 24.5% was transferred from Assiniboine to Brandon, 0.01% was transferred to Burntwood and 18.4% was transferred from Assiniboine to Winnipeg. Using a similar approach, 0.2% of the cost of Winnipeg residents' care was received in Assiniboine RHA facilities and 97.9 % in Winnipeg—0.2% of the Winnipeg allocation was transferred to Assiniboine. These adjustments make a significant difference in the final allocations, as will be seen later.

Table 4: Where residents of each region incurred their hospital inpatient and day surgery costs, 2001/02-2003/04

	Region Where Hospital Care Was Received										
Region of Residence	Assiniboine %	Brandon %	Burntwood %	Central %	Churchill %	Interlake %	Nor-Man %	North Eastman %	Parkland %	South Eastman %	Winnipeg %
Assiniboine	54.1	24.5	0.0	2.1	0.0	0.0	0.0	0.0	0.9	0.0	18.4
Brandon	1.4	81.2	0.1	0.3	0.0	0.1	0.1	0.0	0.3	0.0	16.5
Burntwood	0.1	0.4	38.2	0.1	0.2	0.1	0.5	0.0	0.1	0.1	60.3
Central	1.2	1.7	0.0	56.8	0.0	0.1	0.0	0.0	0.2	0.3	39.6
Churchill	0.0	0.3	4.3	0.0	49.6	0.0	0.2	0.0	0.2	0.0	45.4
Interlake	0.1	0.2	0.1	0.3	0.0	31.7	0.0	0.5	0.5	0.1	66.6
Nor-Man	0.1	0.6	1.9	0.0	0.0	0.1	51.4	0.1	0.4	0.0	45.3
North Eastman	0.0	0.1	0.1	0.2	0.0	2.8	0.1	31.3	0.1	1.5	63.9
Parkland	0.7	4.4	0.1	0.4	0.0	0.1	0.3	0.0	67.3	0.0	26.7
South Eastman	0.0	0.1	0.1	1.4	0.0	0.1	0.0	0.1	0.1	43.3	54.7
Winnipeg	0.2	0.5	0.3	0.3	0.0	0.3	0.1	0.1	0.2	0.1	97.9
All	4.4	5.9	1.6	4.9	0.1	2.1	1.1	1.1	3.3	1.7	73.9

Source: Manitoba Centre for Health Policy, 2007

A further adjustment to hospital costs was necessary. When someone who is not a resident of Manitoba receives care in a Manitoba hospital, those costs are incurred by the region in which the facility is located, but the recovery of costs for the care is made by Manitoba Health. There were over $28 million in such recoveries in 2003/04. For some regions, services to residents from outside of the province account for a significant proportion of their hospital expenditures. This adjustment involved increasing the allocation based on the actual 2003/04 reciprocal billing amounts for services provided by each region.

An adjustment was also necessary for the PCH allocation. Prior to regionalization, services provided by proprietary PCHs (i.e., for-profit facilities) were paid for by Manitoba Health. The Winnipeg Regional Health Authority (WRHA) now has responsibility for making these payments, regardless of where the facility is located. In addition to Winnipeg, proprietary PCHs are located in Brandon, Interlake and South Eastman RHAs. To ensure the funding necessary for these PCHs was assigned to the WRHA, an amount associated with the proportion of bed-days that were utilized in proprietary PCHs was transferred from each region in which the beds are located to WRHA. Non-proprietary PCHs are funded by the RHA in which they are located.

In preparing the final proportional allocation that included adjustments to the values produced by the models, it was necessary to use actual dollars. The amounts reported in the 2003/04 Manitoba Health Annual Report (Manitoba Health, 2004) were used to make these calculations.

3.0 RESULTS

3.1 HOW THE RESULTS ARE PRESENTED

Once the modelling was completed, the results were considered in two different ways:

1. A user-based approach.
2. A population-based approach.

The user-based approach is based on an assumption that the individuals who have used health services in the past will continue to use services in a similar manner in the future. That is, funding reallocation will not change who uses and who does not use services; it will only make these services available at a level that would be consistent with the provincial mean for people with similar characteristics. If this assumption is accepted, the only change in utilization would result from increasing or decreasing an individual's use to the provincial average.

The population-based approach assumes that everyone will have an equal chance of utilizing health services, based on their individual characteristics. That is, the funding reallocation will allow for some individuals who previously did not use health services to use them at a level similar to other individuals with similar characteristics. This will 'correct' for historical under- and overutilization in regions that may have been due to factors such as supply or other issues of access to health services.

Two additional scenarios are provided for looking at the data. The "all services received in-region" approach assumes that every resident can receive all their services in their home region[6]. Clearly this is unrealistic and potentially undesirable for inpatient hospital services as certain services in the province are centralized, necessitating interregional movement. There are also other reasons why a person may choose to receive services in another region—a hospital in a neighbouring region may be closer even though it is in a different region, there may be differential waiting lists between regions, or a person may choose to go into a hospital that is closer to family or friends. People may also enter a PCH that is not in their region of residence. This could be due to lack of a bed in their home region, or it may be the choice of the individual and/or their family to relocate to facilitate social support. This approach assumes that a person enters a PCH in the region in which they live at the time they are admitted to the PCH (i.e., they do not go to a PCH in another region). Home care services are provided in the region in which a person lives and therefore are not affected by the factors that have been identified for inpatient hospital care and PCHs, so there are no differences between the two approaches. The "some services will be received outside of the region" approach assumes that the patterns of interregional movement for hospital services that have

[6] Alternatively, this scenario could assume that the home region would purchase services for all of its residents. The administrative burden (and cost) of adopting this approach makes it unrealistic.

occurred in the past will continue in the future, and that the region in which a person resides in a PCH will continue to be the region where they will live.

We will present the results of each of these four ways of looking at the modelling in the following sections. Detailed results are presented in Appendix B.

3.2 CONSOLIDATED RESULTS OF THE FOUR APPROACHES

Table 5 presents the results of the models according to each of the four approaches.

Table 5: Percent of funding allocated to each region, using the user-based and population-based approaches for hospital inpatient care and day surgery, home care, and personal care homes. Adjustments for hospital reciprocal billings and proprietary Personal Care Homes have been made.

	User-Based		Population-Based	
	All services will be received in home RHA %	Some services will be received outside of home RHA %	All services will be received in home RHA %	Some services will be received outside of home RHA %
Assiniboine	7.92	5.69	6.46	4.88
Brandon	3.98	5.12	3.51	4.36
Burntwood	2.39	1.12	2.65	1.35
Central	7.93	5.99	7.49	5.78
Churchill	0.23	0.21	0.21	0.20
Interlake	5.55	3.05	5.69	3.23
Nor-Man	1.73	1.15	1.69	1.14
North Eastman	2.91	1.49	3.23	1.78
Parkland	4.82	4.03	3.91	3.35
South Eastman	3.52	2.28	3.85	2.54
Winnipeg	59.02	69.84	61.31	71.39

Source: Manitoba Centre for Health Policy, 2007

As was described above, the user-based approach assumes that the same people who used services in the past will continue to use them in the future. Given the reality of the location of healthcare facilities in Manitoba, if one were to adopt the user-based method and not plan to build additional facilities in the province (i.e., "user-based—some services will be received outside of home RHA), Assiniboine RHA would receive 5.69% of the total funding available for inpatient hospital care/day surgery, PCHs and home care; Brandon would receive 5.12%, Burntwood 1.12% and so on. If a population-based approach (i.e., all individuals with similar characteristics would use services at the provincial average level as those who have used services in the past) were adopted (still assuming existing patterns of interregional travel for health services would occur), Assiniboine would receive

4.88%, Brandon 4.36% and so on. In cases where the user-based proportion is greater than the population-based proportion, this would suggest that, based on the characteristics of the population in a region, more resources are currently being used than would be expected.

Recall that the allocations described here are only for those health services for which the characteristics of the population could and should be taken into account. We were not able to include community and mental health services, emergency response and transportation, and ambulatory care services provided in hospitals, including outpatient clinics and emergency departments. Services that are based on geography (e.g., the location of a centralized laboratory) or policy (e.g., maintaining low occupancy hospitals) are not necessarily associated with the characteristics of the people living in a region. Therefore, these consolidated results only represent the portion of the total funds allocated to regions for inpatient hospital care and day surgery, PCHs and home care, when only population characteristics are considered.

3.3 RESULTS BY SECTOR—BY APPROACH

As was described above, the proportional distribution of funding was calculated for each sector (inpatient hospital care/day surgery, PCHs, home care) independently. In Table 5 we have combined all of the sectors to provide a single allocation for each region, using each of the four approaches. In the following sections we provide results for each of the sectors. This information may be useful to planners in considering how the models indicated funds should be allocated between these three health services.

3.3.1 User-Based: All Services in Home Region

Table 6 presents the results for each of the sectors, assuming that those individuals who have used services in the past will continue to use services in the future, and that their RHA of residence will provide or pay for these services. This approach assumes that if an individual enters a PCH, the PCH they are admitted to is in the region in which they lived at the time of admission.

Table 6: Percent of funding by region and health service using the user-based approach assuming all services will be received in an individual's RHA of residence. Adjustments for hospital reciprocal billings and proprietary Personal Care Homes have been made.

	Hospital Inpatient and Day Surgery %	Personal Care Homes %	Home Care %	Overall Proportion %
Assiniboine	7.29	10.09	7.18	7.92
Brandon	4.15	3.92	3.10	3.98
Burntwood	3.42	0.13	0.87	2.39
Central	7.64	8.94	7.51	7.93
Churchill	0.33	0.00	0.06	0.23
Interlake	5.71	4.44	6.98	5.55
Nor-Man	1.91	1.26	1.64	1.73
North Eastman	3.08	2.42	2.97	2.91
Parkland	4.38	5.46	6.19	4.82
South Eastman	3.55	3.05	4.36	3.52
Winnipeg	58.55	60.29	59.15	59.02

Source: Manitoba Centre for Health Policy, 2007

3.3.2 Population-Based: All Services in Home Region

Table 7 presents the results for each of the sectors, assuming that the individual characteristics of each resident drives their utilization of health services, and that their RHA of residence will provide or pay for these services. The population-based approach recognizes that there are different patterns of utilization in the province that are not associated with population characteristics, and

Table 7: Percent of funding by region and health service using the population-based approach assuming all services will be received in an individual's RHA of residence. Adjustments for hospital reciprocal billings and proprietary Personal Care Homes have been made.

	Hospital Inpatient and Day Surgery %	Personal Care Homes %	Home Care %	Overall Proportion %
Assiniboine	5.52	9.38	6.05	6.46
Brandon	3.67	3.06	3.52	3.51
Burntwood	3.45	0.23	2.91	2.65
Central	6.97	8.64	8.23	7.49
Churchill	0.30	0.00	0.09	0.21
Interlake	5.70	5.10	6.91	5.69
Nor-Man	1.82	1.09	2.17	1.69
North Eastman	3.14	3.31	3.60	3.23
Parkland	3.31	5.59	4.02	3.91
South Eastman	3.80	3.42	5.09	3.85
Winnipeg	62.33	60.19	57.41	61.31

Source: Manitoba Centre for Health Policy, 2007

assumes that different funding allocation will remove these different patterns. This approach assumes that if an individual enters a PCH, the PCH they are admitted to is in the region in which they live at the time of admission.

3.3.3 User-Based: Services in Home and Other Regions

Table 8 presents the results for each of the sectors, assuming that those individuals who have used services in the past will continue to use services in the future, and that the costs of some of these services will be incurred in a region other than the one in which they live. It is also assumed that the pattern of movement for hospital care that has happened in the recent past will continue into the future. Unlike the first two approaches where PCH funding is assigned to the region in which a person lives before they are admitted to a PCH, this approach assigns the funds to the region where the individual actually resides in the PCH. For example, if a person lived in Assiniboine RHA but entered a PCH in Brandon, under the first two approaches the funds would be assigned to Assiniboine, while under the last two approaches the funds would be assigned to Brandon.

Table 8: Percent of funding by region and health service using the user-based approach assuming some services will be received outside of an individual's RHA of residence. Adjustments for hospital reciprocal billings and proprietary Personal Care Homes have been made.

	Hospital Inpatient and Day Surgery %	Personal Care Homes %	Home Care %	Overall Proportion %
Assiniboine	4.28	9.03	7.18	5.69
Brandon	5.78	4.18	3.10	5.12
Burntwood	1.54	-*	0.87	1.12
Central	4.76	8.81	7.51	5.99
Churchill	0.30	0.00	0.06	0.21
Interlake	2.09	4.00	6.98	3.05
Nor-Man	1.06	1.21	1.64	1.15
North Eastman	1.07	1.99	2.97	1.49
Parkland	3.21	5.37	6.19	4.03
South Eastman	1.69	3.00	4.36	2.28
Winnipeg	74.21	62.41	59.15	69.84

* At the time of preparation of this report, there were no provincially operated PCHs in Burntwood

Source: Manitoba Centre for Health Policy, 2007

3.3.4 Population-Based: Services in Home and Other Regions

Table 9 presents the results for each of the sectors, assuming that the individual characteristics of each resident drives their utilization of health services, and that the costs of some of these services will be incurred in a region other than the one in which they live. As is noted above, the population-based approach recognizes that there are different patterns of utilization in the province that are not associated with population characteristics, and assumes that different funding allocation will adjust for these different patterns. This approach also assumes that the pattern of movement for hospital services that has happened in the recent past will continue into the future, and for PCHs, like the previous approach, funds are assigned to the region in which a person actually lives in a PCH. If in some regions people overutilize services compared with the provincial average and in other regions people underutilize services compared with the provincial average, this approach uses modelled results to reduce funding for overutilization and increase funding for underutilization.

Table 9: Percent of funding by region and health service using the population-based approach assuming some services will be received outside of an individual's RHA of residence. Adjustments for hospital reciprocal billings and proprietary Personal Care Homes have been made.

	Hospital Inpatient and Day Surgery %	Personal Care Homes %	Home Care %	Overall Proportion %
Assiniboine	3.30	8.86	6.05	4.88
Brandon	4.92	3.16	3.52	4.36
Burntwood	1.56	-*	2.91	1.35
Central	4.36	8.70	8.23	5.78
Churchill	0.28	0.00	0.09	0.20
Interlake	2.10	4.76	6.91	3.24
Nor-Man	1.01	1.05	2.17	1.14
North Eastman	1.09	2.91	3.60	1.78
Parkland	2.49	5.51	4.02	3.35
South Eastman	1.81	3.46	5.09	2.54
Winnipeg	77.08	61.58	57.41	71.39

* At the time of preparation of this report, there were no provincially operated PCHs in Burntwood

Source: Manitoba Centre for Health Policy, 2007

4.0 DISCUSSION

The consolidated and four approaches that are presented here provide insights into the use of health services by residents of different regions. The "population-based, some services will be received outside of the home RHA" approach could be considered the most realistic, taking into account characteristics of all of the residents of each region—not just those who have historically used health services—and it acknowledges that inter-regional movement occurs for accessing some health services. It is interesting to compare this approach to that of the "user-based, some services will be received outside of the home RHA;" particularly noteworthy is the change in allocation between these two approaches.

Recall that the user-based approach includes only those people who have used services in the past, and the model assumes that they will continue to use services in the future at a rate that is consistent with the provincial average, after taking into account their personal characteristics. For some regions, the allocation is greater using the population-based approach—this indicates that there are residents of the region who, based on their personal characteristics, would be expected to be using more of these health services. These regions include Burntwood, Interlake, North Eastman, South Eastman and Winnipeg. These comparisons would suggest that the other regions have used more of these health services in the past than would be expected. There are a variety of reasons why a population may have been using more or less services than would have been expected. Physical access is one of the possible explanations, that is, if services are not available people will not use them, whereas if services are available then people are more likely to use them. Likewise, practice patterns and availability of health professionals can affect utilization. Much of the cost of hospital care is driven by an individual's length of stay. If patients are routinely kept in hospital longer than would be expected, costs will be higher than expected. A delayed discharge can result from physician practice patterns or from delayed access to discharge resources such as rehabilitation therapists, home care or non-acute care facilities. Health system characteristics can also affect utilization. Populations living in communities with strong integrated and primary healthcare may require fewer resources, especially hospital resources, than others, even after taking into account the characteristics of the population[7]. Finally, different utilization patterns may be associated with different community and/or cultural beliefs or expectations regarding use of health services.

It is also noteworthy, but not unexpected, that both the population-based and the user-based approaches indicate that a shift in funds should occur in recognition that all services cannot be provided in all regions. Under both approaches, the allocation to Winnipeg and Brandon increases, in recognition of the fact that these two centres provide many services to residents of other regions.

[7] It is worth noting that primary healthcare was not included in this funding allocation methodology.

Further insights can be gleaned by comparing the sector specific results that are presented in Tables 6 through 9. For example, Burntwood is one of the regions where the population-based approach predicted more utilization than the user-based approach. The two tables show that home care is the sector that is being underutilized in this region, after controlling for characteristics of the population. For Interlake, it is PCHs that are used less than expected. Both personal care homes and home care are used less than expected in North Eastman. Like Burntwood, South Eastman residents would be expected to use more home care. For Winnipeg, it is inpatient hospital care and day surgery that is less than expected. There are many more observations that can be drawn from these data—these are but a few of the possible areas for further consideration by regional planners.

When this work was initiated, we expected that Aboriginal status would be an important driver of need for health services. One of the important findings of this work is that after controlling for other individual and community characteristics, Aboriginal status was not a strong predictor of health services use. In particular, when socioeconomic status was included as a community level variable, it was better able to predict health service utilization than any of the other characteristics[8]. The important message here is that it is not being Aboriginal that results in relatively higher use of health services, it is having a lower socioeconomic status, and the poorer health status that is correlated with socioeconomic status and has been shown to be highly correlated with population health status (Martens et al., 2003).

Two earlier reports dealing with needs-based funding allocation have been published by MCHP. Based on work by Roos et al. (1996), Frohlich and Carriére (1997) described a two-stage modelling process for allocating physician resources. A number of the indicators of "need" used in their model are similar to those used here, although there are also significant differences in the way the indicators are measured and the analytic approach. Their study suggested that a model using age, sex and socioeconomic status at the first stage, with a second stage re-allocation for premature mortality could be used to allocate funds for physician services. Mustard and Derksen (1997) approached needs-based funding allocation by determining the mean cost of healthcare for six "service pools[9]." The mean cost was calculated separately for men and women, and in five year age groups. These mean costs were then adjusted up or down to reflect premature mortality and social and economic characteristics. The result is "a need-adjusted per capita allocation amount which is specific to each Regional Health Authority, and which is then multiplied by the population count in each age group within each Regional Health Authority population to produce a total need-adjusted

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8 As has been noted, there is a high positive correlation between the premature mortality rate (i.e., rate of death before the age of 75) in a community and the socioeconomic status of the residents. We have chosen to use our SES measure rather than PMR for theoretical reasons (i.e., the Socio-Economic Factor Index includes many of the factors theorized by the Working Group to be predictors of health service use or need)—but using the premature mortality rate provides nearly identical results.

9 The service pools include institutional acute care services; institutional long term care; continuing care, home-based; health promotion/disease prevention; medical remuneration; and Pharmacare.

allocation of healthcare resources" (Mustard and Derksen, 1997). Both reports consider issues related to funding allocation that have also been raised here.

4.1 STRENGTHS AND LIMITATIONS

We believe this work provides important insights into how the characteristics of the people living in different regions may be used to allocate funds for inpatient hospital care, day surgery, home care and PCHs, and that the approach that has been adopted is the most rigorous of all we have reviewed. In particular, this approach reduces potentially avoidable inequities in the provision of healthcare services through assigning funds to regions based on the characteristics of the people living there. One of the strengths of the work is the ability to use the Repository that is housed at MCHP. This resource is second-to-none in providing information necessary to understand who is and who is not using health services. However, there are some limitations inherent in the data. First and foremost, the data do not provide explicit indicators of those who could benefit from health services, but for whatever reason do not receive them, and alternatively, those who are receiving care but are deriving no benefit. However, the population-based approach that we have described here makes a reasonable attempt to compensate for this. These data also do not provide us with province-wide information on use of hospital-based ambulatory care services such as emergency departments and outpatient clinics (e.g., rehabilitation, dialysis, diagnostics), nor do they include information on community and mental health services or emergency response and transportation. As a result we have been unable to include any of these services in the population-based funding allocation methodology.

The dependent variables that have been used in our models include the cost of inpatient hospital care and day surgery estimated using case-mix costing methods, weighted days of PCH care and days that a home care case is active. There is some potential for measurement error in each of these items. The following paragraphs describe the source of this potential error.

Case-mix costing applies "standard" costs to people who are discharged from a hospital. While we do not know the actual cost of each case, a cost is assigned based on the characteristics of the person, their diagnoses and hospital care received, and should be considered a reliable measure, especially for population-based studies. Of particular note is that this approach takes into account situations where an individual is admitted to a hospital in a region other than there own (for, say, a surgical procedure) and then returns to a hospital in their home region for follow-up care. The costs associated with each hospital stay are reported for the region in which they occur.

Weighted days of PCH care use have been used as a measure of cost of PCH use in other MCHP work (Shanahan et al., 1997) and have been recommended as an appropriate method for costing (Jacobs et al., 1999; Jacobs et al., 2000). Of potential concern is that the classification of individuals into one of the four levels of care may not be applied consistently, and changes in level of care may not be immediately reported. However, there is no evidence that these weightings would be systematically biased, and therefore we assume that the errors will be randomly distributed among the population of nursing home residents.

Days of an open home care file is the measure with the greatest limitation as an indicator of resource use. The data that are housed in the Repository do not include measures of either frequency or intensity of home care use. A person receiving weekly homemaker services for a month or daily nursing care for a month would be considered to be receiving the same resources. Clearly this is not the case. However, because we are considering all home care use in the province and are dealing with a proportional allocation, we are again prepared to make the assumption that there is no systematic variation in the mix of utilization of home care services throughout the province.

Limitations exist in other data sources as well. We had been very interested in including behavioural characteristics in our models—items like BMI, seat belt use, smoking and drinking. Although individual-level indicators of these characteristics are not available in the Repository (e.g., we do not (know each individual's BMI or smoking status[10]), survey data were considered a reasonable alternative. Rather than individual measures, we would use community-based rates (e.g., the proportion of population living in a region with a BMI of 25 or more). However, the relevant surveys are not conducted in First Nations communities, and as a result the data were considered incomplete and could not be used for our purposes.

The data contained in the Repository is the most complete source of information on health service utilization by Manitobans that is available. However, there may be data missing for a variety of reasons. Most physicians in the province work on a fee-for-service basis. The claims that they submit are used in this methodology to determine chronic conditions and comorbidities. Some physicians are not paid on a fee for service basis, but most submit shadow bills for the patients they see. However, there are some cases where shadow bills are not submitted.

The methods we adopted also present some limitations. First of all, the specification of the models was based on a review of characteristics that have been used elsewhere as well as input from experts in management of health services. We believe the models to be sound, but there is always a risk of underspecification (i.e., failure to include variables that should be included) when modelling. It was also necessary for us to make some assumptions in preparing the funding allocation methodology. In particular, given that there are constraints on the total funding available for health services, we needed to make an assumption that some overutilization and some underutilization exists in the province. This assumption is supported by evidence of differential utilization between regions (Brownell et al., 2003; Martens et al., 2003; Stewart et al., 2000). Secondly, when adjusting modelled

[10] This information may be available for individuals who were included in the Canadian Community Health Survey sample, but is not available for the entire population, nor is it available for excluded populations.

results to consider interregional movement for inpatient hospital services and day surgery, we assumed that recent past (2001/02-2004/05) patterns of movement would continue into the future. If operational changes are made in hospitals (e.g., programs are relocated or new programs are initiated), adjustments would need to be made to the proportions. Similarly, adjustments were made to increase funding to RHAs for reciprocal billings. If the pattern of services provided to out-of-province residents changes, adjustments would be needed to compensate for these changes.

We had hoped to be able to present data that would show what effect each of these approaches would have when compared to the current allocation. In fact, when reviewing the results with the Working Group and the Health Senior Executives Committee we made such comparisons. However, comparative data are not available for the largest component of healthcare considered in these models—inpatient hospital care and day surgery. As was noted earlier, individual information on utilization of outpatient clinics (including emergency departments) is not available province-wide. As a result, we were not able to model these services. When reviewing the final results it became apparent that for some regions, making the assumption that the utilization pattern of outpatient care was similar to utilization of inpatient services may be incorrect. Published comparative data are only available for all hospital services—both inpatient and outpatient. As a result, comparative data are not presented here. Therefore, the allocations that we have presented in the tables can be interpreted as the percent of the overall RHA budget that would be used for hospital inpatient care, day surgery, PCHs, and home care, but not for hospital outpatient clinics and emergency departments, community and mental health services, and emergency response and transportation. Provincially administered programs are also not included (physician services, Pharmacare, CancerCare Manitoba, etc.). It does not reflect geographic and policy-based allocations such as Westman Regional Laboratory (an example of a geographic-based allocation) or maintaining low occupancy hospitals (an example of a policy-based allocation).

We have also not explicitly considered supply of health services as part of our modelling process, although implementation of the methodology would potentially require re-distribution of supply. Because it was the intent of this work to utilize a provincial mean utilization as the baseline for allocating funds, including supply as a covariate could perpetuate existing supply inequities. We have, however, included distance from a major hospital as an indicator of access to these services.

It is important to note that this methodology does not include the entire healthcare system, and that as a system each part influences another. For example, the supply and practice patterns of physicians will influence the utilization of each of the services that have been considered here (i.e., hospital care, home care and nursing home care). The influence that factors such as these that are beyond the control of the RHAs will need to be considered as part of the implementation plan.

4.2 IMPLEMENTATION

Funding allocation is ultimately a policy decision, and in asking MCHP to develop this methodology, Manitoba Health is indicating its interest in considering alternatives to the current allocation process. However, no single policy (e.g., population-based funding allocation) could possibly deal with all of the issues that need to be considered in a system as complex as healthcare. We therefore see this methodology as a starting point that can be used to more equitably allocate funds in the province.

Ultimately, the actual number of dollars that will flow to regions will be a function of many factors. We propose the population-based approach as being the foundation and that the largest proportion of funding would be allocated according to the methodology that is described here. However, a portion of the total dollars available will need to be allocated through other means. For example, it may not be economical to have as many hospitals as currently exist, or to have them located where they are. It is entirely possible that some facilities are important community features that contribute more to the economic viability of the community than to the healthcare needs of the residents. The decision to maintain such facilities is policy-based and is outside of the population-based allocation. Similarly, the population-based methodology does not consider direct costs that may vary throughout the province—labour and supplies are likely to be more expensive in remote areas than they are in other locations. And, as noted above, the methodology does not include other important services that are operated by RHAs: community and mental health services and emergency response and transportation, nor are hospital-based ambulatory care services other than day surgery.

It may be helpful to consider a hypothetical example of how this methodology could be implemented, given the additional work that will be needed to make it fully functional. The total funding available for RHA-delivered health services can be envisioned as a combination of population-based, geography/policy-based, unmodelled, and community services (including initiatives to promote good and prevent poor health). This report has only considered the population-based allocation—the actual allocation to a region would be:

Population-based funding + Geographic/Policy-based funding + Unmodelled funding + Community services funding

For this hypothetical example, assume that $3 billion is allocated for RHAs to provide all of the services for which they are responsible. Then, assume that $300 million is identified as being the amount of geographic/policy-based funding, $300 million is the amount for unmodelled services (hospital-based ambulatory care, mental health services and emergency response and transportation), and that 10% of total expenditures ($300 million) is committed to community services including health promotion and illness prevention. This would mean that $2.1 billion would be the amount that would be allocated strictly according to population characteristics. For Assiniboine RHA (this region was selected only because it is first in the alphabetical list of regions), this would mean that they would receive the following allocation according to one of the scenarios that are described:

Population-based funding	$2.1 billion x 4.88% = $102,480,000
+ Geographic/Policy-based funding	$A
+ Unmodelled funding	$B
+ Community services funding	$C
= Total Funding	$102,480,000 + $A + $B + $C

Total funding for Assiniboine RHA would be the total of the four funding categories—the population-based proportion is taken from this report, the unmodelled funding will need to be based on historical and/or other funding allocation mechanisms negotiated between RHAs and Manitoba Health, the geographic/policy-based funding will need to be explicitly identified, and community services funding will need to be considered in the context of the health status of the population (the Community Health Assessments and other MCHP reports can inform this process).

It is also important to note that this methodology cannot be static. It was based on utilization and populations presently living in RHAs. If the utilization patterns and/or population composition changes (as could reasonably be expected), the proportional allocation will need to change. This does not mean that the methodology would need to be redeveloped—it simply means that the proportions that are allocated to regions would need to be updated using more current utilization and population data.

In considering implementation of this methodology as part of overall funding for RHAs, it will be important to consider the management of the system, and in particular how to promote efficiency. Häkkinen and Järvelin (2004) have proposed that a funding allocation methodology should include three aspects: efficiency, equity and data availability. If an overall funding structure is put in place, systems for monitoring efficiency and preventing abuse of the funding system (through incentives to manipulate data, for example) will need to be considered. The potential disincentives to promoting good health and preventing poor health must also be considered. Because our model includes variables that may be influenced by prevention programs (e.g., chronic disease, injury hospitalization), if an RHA reduced these programs it would potentially receive increased funding because the population in the region would be less healthy. Clearly this is an undesirable implication of the methodology, and one that will require monitoring. Future research may help in identifying the complex interaction between prevention/promotion activities and overall health system costs.

4.3 ASSESSING OUTCOMES

The purpose of this work is to describe how funds would be allocated to Manitoba RHAs if the characteristics of the populations in each RHA were taken into account. The reason for doing this was that disparities in health status (Brownell et al., 2003; Roos et al., 2001) and health service utilization (Martens et al., 2003; Stewart et al., 2000) have been identified. We would therefore expect that, if the funding allocation methodology is effective, there would be a reduction in disparities. However, we know that healthcare is only one of the factors that affect the health status of a population. It would therefore be inappropriate to measure the effectiveness of this methodology by using population health status measures. A reasonable alternative, and one that should be considered by Manitoba Health in planning for the future, is to look at patterns of utilization of health services (as was done in this project) to determine if they are being equitably delivered throughout the province. This would involve the identification of key indicators and then using modelling to assess if, after controlling for differences in population characteristics, there are differences in utilization that are not explained by population characteristics.

4.4 FINAL WORDS

Healthcare is only one contributor to health status. Indeed, except for primary and other preventive care, healthcare may be considered an indicator of a health system that is placing resources at the end of a causal pathway, rather than at the start. While this work has described how funds would be allocated to RHAs according to the characteristics of the population, reducing need for healthcare through improvement in populations' health would mean that not only would we have a more productive population, but would also reduce the funds required for health services. There are many initiatives underway in Manitoba and throughout the world that are designed to improve population health. One of the important policy decisions that will need to be made is how to best allocate funds between prevention activities and health services. MCHP has done considerable work in describing the health status of populations (Brownell et al., 2003; Fransoo et al., 2005; Lix et al., 2005; Martens et al., 2003; Martens et al., 2004; Roos et al., 2001), and this information can be used to inform the policy development process. While it is important and necessary to have health services available when they are needed, it is equally important to continue to work towards improving the health of Manitobans through prevention activities and health promotion.

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GLOSSARY

Acronyms used in this report:

ACG - Adjusted Clinical Group.
ADG - Aggregated Diagnostic Group
CCHS - Canadian Community Health Survey
CWC – Average Cost per Weighted Case
NPHS - National Population Health Survey
PCH – Personal Care Home
PMR - Premature Mortality Rate
PYLL - Potential Years of Life Lost
SEFI - Socio-Eeconomic Factor Index
SES – Socioeconomic Status

Aboriginal

The descendants of the original inhabitants of North America.

The Canadian Constitution recognizes three groups of Aboriginal People—Indians, Métis and Inuit. These are three separate people with unique heritages, languages, cultural practices and spiritual beliefs. In this study, two indicators of the proportion of the population in a community that could be considered Aboriginal were taken from Census data. Percent of the population of Aboriginal origin refers to those persons who reported at least one Aboriginal origin to the ethnic origin question (North American Indian, Métis or Inuit). Ethnic origin refers to the ethnic or cultural group(s) to which the respondent's ancestors belong. Proportion of the population of Aboriginal identity refers to those persons who reported identifying with at least one Aboriginal group, i.e. North American Indian, Métis or Inuit (Eskimo), and/or those who reported being a Treaty Indian or a Registered Indian as defined by the Indian Act of Canada and/or who were members of an Indian Band or First Nation. The 2001 Census included a question on the individual's own perception of his/her Aboriginal identity. In both cases, the percent was calculated by dividing the number of people of Aboriginal origin/Aboriginal identity by the total number of people in the population for the area, using 2001 census data.

Adjusted Clinical Group (ACG)

A risk adjustment tool developed to measure the illness burden (morbidity) of individual patients and enrolled populations. This system quantifies morbidity by grouping individuals based on their age, sex and all known medical diagnoses assigned by their health care providers over a defined time period (typically one year). Previously called "Ambulatory Care Group". (The John Hopkins University Bloomberg School of Public Health, Health Services Research & Development Center. The John Hopkins ACG® Case-Mix System Version 6.0 Release Notes. (Editor in Chief: Jonathan P. Weiner). The John Hopkins University. April, 2003.)

Administrative Data

Refers to information collected "usually by government, for some administrative purpose (e.g., keeping track of the population eligible for certain benefits, paying doctors or hospitals), but not primarily for research or surveillance purposes (Spasoff, 1999).

Age

Calculated at some point in time for an individual (i.e., age at admission, age at time of claim date, age as of December 31), usually measured in years. In this study, age was calculated as of March 1 of a given year.

Age - proportion of the population in a certain age group

In this study, two age-based proportions were used: the proportion of the population age 65 and over, and age 75 and over. This was calculated by dividing the number of people in the designated age group by the total number of people living in the geographic area, as of March 1 of a given year.

Aggregated Diagnostic Group (ADG)

Formerly known as Ambulatory Diagnostic Groups, ADGs continue to be part of the Adjusted Clinical Group (ACG) case-mix system. The ACG method groups every ICD-9 / ICD-9-CM medical diagnosis code assigned to a patient into one of 32 different ADGs based on five clinical and expected utilization criteria: 1) duration of the condition (acute, recurrent, or chronic); 2) severity of the condition (e.g., minor and stable versus major and unstable); 3) diagnostic certainty (symptoms focusing on diagnostic evaluation versus documented disease focusing on treatment services); 4) etiology of the condition (infectious, injury, or other); and 5) specialty care involvement (medical, surgical, obstetric, haematology, etc.). See "Chronic Disease" and "Comorbidity". (The John Hopkins University Bloomberg School of Public Health, Health Services Research & Development Center. The John Hopkins ACG® Case-Mix System Version 6.0 Release Notes (Editor in Chief: Jonathan P. Weiner). The John Hopkins University. April, 2003.)

At Risk Newborn

An infant who, at birth, is defined as having potential health problems according to the following criteria: birthweight was <2500g or >4000g. Also known as "at-risk birthweight."

Average Cost per Weighted Case - See Cost per Weighted Case

Body Mass Index (BMI)

A measure of health risk that is correlated with body fat based on height and weight that applies to both adult men and women. BMI is calculated as follows: weight in kilograms divided by height in metres squared. The classification system for BMI that is used in Canadian Community Health Survey (CCHS) is: underweight (under 20.0), acceptable weight (20.0-24.9), some excess weight (25.0-27.0), and overweight (greater than 27.0). The index is calculated for survey respondents aged 20 to 64 years, excluding pregnant women and people less than 0.914 metres tall or greater than 2.108 metres tall.

Canadian Community Health Survey (CCHS)

Conducted by Statistics Canada, the CCHS provides regular and timely cross-sectional estimates of health determinants, health status and health system utilization for 136 health regions in Canada, including the territories. Survey respondents were sampled from 11 regions in Manitoba. Respondents were 12 years of age and older; the sampling methodology was designed to ensure over-representation of youth under 19 years of age and seniors 65 years of age and older. The survey excludes populations living in Indian Reserves, on Canadian Forces Bases, and in some remote areas, and those not living in households.

Capitation Funding

A per capita method of funding for health services. It may be narrowly implemented as a compensation plan for physicians where the amount of revenue a practice receives is based on an amount paid per patient (capitation fee) times the number of patients the practice treats (practice population) regardless of the number of visits. More broadly implemented, capitation funding may be used to fund geographical areas to provide all health services to residents, and may be adjusted to reflect characteristic of the residents.

Case Mix Adjustment

A process of assigning weights to different types of hospital cases. Those cases that require substantial resources would be assigned a weight higher than those that require relatively fewer resources. Case mix adjustment takes into account variability in resource requirements for different types of cases and may be used as one measure of hospital efficiency.

Chi-Square Test

This is one of the tests used to measure how well a statistical model fits the data. See also Goodness-of-Fit.

Chronic Disease

Conditions that are generally incurable, often caused by a complex interaction of factors, and usually have a prolonged clinical course. In this study individuals assigned to any one of the following ADGs (using the ACG grouper) were considered to have a chronic condition (1=chronic; 0=not chronic):

Allergies: ADG 5
Asthma: ADG 6
Chronic Medical: stable (ADG 10) and unstable (ADG 11)
Chronic Specialty:
    Orthopedic - stable (ADG 12) and unstable (ADG 16)
    Ear, Nose, Throat - stable (ADG 13) and unstable (ADG 17)
    Eye - stable (ADG 14) and unstable (ADG 18)
    Psychosocial: Persistent/Recurrent: stable (ADG 24) and unstable (ADG 25)
Chronic Disease and Comorbidity: ADG 32

Comorbidity

The independent and simultaneous existence of more than one medical condition in an individual. In this study, comorbidity was assessed by assigning ADGs to each individual. The count of the number of ADGs to which a person was assigned was the value used in the model.

Cost – Inpatient hospital care/day surgery

The cost assigned to each person that is discharged from hospital after having been admitted for an inpatient stay or day surgery. The cost is assigned using the Resource Intensity Weight (RIW) attributed to each discharge by CIHI. This RIW is multiplied by a standard average cost per weighted case (CWC) to produce an estimated cost for each stay. In this study, the 2000/01Manitoba provincial CWC was applied to all discharges. Individuals receiving outpatient care (other than day surgery) are not included in the discharge database and therefore cannot have a cost assigned for their care.

Cost per Weighted Case (Average)

A financial indicator that provides a measure of the cost to provide care to a "standard" hospital patient. A relative, average cost, the cost per weighted case is calculated by summing the weights assigned to all cases treated by a hospital, and dividing this number into the hospital's total inpatient expenditure. It is used for describing and comparing the cost of care, as it removes the effects of differences in the acuity, severity and complexity of individual served in different hospitals on the cost of providing care, and permits the assignment of a cost to each case that is discharged from a hospital. Cost per weighted case may be measured at multiple levels: hospital, RHA, hospital type, province-wide. For this project, the provincial average cost per weighted case for 2000/01 was used for estimating the cost of inpatient care and day surgery.

Death Record

Vital Statistics maintains a registry of deaths in the province.

Distance to a Major Hospital

In this study, all individuals were classified as living near to or remote from a major urban or rural hospital according to an established postal code assignment method.

Equity

"Equity in health care requires that patients who are alike in relevant respects be treated in like fashion and that patients who are unlike in relevant respects be treated in appropriately unlike fashion." (Culyer AJ. Equity - some theory and its policy implications. *Journal of Medical Ethics* 27(4):275-83, 2001 August.)

First Nations Community

Indian and Northern Affairs Canada's legal list of First Nations communities includes the following census subdivision types: Indian Government Districts, Reserves, Indian Settlements, Terre Reservées, Nisga'a Lands, Nisga'a Villages and Teslin Lands.
(http://www.ainc-inac.gc.ca/pr/ra/cwb/int1_e.html)

Gamma distribution

This is a nonzero continuous distribution that can be used to model positively skewed data. Some of the special cases of the gamma distribution are exponential and chi-squared distributions.

Goodness-of-Fit

How well a statistical model fits the actual data. Summary measures of goodness-of-fit are commonly known as test statistic (e.g. Chi-Square test statistic) and typically summarizes the differences between the observed values and the values expected under the model equation. In this study we used the value of the deviance and the likelihood ratio statistics.

Health Administrative Data

Data produced through the routine administration of health care programs. The health administrative databases housed at MCHP contain anonymized records for virtually all contacts with the provincial health care system (including physicians, hospitals, personal care homes, home care, and pharmaceutical prescriptions that are filled in community drug stores).

Hierarchical Generalized Linear Modeling

Hierarchical generalized linear models (HGLM) are used to model hierarchical data structures in which the distribution of the dependent variables is not normal. (Raudenbush S, Bryk A. *Hierarchical linear models: Applications and data analysis methods.* 2nd ed. Newbury Park, CA: Sage; 2002. Snijders T, Bosker R. Multilevel analysis: *An introduction to basic and advanced multilevel modeling.* London: Sage; 1999)

Home Care

Health services provided to residents within their own homes. Unlike other health care services, home care is primarily provided within an RHA for its residents and is unlikely to generate large expenditures on out-of-region residents. The Manitoba Home Care Program, established in 1974, is the oldest comprehensive, province-wide, universal home care program in Canada. Home Care is provided to Manitobans of all ages assessed as having inadequate informal resources to return home from hospital or to remain at home in the community. Reassessments at pre-determined intervals are the basis for decisions by case managers to discharge individuals from the program, or to change the type or amount of service delivered. The types of services provided through the Manitoba home care program may include: personal care assistance, home support, health care, family relief, respite care and supplies and equipment.

Home Care Database

A database housed in the Repository that includes information on open home care cases. In this study a home care recipient was measured by the number of days an individual has an open file within the home care database in a fiscal year.

Hospital Abstract

A form/computerized record filled out upon a patient's separation (discharge) from a hospital, containing patient information/characteristics such as a personal health information number (which is anonymized through encryption prior to inclusion in the Repository), place of residence, length of stay, diagnoses and procedures, using ICD-9-CM codes, and service type (inpatient, day surgery, outpatient). Also called "Hospital Discharge Abstract" and "Hospital Separation Abstract." The Hospital Abstract User Manual (HAUM) contains the appropriate coding rules and processing details.

Hospital Discharge Database

A health administrative database consisting of hospital abstracts of demographic and clinical information (up to 16 diagnosis codes and 12 procedure codes) completed at the point of discharge. Several hundred thousand abstracts per year are submitted for all separations from acute and chronic care facilities in Manitoba and for all Manitobans admitted to out-of-province facilities. Out-of- province hospitals are required to submit these abstracts as part of the global operating budget funding process, which is covered by funding transfers from the provinces and the territorial Departments of Health. The hospital discharge database in the Repository is anonymized prior to use. In this study, the discharge database was used for several purposes including assigning hospitalization costs, identifying persons with chronic diseases, comorbidities, injury hospitalizations, newborn status and at risk newborn status. It was also used to determine whether or not a person was admitted to or discharged from hospital, and if so, the number of days they were hospitalized.

Hospital Separation - See Separation.

Indian Reserve

A reserve is tract of land, the legal title to which is held by the Crown, set apart for the use and benefit of an Indian band. Some bands have more than one reserve. Many First Nations now prefer the term "First Nation community," and no longer use "reserve." (http://www.ainc-inac.gc.ca/pr/pub/wf/trmrslt_e.asp?term=31)

Infant Mortality Rate

The number of deaths among infants under one year of age per 1000 live births. Rates fluctuate in areas with small populations, therefore several years' averages should be chosen over a single year of data. The infant mortality rate in this project was calculated using Registry and hospital discharge data.

Injury Hospitalization

Hospitalizations lasting one day or longer that resulted from an injury as indicated by the presence of one of the ICD-9-CM E-Codes listed on the hospital separation record.

Inpatient Hospital Care

All admissions/separations in which patients had hospital stays of one or more days.

Life Expectancy

The average number of years an individual of a given age is expected to live if current age- sex-specific mortality rates remain stable. Life expectancy is a commonly accepted indicator of population health. Typically calculated at birth, this indicator describes the experience of all people in the population, not just those 0-74 (as for the premature mortality measure). May also be calculated at any age (e.g., at age 65).

Likelihood Ratio Test (LRT)

As the name implies, the likelihood ratio is a ratio of two likelihoods. It is widely used as a test statistic, perhaps especially for relations among categorical variables displayed in contingency tables. The smaller the LR, the stronger the relationship: this is because (in comparison with the chi-square method) the LR attempts to accept a particular model, not reject a null hypothesis.

Logarithmic Transformation

This is the replacing of data values with the equivalent values in logarithm form. This type of transformation can make skewed data to be approximately normal.

Log-normal distribution

This is the probability distribution of any random variable whose logarithm is normally distributed. Thus, if Y is a random variable with a normal distribution, then exp(Y) has a log normal distribution. This distribution can be used to model nonzero positively skewed data.

Long Term Care Database

A health administrative database containing records of chronic and rehabilitative services provided in Manitoba by long term care hospitals and personal care homes (including patients awaiting placement). Information is included on admissions, separations, assessments, levels of care and drug prescriptions. The LTC program at Manitoba Health, originally known as the Personal Care Home (PCH) program, which began July 1, 1973, changed as other forms of long term care became part of the program in the mid-1990s. Insured services include basic nursing care and assistance with, or supervision of, activities of daily living. All pharmaceuticals are supplied.

Marital Status

The Manitoba Health registry includes the categories: married, single, and widowed.

Matching (Moments and Percentile)

This is one of the methods used in obtaining parameter estimates of a statistical model by equating the theoretical and empirical moments or percentiles. For moment matching for instance, the theoretical mean or standard deviation will be equated to the empirical mean or standard deviation. For percentile matching, the theoretical mode, for example, will be equated to the empirical mode.

Maximum Likelihood Method

This a method of obtaining the parameter estimates of a statistical model by maximizing the likelihoods (probabilities).

Modelling

A statistical approach to looking at relationships between variables. There are two major stages in modelling—the model specification and the development of estimates. The specification stage involves the testing of theoretically relevant variables to see if they actually predict differences in an outcome. Once the variables that will be used in the model are selected (i.e., the characteristics that are both theoretically relevant and have been found to predict the outcome), weights for each of the variables are developed.

National Population Health Survey (NPHS)

Administered by Statistics Canada, this survey collects sample information related to the health of the Canadian population and related socio-demographic information. It is composed of three components: the Households, the Health Institutions, and the North components. The survey excludes populations living in Indian Reserves, on Canadian Forces Bases, and in some remote areas

Newborn Separation Abstract

Contained in the hospital abstract database and includes information on birthweight, the Apgar scores at 1 and 5 minutes, gestational age, and numerous ICD-9-CM diagnostic codes describing neonatal morbidity.

Panelled

The point at which a person is assessed as needing Personal Care Home placement.

Per Capita

An amount (often, though not always dollars) that is usually expressed per person, but may also be per hundred people, per thousand, or per hundred thousand.

Personal Care Homes

Residential facilities for predominantly older persons with chronic illness or disability, also known as nursing homes. They may be proprietary (for profit) or non-proprietary. Non-proprietary PCHs may further be classified as secular or ethno-cultural (associated with a particular religious faith or language other than English) as well as either freestanding or juxtaposed with an acute care facility. In order to be admitted to a PCH an application form must be completed and reviewed by a panel which determines whether the person requires admission. Many persons who apply to enter a PCH have been home care clients for a considerable period of time, but their care needs have become too great to manage in the community. They generally continue to receive home care until admitted to a PCH.

Personal Care Home Resident

In this study, a personal care home resident was measured by the number of days they resided in a personal care home, weighted by their level of care.

Population Density

A census definition used to distinguish between urban and rural areas. "Urban" represents continually built up areas with a population concentration of at least 1,000 and a population density of 400 persons or more per square kilometre (per 256 acres) based on the previous census. Areas with less than 400 persons per square kilometre are designated as "rural" areas. For this study, 2001 Census data were used.

Population Size

For this study, the number of people living within the geographic area as of the 2001 Census.

Potential Years of Life Lost (PYLL)

An indicator of premature mortality (death between the ages of 1 and 75), that gives greater weight to causes of death occurring at a younger age than to those at later ages. This measure is calculated by subtracting the actual age of death from 75, dividing the total potential years of life lost by the total population under age 75, and then presented as "years lost per thousand people." By emphasizing the loss of life at an early age, PYLL focuses attention on the need to deal with the major causes of such early deaths - cancer, accidents and cardiovascular disease - in order to improve health status. PYLL has also been found to vary with characteristics such as sex, socioeconomic status and place of residence.

Premature Mortality Rate (PMR)

The rate of deaths of residents aged 0-74 years, per 1,000 residents aged 0 to 74 years. When comparing PMR for different areas the values are standardized to account for age/sex differences in populations. PMR is an important indicator of the general health of a population; high PMR indicates poor health status.

Research Registry

Contains longitudinal population-based information for all individuals eligible or registered for health insurance benefits through the Manitoba Health Services Insurance Plan. Snapshot population registries are generated by Manitoba Health for administrative purposes, typically relevant for a short period of time and used by various claim-processing systems to verify eligibility requirements. These snapshots are combined to create a longitudinal population registry such that individual histories can be constructed over the entire period of the database. Every family is assigned a family registration number, and every individual is assigned a unique Personal Health Identification Number (PHIN) by the Ministry of Health. Histories generated using encrypted versions of these identifiers permit following individuals across time and across databases. This information helps to distinguish between those individuals with no contact with the health care system, those lost to follow-up (ineligibility associated with leaving the insurance plan), loss of continuity (two or more unlinked registrations over time for the same person), and mortality. The PHIN included in the research registry has been encrypted to protect privacy, but it does permit record linkage.

Risk Adjustment

A process used most frequently in the insurance industry to recognize that some individuals or groups may require more costly healthcare than others. Risk adjustment considers past utilization of services and basic demographic information (i.e., age and sex) as predictors of future cost of care.

Sensitivity Analysis

A procedure for assessing the robustness of a model through changing parameters.

Separation

A separation from a health care facility occurs any time a patient (or resident) leaves because of death, discharge, sign-out against medical advice or transfer. The number of separations is the most commonly used measure of the utilization of hospital services. Separations, rather than admissions, are used because hospital abstracts for inpatient care are based on information gathered at the time of discharge. Both inpatient and surgical outpatient records are included. The terms 'separation', 'discharge', 'hospital discharge', 'hospital separation' and 'stay' are used interchangeably.

Socio-Economic Factor Index (SEFI)

A score based on census data that reflects non-medical social determinants of health and includes factors such as age, single parent status, female labour force participation, unemployment and education. SEFI is calculated at geographic level of Dissemination Area (DA) and then assigned to residents based on their postal codes. SEFI scores less than zero indicate more favourable socioeconomic conditions, while SEFI scores greater than zero indicate less ideal socioeconomic conditions.

Socioeconomic Status

Characteristics of economic, social and physical environments in which individuals live and work, as well as demographic and genetic characteristics (MCHP Concept Dictionary accessed 2006-12-27). In this study, socioeconomic status was measured using the Socio-Economic Factor Index (SEFI).

Tertiary Care

Care that requires highly specialized skills, technology, and support services. This care is often only provided in a small number of locations.

APPENDIX A: Technical Method

A.1 Hierarchical Generalized Linear Models

This section describes the random intercept model of the hierarchical generalized linear models (HGLM). HGLM is an extension of hierarchical linear models (HLM) (Raudenbush and Bryk, 2002; Snijders and Bosker, 1999). As mentioned in the Methods Section of this report, individuals shall be referred to as level 1 and communities as level 2.

Hierarchical data structures can be described in two ways namely: (1) level by level representation and (2) composite representation (Snijders and Bosker, 1999). In level by level representation, separate regression equations are written for each level of the hierarchy of the study. This type of representation makes for easy interpretation of the outputs. In the composite representation, the different regression equations for all levels of the hierarchy are combined into one. This approach provides an alternative way of codifying hypotheses and is the one that is commonly used in most statistical software. We shall present both approaches in this section.

The random intercept model is a special case of HLM and HGLM. This model can be specified with or without predictors. When specified without predictors, the model is otherwise known as empty, null, or unconditional means model. It serves as a benchmark with which other models are compared. Using level by level representation, the level 1 sub-model of this model for the i^{th} individual in the j^{th} community is:

$$Y_{ij} = \beta_{0j} + \varepsilon_{ij}, \qquad \text{where } \varepsilon_{ij} \sim N\left(0, \sigma_e^2\right). \tag{1}$$

Equation (1) expresses the level 1 outcome Y_{ij} (hospital cost, weighted PCH days, and Home Care days) as function of the intercept β_{0j} and a random error ε_{ij} associated with the i^{th} individual in the j^{th} community. The level 2 sub-model for the j^{th} community is given by:

$$\beta_{0j} = \beta_{00} + u_{0j}, \qquad \text{where } u_{0j} \sim N\left(0, \sigma_u^2\right). \tag{2}$$

This equation expresses the level 2 intercepts β_{0j} as a function of the overall mean β_{00} and random deviations u_{0j} from that mean. The composite model is:

$$Y_{ij} = \beta_{00} + u_{0j} + \varepsilon_{ij}, \qquad \text{where } \varepsilon_{ij} \sim N\left(0, \sigma_e^2\right) \text{ and } u_{0j} \sim N\left(0, \sigma_u^2\right). \tag{3}$$

This is obtained by substituting (2) into (1). From (3) the dependent variable Y_{ij} can be said to be partitioned into two parts: the fixed part β_{00} and the random part u_{0j} and ε_{ij}. Hence, the model partitions the total variation in the dependent variable into variation within communities and across communities.

The Random Intercept Model With Predictors

If level 1 predictors are added to equation (1) we have:

$$Y_{ij} = \beta_{0j} + \sum_{p=1}^{P} \beta_{p0} X_{pij} + \varepsilon_{ij}, \qquad \text{where } \varepsilon_{ij} \sim N\left(0, \sigma_e^2\right). \tag{4}$$

Adding level 2 predictors to equation (2) gives:

$$\beta_{0j} = \beta_{00} + \sum_{q=1}^{Q} \beta_{q1} Z_{qj} + u_{0j}, \qquad \text{where } u_{0j} \sim N\left(0, \sigma_u^2\right). \tag{5}$$

The composite model is obtained by substituting (5) into (4).

$$Y_{ij} = \beta_{00} + \sum_{p=1}^{P} \beta_{p0} X_{pij} + \sum_{q=1}^{Q} \beta_{q1} Z_{qj} + u_{0j} + \varepsilon_{ij}, \quad \text{where } \varepsilon_{ij} \sim N\left(0, \sigma_e^2\right) \text{ and } u_{0j} \sim N\left(0, \sigma_u^2\right). \tag{6}$$

In equations (1) to (6), if the distribution of Y_{ij} is normal, then we have HLM otherwise we have HGLM.

Implementation of HLM and HGLM in SAS®

The implementation of HLM in SAS® is accomplished using PROC MIXED, while HGLM is performed using PROC NLMIXED.

Model goodness-of-fit

All final models were first run without the random intercept using SAS® PROC GENMOD and the goodness-of-fit statistics were assessed by the value of deviance divided by the degrees of freedom. For models with random intercept, their goodness of fit was assessed by using the likelihood ratio test (LRT), which is computed as the -2 times the natural logarithm of the difference between two models (Snijders and Bosker, 1999). In this case, the null hypothesis is the final model without random intercept and the alternative is the final model with random intercept. A statistically significant LRT indicates that the model with random intercept is a better fit than the one without and that even after controlling for the effects of the independent variables in the model, the differences between community areas are strongly significant. The models with random intercepts were implemented in SAS® PROC NLMIXED and their LRTs are all statistically significant for hospital cost of care, weighted PCH days and days of an open home care file.

A.2 Adjustments to modelled proportions

Once the parameter estimates had been applied to the users, it was necessary to make adjustments to:

1. account for hospital reciprocal billings
2. recognize that people travel from one region to another to receive inpatient hospital and day surgery care
3. account for proprietary PCH costs, which are paid by the Winnipeg Regional Health Authority for facilities that are located in other regions.

Following is a description of the steps that were involved in arriving at the final proportions.

Inpatient hospital and day surgery care

For the "All services received in home region" approaches:

1. Modelled proportions are multiplied by the total 2003/04 hospital expenditures for all regions.

2. An amount equivalent to the actual 2003/04 reciprocal billings for services provided by the region and collected by MB Health is added.

3. The proportion of total expenditures is re-calculated (base amount + reciprocal billing amount).

This is the proportion for each region, assuming everyone receives their services in their home region.

For the Inter-Regional Movement approaches:

1. The predicted expenditures for each region are "re-distributed" according to where the actual per cent of costs incurred in 2001/02 - 2003/04, i.e., if 10% of the cost for hospital inpatient and day surgery care for the residents of a region were incurred in another region, 10% of the predicted expenditures would be allocated from one region to another.

2. Adjusted predicted proportions for services provided in each region are calculated.

3. Adjusted proportions are multiplied by the total hospital expenditures for all regions.

4. An amount equivalent to the actual 2003/04 reciprocal billings for services provided by the region and collected by MB Health is added.

5. The proportion of total expenditures is re-calculated (base amount + reciprocal billing amount).

This is the proportion for each region, assuming people follow similar patterns of movement to receive services.

Personal Care Home

For the "All services received in home region" approaches (people are assigned to their home region according to the region in which they lived prior to PCH admission):

1. Modelled proportions are multiplied by the total 2003/04 PCH expenditures for all regions.

2. The proportion of bed days in proprietary PCHs in each region is multiplied by the total modelled expenditures. This is subtracted from each of the regions and added to Winnipeg.

3. The proportion of total expenditures is recalculated (base amount +/- proprietary PCH amount).

For the Inter-Regional Movement approaches (people are assigned to their home region according to the region of the PCH in which they reside):

1. Modelled proportions are multiplied by the total 2003/04 PCH expenditures for all regions.

2. The proportion of bed days in proprietary PCHs in each region is multiplied by the total modelled expenditures. This is subtracted from each of the regions and added to Winnipeg.

3. The proportion of total expenditures is re-calculated (base amount +/- proprietary PCH amount).

Home Care

No adjustments were made.

Moving from modelled proportions to final results – Population-Based Approach

Parameters were applied to every individual in the Registry, not just those who were users of services.

The same adjustment process was followed as above.

APPENDIX B: Detailed Results

The predicted proportion for each RHA is obtained as total predicted value for that RHA divided by the total predicted value for the entire province. The predictive model for inpatient hospital and day surgery costs is:

$$\log\left(\hat{y}_{\text{hosp}}\right) = 6.7460 + 0.07279(\text{sex}) - 0.00726(\text{age}) + 0.000176(\text{age x age}) + 0.06987(\text{sefi}) + 1.3935(\text{death}) - 0.1384(\text{newborn}) + 1.8517(\text{atriskbaby}) + 0.1249(\text{ADGsum}) + 0.6089(\text{injury}) + 0.1759(\text{chronic}) - 0.02879(\text{majorurban}) - 0.2798(\text{majornorth}) - 0.03114(\text{majorsouth}) + \hat{u}_{\text{hosp}},$$

where $\hat{y}_{\text{hosp}}$ is the predicted health care costs for an individual and $\hat{u}_{\text{hosp}}$ is the deviation of each level 2 (community area) from the overall mean.

Thus, the predicted inpatient hospital and day surgery cost for an individual is $\exp\left(\hat{y}_{\text{hosp}}\right)$.

The predictive model for PCH residents ages 70 and above is:

$$\log\left(\hat{y}_{\text{pch}}\right) = 6.9596 - 0.1097(\text{sex}) + 0.001524(\text{age}) + 0.01134(\text{sefi}) + 0.1181(\text{marital status}) - 0.5365(\text{death}) - 0.02818(\text{ADGsum}) + \hat{u}_{\text{pch}},$$

where $\hat{y}_{\text{pch}}$ is the predicted weighted days for an individual and $\hat{u}_{\text{pch}}$ is the deviation of each level 2 (community area) from the overall mean.

Thus, the predicted weighted days for an individual who is aged 70 or over is $\exp\left(\hat{y}_{\text{pch}}\right)$.

The predictive model for days of home care is:

$$\log\left(\hat{y}_{\text{hcare}}\right) = 4.7231 - 0.06054(\text{sex}) + 0.006248(\text{age}) - 0.03016(\text{sefi}) - 0.1140(\text{marital status}) - 0.5780(\text{death}) - 0.0260(\text{ADGsum}) + 0.4826(\text{chronic}) - 0.00031(\text{hospital days}) + \hat{u}_{\text{hcare}},$$

where $\hat{y}_{\text{hcare}}$ is the predicted days of home care for an individual and $\hat{u}_{\text{hcare}}$ is the deviation of each of the level 2 (community area) from the overall mean.

Thus, the predicted days of home care for an individual is $\exp\left(\hat{y}_{\text{hcare}}\right)$.

The parameter estimates are found in Table A.1 and the values used for u_{hosp}, u_{pch}, and u_{hcare} are found in Table A.2.

Table A.1: Model Parameter Estimates

Variables	Hospital Inpatient and Day Surgery Cost	P-value	Personal Care Home Weighted Days	P-value	Home Care Case Days	P-value
Intercept	6.746	<.0001	6.960	<.0001	4.723	<.0001
Sex	0.073	<.0001	-0.110	<.0001	-0.061	<.0001
Age	-0.007	<.0001	0.002	0.0082	0.006	<.0001
Age * Age	0.0001	<.0001				
Socio-Economic Status	0.070	<.0001	0.011	0.177	-0.030	0.0155
Died during the year	1.394	<.0001	-0.537	<.0001	-0.578	<.0001
Newborn during the year	-0.138	<.0001				
Comorbidities	0.125	<.0001	-0.028	<.0001	-0.026	<.0001
Injury hospitalization during the year	0.609	<.0001				
Chronic disease	0.176	<.0001			0.483	<.0001
Proximity to major urban hospital	-0.029	0.0148				
Proximity to major northern hospital	-0.280	<.0001				
Proximity to non-urban major southern hospital	-0.031	0.0022				
At risk newborn	1.852	<.0001				
Marital status			0.118	<.0001	-0.114	<.0001
Hospital days					-0.0003	0.0003

Table A.2: Random Effects (Deviation of the community value from the overall mean)

RHA	Community	Hospital Costs	PCH Weighted Days	Days with an open Home Care file
Central	Cartier/St François Xavier	0.055	-0.008	-0.137
Central	Portage	-0.126	-0.023	-0.002
Central	Seven Regions	-0.099	0.005	0.101
Central	Carman	-0.139	-0.009	0.038
Central	Swan Lake	-0.104	-0.004	-0.004
Central	Louise/Pembina	-0.032	-0.019	-0.077
Central	Morden/Winkler	-0.089	-0.002	0.030
Central	Altona	-0.045	0.023	-0.063
Central	Red River	-0.064	-0.027	0.017
North Eastman	Blue Water	-0.221	-0.016	0.180
North Eastman	Brokenhead	-0.159	-0.008	0.087
North Eastman	Iron Rose	0.057	-0.030	0.152
North Eastman	Springfield	0.041	-0.006	0.061
North Eastman	Northern Remote	0.190	0.003	-0.230
North Eastman	Winnipeg River	0.174	-0.013	0.082
South Eastman	Central	-0.116	0.011	0.075
South Eastman	Northern	0.032	-0.029	0.121
South Eastman	Southern	-0.077	0.016	0.063
South Eastman	Western	-0.045	0.034	0.033
Interlake	Northeast	-0.111	-0.045	0.043
Interlake	Northwest	-0.094	0.020	0.104
Interlake	Southeast	-0.038	0.071	0.096
Interlake	Southwest	-0.018	0.007	0.023
Nor-Man	Flin Flon/Snow Lake/Cranberry Portage	0.244	-0.054	0.063
Nor-Man	The Pas/Opaskwayak Cree Nation/Kelsey	0.032	-0.017	0.109
Nor-Man	Nor-Man Other	-0.088	-0.001	0.165
Parkland	Central	-0.245	-0.039	0.017
Parkland	East	-0.276	-0.006	0.172
Parkland	North	-0.238	-0.028	0.140
Parkland	West	-0.062	-0.022	0.042
Burntwood	Thompson	0.030	-0.017	-0.161
Burntwood	Lynn Lake/Leaf Rapids/South Indian Lake	0.235		0.130
Burntwood	Gillam/Fox Lake	0.424	0.002	-0.062
Burntwood	Nelson House	-0.208		-0.017
Burntwood	Norway House	-0.096	-0.003	-0.127
Burntwood	Cross Lake	0.003	-0.005	-0.102
Burntwood	Island Lake	0.281	0.010	-0.236
Burntwood	Thicket Portage/Pikwitonei/Waboden	-0.071	-0.001	0.042
Burntwood	Tadole Lake/Brochet/Lac Brochet	-0.114		-0.042
Burntwood	Oxford House & Gods Lake	-0.093	0.005	-0.119
Burntwood	Shamattawa/York Landing/Split Lake/War Lake Band	0.042		-0.165

RHA	Community	Hospital Costs	PCH Weighted Days	Days with an open Home Care file
Churchill	Churchill	0.069		0.027
Brandon	Rural	-0.156	0.033	-0.109
Brandon	East	-0.037	0.000	-0.106
Brandon	West	-0.155	0.005	-0.228
Assiniboine	North 1	-0.121	-0.032	-0.029
Assiniboine	North 2	-0.166	-0.018	0.006
Assiniboine	East 1	-0.216	-0.072	0.009
Assiniboine	East 2	0.053	-0.012	-0.027
Assiniboine	West 1	-0.186	-0.114	-0.044
Assiniboine	West 2	-0.105	-0.138	-0.008
Assiniboine	South	0.019	0.031	-0.022
Winnipeg	Transcona	0.055	0.040	-0.002
Winnipeg	St. James - Assiniboia W	0.022	0.011	0.010
Winnipeg	St. James - Assiniboia E	0.060	0.020	-0.005
Winnipeg	Fort Garry N	0.030	0.021	-0.040
Winnipeg	Fort Garry S	0.020	0.056	-0.072
Winnipeg	St. Vital North	0.086	0.002	0.001
Winnipeg	St. Vital South	0.031	0.029	-0.064
Winnipeg	St. Boniface W	0.250	-0.007	-0.012
Winnipeg	St. Boniface E	0.123	0.016	-0.128
Winnipeg	River East S	0.058	0.018	0.018
Winnipeg	River East W	0.063	0.011	0.046
Winnipeg	River East E	0.017	0.025	-0.117
Winnipeg	River East N	0.012	-0.003	-0.080
Winnipeg	Seven Oaks W	0.113	0.020	-0.002
Winnipeg	Seven Oaks E	0.118	0.042	0.072
Winnipeg	Seven Oaks N	0.095	0.027	-0.053
Winnipeg	Inkster West	0.164	0.023	-0.062
Winnipeg	Inkster East	0.137	0.007	0.063
Winnipeg	Point Douglas N	0.094	-0.008	0.045
Winnipeg	Point Douglas S	0.125	0.028	0.053
Winnipeg	Downtown W	0.172	0.024	0.075
Winnipeg	Downtown E	0.274	0.056	0.106
Winnipeg	River Heights W	0.077	0.024	0.017
Winnipeg	River Heights E	0.143	0.046	-0.020

The user-based approach for determining the predicted proportion of hospital inpatient and day surgery costs, weighted PCH days, or home care days applies the predictive models on the entire population of users. The population approach applies the predictive models to the whole population; in the case of this work, the population of Manitoba on July 30, 2004.

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