

Healthcare Services in Nova Scotia: A Conceptual Model to Optimize Resource Allocation
and Reduce Waiting Time in Homecare Services.

By
Rita Joseph Beainy

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Approved: Dr. Michael Zhang
Supervisor

Approved: Dr. Mark Raymond
Associate Dean
Masters Programs

Date: December 6, 2012

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Abstract

Abstract: This research provides a review of healthcare services in Nova Scotia, specifically continuing care. The research examines a variety of existing challenges, and possible solutions to waiting times in continuing care services for seniors. Homecare support is proposed as a probable solution to address significant challenges resulting from aging population. The research also presents a brief overview of existing literature for optimizing healthcare operations. Finally a conceptual mathematical model is discussed with the objective of reducing waiting times for homecare services, while minimizing the overall costs of the homecare support system.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

According to the 2011 Canadian population census 14.4% of Canadians are aged 65 and older. This number is expected to increase rapidly and reach almost 23% by the year 2031. Among provinces, Nova Scotia holds the highest number of seniors with a 16.5% of its population aged 65 and older (Statistics Canada, 2011).

The wait times for a bed in a long term care facility in Nova Scotia varies between 86 days to 238 days (Continuing Care Strategy, 2011). Nova Scotia's long term care has 6968 operational beds in long term care facilities, 36 of which are respite beds (Nursing Homes and Homes for The Aged Accurate Bed Count, 2012). According to a Nova Scotia Department of Health report issued in 2011, the number of people on the long term care waiting list increased by 35.5%, from 1,284 in 2007 to 1,740 in 2010. The waiting list increased, despite the commitment from Nova Scotia's Department of Health and Wellness's to increase long term beds by 1000 units from year 2006 to year 2010 (The Chronicle Herald, 2011).

The province of Nova Scotia has an estimated debt of \$13.1 billion according to the 2011 provincial budget (Nova Scotia Provincial Budget, 2011). The Nova Scotia provincial healthcare budget was also cut by 3% in 2011. The budget cuts indicate that the government will not be able to increase the capacity in long term care at a rate to keep up with our aging population. This situation, if not remedied, will result in even longer waiting times. Low budgets will also have a negative effect on the availability and the

quality of healthcare employees. Healthcare providers will eventually move to other provinces or industries with more attractive employment opportunities. The healthcare crisis is not exclusive to Nova Scotia.

Long waiting times to nursing homes have caused a crisis in hospitals across Canada. Seniors, who are recovering from a health episode but no longer need acute medical care, are left waiting in hospital beds till an appropriate post-acute discharge location is available. These elderly people who require an alternate level of care (ALC) are also referred to as “Bed Blockers”, though many have debated the ethical implications of using this term. According to the “Center for Health Services and Policy Research”, it is estimated that ALC patients occupy almost 14% of acute care beds in hospitals. In 2010 the Canadian federal government spent around 29% of the healthcare budget on hospitals; those expenses are expected to increase with the ALC patients’ crisis (Acute Care, 2010).

Long waits in hospital wards also have an adverse effect on the health and morbidity of ALC patients, since they don’t get the care and support needed for their wellbeing. The long waits of ALC patients are also causing a public health and safety crisis. People in need of acute care in emergency rooms sometimes find themselves waiting for a vacant bed at hospitals. This indicates that the risks of health deterioration and morbidity for these patients will increase.

1.1.1 Long waiting times in continuing care

Governments in Canada are facing a critical situation in the healthcare sector. Rapidly aging populations across provinces are requiring more resources for healthcare,

specifically for continuing and long term care. However, with limited funding and budget deficits, provincial and federal governments are not able to match the demand for healthcare with the adequate amount of resources. Governments have to look for new solutions to deal with this problem. Since increasing resources significantly is a constraint, the proposed solutions should include alternative services to nursing homes. Homecare support services could be a possible alternative to nursing homes. The developed solution should be able to reduce waiting times for nursing home to acceptable levels.

In the second section of this chapter we talk about actions that provincial governments across Canada have used or could possibly implement, to solve waiting time issues in continuing care facilities. The third section demonstrates the construct of the continuing care healthcare system specifically in Nova Scotia. The fourth section discusses the structure of homecare support in Nova Scotia, and it lists the services that fall under homecare support and nursing activities. The fifth section explores challenges that face homecare support systems in Nova Scotia and other provincial governments. Finally, the sixth and last section in this chapter raises a number of questions that are worth future research in the area of homecare services and waiting times in healthcare.

1.2 POSSIBLE GOVERNMENT INITIATIVES TO SOLVE NURSING HOME WAITING TIMES

Provincial governments have implemented and explored a number of solutions to address the issue of long waiting times in nursing homes. These solutions include short

term restorative beds or facilities, capacity and process optimization models and an integrated holistic homecare system

1.2.1 Short term restorative beds or facilities. To address the issue of ALC patients in hospital beds, the minister of health in Ontario proposed creating interim or short term restorative beds in existing retirement homes and nursing homes, for those seniors who no longer require acute emergency services. ALC seniors can move to interim beds till they recover fully and go home, or till they can find a bed in a nursing home of their choice (Adler, Follert, & O’flanagan, 2010). However, long term care (LTC) facilities are already at their maximum capacity and cannot allocate substantial resources for interim beds.

A more effective long term solution might be for the government to establish Specialized Community Care Centers or units. These facilities provide post-acute care for individuals who need a few months, or more, in a supervised environment to recover from an acute health episode. The seniors admitted to these facilities should be able to go back and live in their homes and communities after their recovery. Nova Scotia has recently opened Community Care Units for the care of people recovering from mental illnesses (Health and Wellness, 2012). According to Hollander (2003) there is large overlap between the care needs of mental patients and seniors needing restorative care. Facilities available for patients recovering from mental illness can also be established to benefit seniors in need of restorative care and relieve some of the long waiting pressure.

1.2.2 Capacity and process optimization models. Long waiting lists cannot be reduced by only increasing the capacity of nursing homes and residential care facilities. Every year more and more Canadians are turning 65 and older. Moreover, federal and

provincial governments' resource limitations do not allow capacity to increase at a matching rate. To make up for the public health services resource limitations, there has been an increase in the number of for-profit private healthcare services providers at the provincial level (Palley, Pomey, & Forest, 2011). The rationale behind privatization is that the public sector lacks the ability to finance the extent of services needed by the Canadian people. It is argued that the private sector is needed to maintain the market efficiency (Makie, 2001). However, Canadians have many concerns regarding privatization. The provision of certain services by the private sector can cause "load-shedding". This implies that provinces will then remove those healthcare services provided by privatization from the package of necessary health services of the provincial public system (Deber, 2002).

Governments could also formulate and implement strategies for improving and streamlining operations at LTC facilities. Service quality and waiting times could be improved by effective scheduling and staffing processes, quality control as well as using right optimization models for capacity and location decisions.

1.2.3 Integrated holistic homecare support system. With the LTC challenges rising in provinces across Canada, governments need solutions that would decrease the demand for nursing homes and keep elderly people in their homes as long as possible. The new strategies for continuing care are more focused on building a holistic and Integrated Homecare Support system rather than just increasing capacity (Canadian Home Care Association, 2011). An integrated homecare support system is one which is viewed as an essential and integral part of the continuing care department. Homecare has been viewed as an added expense and separate service to continuing care, and not as a

substitute for existing long term care services. An integrated homecare support system considers homecare services as primary means of care rather than complementary services. Homecare support systems make it possible for people to receive needed care at home, thus preventing extended stays in acute care facilities. This in turn could decrease the waiting time for nursing homes and prevent the use of emergency services and acute care facilities for treatment of elderly people. This can also indicate that homecare support could in turn decrease government costs.

Studies and research done by Dr. Marcus J. Hollander show that clients and care givers satisfaction, as well as the quality of the services provided have no significant variations between homecare and institutions; results were even more favorable for homecare in some cases (Hollander M. , 2001). Research also indicates that a large number of seniors prefer to age at home (Kucharska, 2004). According to a research conducted by Professor Don Shiner of Mount Saint Vincent 93% of Atlantic Canadian seniors prefer to stay at home (SSHRC, 2011). Therefore, using homecare as an integrated effective system to substitute, in some cases, facility care and nursing home services is probably the optimal solution to the long waiting times, governments of Canada are currently suffering from.

1.3 OVERVIEW OF NOVA SCOTIA'S CONTINUING CARE SYSTEM

To understand the role of the homecare support system, it is imperative to understand the construct of long term care and continuing care systems. In Nova Scotia, long term care is delivered through residential care and community care facilities, nursing homes and homecare support.

1.3.1 Residential care facilities. Residential Care Facilities (RCF), also known as community care facilities in Nova Scotia, are living units that provide personal care services, illness supervision and community skills and activities to seniors who are ambulatory or semi-ambulatory and do not have major health needs. However, Residential Care Facilities do not provide professional nursing services (Health Association, 2012)

1.3.2 Nursing homes. Nursing homes provide long term accommodation, personal care as well as professional nursing services to seniors who require 24/7 high level medical care. Nursing homes aim at improving the overall life quality of the elderly. They provide support activities such as spiritual services, recreational therapy and nutritional care (Health Association, 2012).

1.3.3 Homecare support. The homecare and support system provides services such as personal care, home keeping and respite, professional nursing services and home oxygen. Homecare services are not meant to replace the existing informal care provided by family, friends and community, they are only meant to add help. Homecare support is usually associated with assisted living care. However, in Nova Scotia, the two services are distinct. Homecare services are delivered in the homes and communities of the clients. Assisted living facilities on the other hand are similar to retirement homes in the services they provide. Seniors living in assisted living facilities are mostly independent and do not need professional care (Continuing Care Strategy, 2011)

1.4 OUTLINE OF NOVA SCOTIA'S HOMECARE SUPPORT MODEL

According to Nova Scotia's Department of Health and Wellness policy, all District Health Authority homecare programs should provide acute, chronic and palliative homecare services to patients in need.

1.4.1 Acute homecare. This is a short term service provided only to patients who are recovering from an acute health episode. These patients are in a stable medical condition and can be stabilized with monitoring, or minimal intervention from specialized and skilled nurses, for a short period of time.

1.4.2 Chronic homecare. This is an ongoing service that can be categorized into supportive care, maintenance care, and/or rehabilitative care. The services provided are neither acute nor palliative. Chronic homecare services are focused on supporting the client to have a successful life at home and in the community.

1.4.3 Palliative homecare. This is an end-of-life service provided to people who are terminally ill, and where life prolongation is no longer the goal (Nova Scotia Department of Health and Wellness, 2011).

Nova Scotia's Department of Health and Wellness lists the services available under its homecare program, and it also defines what services are categorized as nursing activities.

1.4.4 List of available homecare services. The Canadian Research Network for Care in the Community (CRNCC) and a report from the Provincial Steering Committee for continuing care strategy show that the homecare services provided and delivered

under the Nova Scotia model are Assessment and Case Management; Nursing; Home Support Services such as Personal Care; Housekeeping and Meal Services; Respite Care and Home Oxygen (Greenwood, 2006, Provincial Steering Committee, 2008).

The tasks performed by nurses providing homecare services include treatments and procedures such as dressing changes, catheter care, and intravenous therapy; teaching and supervising self-care to clients receiving personal care or nursing services; teaching personal care and nursing procedures to family members and other caregivers; as well as providing services for personal care and respite when a patient is found to be in need of these services specifically by a specialized nurse (Nova Scotia Department of Health and Wellness, 2011).

1.5 CURRENT SITUATION AND CHALLENGES FACING THE HOMECARE SUPPORT SYSTEM

Homecare support faces a number of challenges that limit the service hours available and effectiveness of this system.

1.5.1 Increasing costs and limited funding and resources. Demand for homecare is increasing due to the increasing aging population and limited spaces in nursing homes. Subsequently homecare costs will rise due to this increased demand. Homecare costs continue to escalate due to increased demand, increased costs of human resources and a growing need for equipment and technology to deliver homecare services.

1.5.2 Inconsistent access to core services. Homecare services offered vary within regions and among provinces across Canada. Variations among provinces are related to the type of service offered, fees paid, public coverage of drug costs, supplies, equipment and the minimum amount of homecare a client can receive. Differences among regions also occur due to geographic dispersion. Rural areas for instance have less access to homecare services and suffer from a scarcity of human resources for professional caregivers. According to a 2003 healthcare survey, this inconsistent access to core homecare services has left 35% of Canadians dissatisfied with home and community services (Health Care Canada, 2003).

1.5.3 Insufficient homecare services in rural and remote communities. Canadians living in rural and remote areas have difficulty accessing homecare services. This issue has not been well addressed by policy maker (Health Canada, 2001). Perhaps one of the most challenging difficulties in delivering homecare services in rural communities is the scarcity of professional staff. This makes recruitment and retention of employees by providers really difficult. The government on the other hand faces the challenge of delivering a cost effective and efficient healthcare service to remote and rural regions. The mentioned challenges, as well as the absence of family members' support in remote areas, has caused seniors to leave their homes and move closer to where homecare services are readily available (Canadian Home Care Association, 2008).

1.5.4 Shortages in human resources. Lack of professional health and social care human resources is one of the major challenges facing all Canadian provinces. The staff shortages aggravate the already long waiting lists for services. It also negatively affects the quality of care provided, since caregivers are overloaded with work and cannot

perform as per standards or do follow up visits. Some reasons causing staff shortages are the difference in wages between institutions and community service; higher security and fulltime stability in institutions; and the higher rate of employment from institutions (Anderson & Parent, 2000).

1.5.5 Existing layout of seniors' houses. One of the biggest barriers for seniors to stay at home is the layout of their houses. To make it possible for seniors to be somehow independent, or require minimal assistance, their houses should have safety standards such as first floor bathrooms and bedrooms, chair lifts, walk-in bathtubs and living spaces that can accommodate a wheel chair (SSHRC, 2011).

1.5.6 Insufficient government paid homecare hours. The government of Nova Scotia provides subsidized homecare services to seniors and citizens who are found to require assistance in their daily life activities, in order to help them to continue living safely in their homes. However the number of hours provided by the Department of Health in Nova Scotia are limited to a maximum of 3 hours per month for homemaking; 4.5 hours per week for personal care; and 2 hours per a week for meals services. These scarce hours are provided for the neediest only. A substantial number of seniors who need moderate assistance at home are left to pay for private homecare support from their own money (Manulife Financial & Takingcare Inc., 2010). Seniors who can't afford such services are then pushed to move into nursing home to get the needed care.

1.5.7 Lack of homecare integration in the healthcare system. Perhaps one of the biggest challenges facing homecare is the lack of integration in the provincial and federal continuing care healthcare systems. Homecare is perceived as an added expenditure and not substitute services that could lead to less utilization of facility

resources, and hence cut costs. There is a large overlap in the services needed by seniors, persons with disabilities and chronic mental and health conditions. A well structured and integrated homecare system can increase the efficiency in the processes that cater to the needs of these patients. Studies show that in some situations, home support might be a more efficient and cost effective substitute for acute care facilities and residential care. However, this lack of integration prevents policy makers from seeing the benefits that could come from delivering more homecare. It is viewed as an added expenditure that will increase costs in a time where budget reductions and constraints are pushing governments to limit the range of health services (Hollander, 2003).

1.5.8 Focus on short term, post-acute homecare rather than preventive long term homecare. Another major challenge is the governments' strategies that focus on delivering short term homecare services to post-acute patients. The goal is to release hospital beds and reduce costs, by providing less costly home services instead of expensive services in acute care facilities. However, this strategy doesn't address the causes that lead people into the acute care facility in the first place. This strategy only deals with the outcome and aims at decreasing hospital beds occupancy. Long term preventive care, on the other hand, has the ability to reduce acute health episodes of seniors, and hence decrease the demand for acute care facilities in the first place (Hollander, 2003).

1.6 RESEARCH QUESTIONS

1.6.1 *What is the optimal amount of resources the government should allocate to the homecare support system?* According to the new policy for the Department of Health and Wellness in Nova Scotia, the government is growing the homecare support services. What budget should the government allocate to homecare support, to minimize the overall costs in an acceptable waiting time frame?

1.6.2 *To what extent can homecare reduce waiting times in nursing homes?* We consider that seniors, who do not require extreme medical attention for 24 hours a day, prefer to stay at home rather than move into a nursing home. If the government increases the provided hours and services for homecare support, would that reduce the demand and waiting times for nursing homes? Moreover, given the fixed healthcare budget, how many resources should the government reallocate to homecare support to achieve a relevant decrease in nursing homes waiting times?

1.6.3 *What are the consequences on waiting times if the government relies mostly on nursing homes?* If homecare was not improved and grown as a substitute to nursing home services, what are the consequences on waiting times if the government doesn't have enough funds to increase the capacity in nursing homes in a way that matches demand? How much more resources would the government need to spend on new nursing homes beds, to accommodate the increasing demand and reduce waiting times?

1.6.4 *Will preventive homecare reduce government healthcare expenses in the long run?* If the government increases hours and services provided under preventive homecare support, would that improve the wellbeing and overall health of the aging

population who require a form of assisted living? How much would the government save in the long run, if it increased homecare support resources spent today? Will a population with better health require less continuing care in the future, and thus reduce the demand for nursing homes, and in turn future government spending?

1.7 PURPOSE OF THE STUDY

The purpose of this study is to provide policy makers with a model to reduce the waiting times for homecare, and evaluate the optimal amount of resources needed for homecare services to attain the new shorter waiting time. This research will specifically address the first question proposed in the previous section. The model suggested in chapter four is a mathematical model. It will solve for the optimal amount of resources needed to minimize homecare costs and homecare waiting times.

The proposed model is conceptual. Due to lack of available data, the research will provide a sensitivity study on the different variables of the model. The results generated from the sensitivity study will give policy makers possible estimates of resources the Nova Scotia government should spend on homecare to reduce waiting times to required levels.

Chapter two of this study will review the published literature on healthcare operations research. It will discuss most common models used to optimize healthcare processes and resource allocations.

CHAPTER II

LITERATURE REVIEW

2.1 HEALTHCARE OPERATIONS RESEARCH

Numerous new challenges face the healthcare industry today, a few of which were discussed in chapter one. For example, low birth rates in developed countries have led to an increasing aging population. Advanced medical treatments have also contributed in increasing the life expectancy for most seniors. This has also led to the development of diseases and illnesses that require new methods of treatment, as well as sophisticated technologies. The level of care expected for seniors has risen significantly, and the expenses paid by the governments for healthcare have dramatically increased. It is thus no surprise that healthcare optimization problems have attracted attention from operations researchers. The last few decades have seen a focus on research related to operations optimization for healthcare planning and healthcare management and logistics fields. The subsequent sections provide a brief literature review on the research done on these healthcare areas (Rias & Viana, 2010).

2.1.2 Healthcare planning. With the growing longevity and aging populations, governments' healthcare planning has gained importance. Governments should be well prepared to provide adequate and high quality service. To achieve that the right amount of resources should be made available. This requires an optimization of capacity planning, which depends on the demand for services, location planning and resource allocation.

2.1.2.1 Demand forecasting. To determine the right capacity of resources needed in the future, the government of Nova Scotia should be accurately forecast demand using either quantitative or qualitative methods. Demand for healthcare services, particularly nursing homes, is affected by a number of factors. These factors include the distance between the clients and healthcare centers and the cost of services offered. Generally, the further away the client is from a given facility, the less likely he/she will visit it. This causes a decrease in the demand for this facility. On the other hand, distance also plays a factor in determining the availability of staff for healthcare facilities in rural and distant areas. Employees find it hard to commute to work, and therefore, refuse to work in remote locations. Hence a facility short on staff might not be able to provide a full range of services, thus reducing the client's demand (Khan, Ali, Ferdousy, & Al-Mamun, 2001).

The cost of services for which the client would be charged is also a very critical factor in determining the level of demand. Not all services provided by the Department of Health and Wellness in nursing homes and healthcare centers are fully subsidized. Clients and patients are sometimes expected to pay a certain percentage of the cost. Higher charges tend to decrease the demand for certain healthcare services. An example of these services would be homecare support services mentioned in chapter one. The Nova Scotia government provides minimal subsidization for homecare services. Low subsidies cause seniors to demand less homecare assistance, since they don't have enough funds to buy it from private companies. It is very important to note that the cost of services utilized from a customer's perspective, include both the economic cost and social costs. The social costs are those incurred by the customer due to the availability or absence of services.

They also include the cost of delivering the service from the providers' side as well as the costs a client faces when he/she has to move from his/her community to access the healthcare facility (Khan, Ali, Ferdousy, & Al-Mamun, 2001).

One more significant factor to consider when forecasting and estimating demand, is the customers' perceptions regarding quality and availability of services in a certain healthcare center. This concern from clients is most prominent in their decisions regarding nursing homes. Families take great care in choosing long term care facilities for their loved ones. They usually prefer centers that are well reputed and commended for quality of services and care. Seniors sometimes opt to incur the social and economic costs of leaving their communities and traveling for long distances to be in a nursing home they perceive to be of premium reputation (Ager & Pepper, 2005).

2.1.2.2 Location selection. Once demand is forecasted, capacity planning is more optimized and healthcare providers then have the responsibility of selecting the right locations for healthcare centers. Location optimization aims at providing maximal coverage for all populations. Timely treatment is decisive in the level of recovery. Locations for healthcare centers should be within a pre-specified distance from populations. Opening healthcare facilities in rural areas are usually the most challenging, since accessibility is hindered by factors such as weather conditions and roads infrastructures. Planners should address those problems to find suitable geographically accessible and sustainable locations in remote regions. Moreover, the choice of location should take into consideration the availability and accessibility of employees. Facilities with staff shortages find it hard to provide a wide range of high quality services, since their limited employees are usually stressed and overworked (Rias & Viana, 2010).

2.1.3 Healthcare management and logistics. Healthcare management is concerned with the scheduling of resources and logistics, in particular nurse scheduling. It also involves the management of patient flows or also known as patient scheduling. In general, it is the strategic planning and scheduling processes in a healthcare center.

2.1.3.1 Patient flow management. Patient flow management and scheduling researches were aimed at maximizing the number of patients that go through the facility during a given time, in a way that balances the workloads of staff and physicians, and yet minimizes patient waiting times. Planners should first take into account the selection process of patients based on their condition. Then they assign the selected patients to appropriate employees. Finally they set the schedule for patients' flows during a determined period of time. Patient scheduling optimization models are also concerned with maximizing the utility of equipment. This helps in increasing efficiency and reducing costs. It also helps in reducing waiting times, and hence increasing the quality of services provided to clients (Ogulata, Koyuncu, & Karakas, 2008).

2.1.3.2 Resource scheduling. Optimization models for nurse scheduling have attracted the most attention in healthcare operations research. Nurse schedules are constrained by the availability of nurses, the different skills of each nurse and the hospital requirements per shift. Some other aspects that cause problems to setting nurse schedules are patients with special needs that require a certain skill set from the healthcare provider. Another issue arises when a patient requests the services from a particular nurse and no other. Finally, nurses might have situations where they are available to work only on certain days and shifts. These hard and soft constraints should be taken into consideration when allocating nurses to patients over a predefined period of time. When nurses are

expected to provide services to patients at home rather than in a facility, more aspects play a role in determining the optimal allocation model. One factor is the routing problem. Nurses should be able to access and visit the patients on his/her roster without difficulty or delay (Rias & Viana, 2010).

2.1.3.3 Logistics. Healthcare logistics determine the levels of stock needed as well as the allocation of available resources. Optimal stock levels are constrained by the available storage place, the critical levels of products and their related services as well as the costs of delivery. Logistics operations research has been concerned with streamlining processes and minimizing costs. In healthcare facilities, costs can be reduced by optimizing the flow of supplies from various departments to operation sites. Costs can also be cut back by implementing cost minimization models that centralize supplies in one location, and then distribute them to various facility and departmental locations. An example of such models is centralizing sterilization departments in hospitals. The central departments then distribute supplies to all other operation locations (Rias & Viana, 2010).

2.2 HEALTHCARE OPERATIONS RESEARCH MODELS

Increases in aging populations have led to higher costs of treatment in the healthcare industry, as well as higher demands for services. However, with constrained resources, researchers are constantly looking at finding ways to increase the efficiency of operations and reduce costs, yet at the same time improve the quality of healthcare services delivered. Developed optimization models aim to decrease the gaps between the capacity of resources available and the demand for healthcare services. These models aim to provide the widest range of services to the largest number of customers, using the

lowest cost possible. Optimization models mostly address resource scheduling, process optimization and location – allocation problems.

Process optimization problems have been solved using simulation models based on queuing theory. One example would be Wang et al. (2006) who developed a simulation system based on a queuing theory. Their model incorporated human factors, for healthcare organizations in Taiwan. The purpose of this study was to apply the model to improve and increase the effectiveness of hospitals operations.

Deciding on the optimal number of healthcare facilities, as well as selecting the optimal locations for these facilities are issues which have been addressed using simulation models as well as integer-programming models. Harper et al. (2005) provide a geographical simulation for location selection. Their model provides a practical viewpoint on where healthcare centers can be optimally opened. This geographical simulation model takes into account patient demand, patient access, patient preferences and the number of existing service centers and organizations. The optimal number of healthcare facilities is addressed in Smith et al. (2009). Their research puts forward a mixed integer program for deciding the optimal number of healthcare facilities. They also propose a top-down and bottom up hierarchal location model to maximize the efficiency of planning locations and resource allocations in healthcare in rural areas.

Resource allocation and scheduling issues have also been addressed using simulation and integer-programming models. Persson and Persson (2009) address the scheduling of surgery patients in a Swedish hospital. They developed a hybrid simulation and integer-programming approach that considered medical, economic constraints. Mathematical models are also popular in creating the optimal staffing schedules. Ogulata

et al. (2008) built hierarchal mathematical models which created staffing schedules in healthcare organizations. These models took into account the selection process of patients, the scheduling of patients throughout the day and the assignment of patients to specific staff members.

CHAPTER III
OVERVIEW OF RELEVANT FACTORS AND ASSUMPTIONS FOR OPTIMAL
SOLUTIONS

3.1 FACTORS INCLUDED IN MODEL

The resource allocation decision for homecare services and nursing homes is constrained by a number of factors which are listed in the following subsections.

3.1.1 List and cost of homecare services and nursing homes. Homecare services are categorized into three major divisions as previously described in chapter one. Those divisions are acute homecare, chronic or preventive home care and palliative home care. However, our research and proposed model focus on the basket of services under chronic homecare or also considered as preventive care, supportive care or maintenance care. The services that we recommend the government spend more resources on are neither acute nor palliative. The goal of these services is to support patients and keep them in their homes and communities for the longest time possible.

The services included in our proposed basket of homecare support are assessment and case management; basic nursing activities; support services such as personal care; housekeeping and meal services; respite care and home oxygen. The government of Nova Scotia estimates the cost per hour for homecare non-nursing services to be \$11.83. The government of Nova Scotia subsidizes 3 hours a month for homemaking, 4.5 hours weekly for personal care and 2 hours a week for meal preparation. In cases where clients need more than the maximum subsidized hours, they would have to purchase homecare services from private providers. Private care providers charge between \$10 to \$23 per

service hour, depending on the type of care and service delivered. On the other hand, the alternative for homecare services would be nursing homes. Nova Scotia nursing homes have an estimated cost of \$96 per day for board and meals. (Manulife Financial & Takingcare Inc., 2010)

3.1.2 Estimating the demand for homecare services and nursing homes. We are able to estimate the demand for people who will require long term care in Nova Scotia by considering the future projections of people turning 65 and older. According to the provincial government's Annual Accountability Report for the Fiscal 2011-2012 there were 23,423 people receiving homecare services in Nova Scotia (Nova Scotia Health and Wellness, 2012). Statistics Canada (2011) latest census of Nova Scotia shows that there are 153,370 people aged over 65. Assuming that all people who received homecare in the given year are over 65, we can estimate that almost 15% of the senior population was provided with assistance to remain in their communities.

Based on the provincial number of seniors who received homecare hours in 2011, and considering that the provincial government has increased the budget for homecare services by \$20 million for the next year, we can subsequently estimate that 17% of seniors will be interested in demanding homecare services in 2012-2013 rather than move to a nursing home. Therefore, the estimated numbers of seniors who might be applying for a nursing home bed are 127,297 and comprise 83% of the senior population. (add figure, table or pie chart, demand is a normal distribution)

3.1.3 Estimating the available funding and resources of Nova Scotia's government. In 2011 the provincial government in Nova Scotia spent approximately 4.7% of its healthcare budget on homecare. It spent almost 14% of the overall healthcare budget on nursing homes and long term care. The overall actual budget was approximately \$3.75 billion. There was an unexpected under spending of \$16.1 million on long term care due to delays in opening new beds. The government has already declared a \$20 million increase in homecare support budget for the upcoming year. This budget increase raises the estimated total budget for homecare support to approximately \$198,284 million. Taking into consideration that the current construction of the new nursing beds will be completed, we can estimate that the budget for long term care and nursing homes will also increase by \$16.1 million from the previous year's actual numbers. We can then estimate the budget for nursing homes to be almost \$ 515 million for the upcoming year (Nova Scotia Health and Wellness, 2012).

3.2 ASSUMPTIONS

Assumption 1: For the purpose of our study we assume that the government will match every dollar spent on nursing homes per client, with a dollar spent on homecare services per client. In other words, we assume that the government will provide clients who request homecare service with the same amount of money, \$96 per day, that would otherwise have been spent on that same client should he/she be admitted into a nursing home.

There is no evidence or research that proves whether or not the provincial government is in fact providing that much dollar amounts for homecare services to

patients in Nova Scotia. However, we cannot evaluate the effect of an integrated homecare support to that of a nursing home system if they each have different cost values. Therefore, we make our current assumption to bring both systems to par with regards to maximum costs per client. We can then compare the results after introducing an integrated homecare system.

Assumption 2: For the purpose of this study we assume that if given the chance, customers will prefer to receive homecare support rather than move into a nursing home. We base our assumption on the fact that Nova Scotia's Department of Health and Wellness policy for 2012, aims at increasing the focus on homecare and works hard at keeping people in their homes and communities for the longest time possible.

There is no definitive research evidence that shows to what extent patients would prefer to stay at home. However, Kruchaska (2004) indicates that seniors on average favor staying at home. Research conducted by Professor Don Shiner of Mount Saint Vincent, also supports this assumption. The results of the research show that 93% of Atlantic Canadians would choose staying in their communities over nursing homes (SSHRC, 2011). Based on these findings we can assume that a number of people waiting in line for nursing homes would also prefer to stay at home. Therefore, it could be implied that if adequate homecare was provided, these clients would dropout from the nursing home waiting list and remain in their communities. The above mentioned findings support our current assumption.

Assumption 3: This research involves studying the effect of increasing preventive or supportive homecare service. We assume that if patients were provided with adequate support in their homes, this will help reduce the rate of falls and injuries in elderly

people. This support in return, will help decrease the visits to the emergency room in hospitals.

Adequate help at home will also assist people in remaining independent and living at home for the longest time possible. Hence we assume that homecare services will also decrease the number of people waiting in queue for nursing homes. The government of Nova Scotia has been placing more focus on increasing the resources available for homecare in order to decrease the pressure on long term care. The future goals for the government are to exhaust all possible community and home support services for clients, before using nursing homes as an option. This policy supports our proposed assumption (Nova Scotia Health and Wellness, 2012).

Assumption 4: For the purpose of this study, we assume that the safety and quality standards of homecare services meet the measures and requirements set by the government. We base our assumption on the priorities of the new policies set by the Department of Health and Wellness. These priorities have been focused on making healthcare better for everyone. Quality and patient safety fall under the list of priorities for Nova Scotia. The provincial government has set a framework for surveillance and measure to track, monitor and evaluate health services including continuing care services. Moreover, to support the increased focus on homecare support, and the emphasis on quality and safety, the Department of Health and Wellness has partnered with the Department of Community Services to help upgrade the houses of seniors. The Department of Community Services is increasing the funding available for seniors. These funds will help upgrade senior homes in a way that meets their special needs, and at the same time satisfy the standards of safety for independent senior living. These initiatives

and programs set by the provincial government support our assumption that homecare services will meet the same quality and safety standards of nursing homes. Thus there will be no compromise in those aspects for seniors who prefer to stay at home (Nova Scotia Health and Wellness, 2012).

CHAPTER IV

HEMOCARE RESROUCE ALLOCATION MODEL

4.1 PURPOSE OF THE MODEL

The purpose of the model described in this chapter is to find the optimal solution to reduce waiting times for homecare, while aiming to minimize the overall costs of the service. As previously mentioned in chapter 3, we assume that clients will prefer to receive homecare support rather than move into a nursing home. We also assume that an adequate supply of homecare services will drop the number of people in waiting lines for nursing homes. Therefore, an optimized homecare support system can serve as a solution for nursing home waiting times faced by Nova Scotia.

4.2 DESCRIPTION OF THE MATHEMATICAL MODEL

The proposed model is a conceptual mathematical model, due to lack of actual data. The model breaks down the overall cost of homecare support into two parts, the societal costs and the service costs.

The societal costs are the intangible costs patients and caregivers incur while waiting to receive homecare. Societal costs are very broad and include many factors. As previously identified, one challenge of homecare is the lack of availability of services in remote areas. Patients who move closer to the source of services are subject to societal costs, since they are leaving their communities and the comfort of their own homes. Another challenge mentioned in chapter one was the shortage of employees. Overworked and stressed employees are incurring societal costs when their stressful jobs affect their

way of life, relationships and health. Another important factor of the societal costs, are those sacrifices experienced by family caregivers. These are family members who sometimes quite their jobs to take care of a loved one, since there is no adequate government support. There are more issues that affect and increase societal costs. The aspects mentioned above are just a few. Due to their intangible nature, societal costs are hard to quantify.

The service costs are those incurred in delivering the actual homecare support. Service costs include medication and equipment to care for the client, where applicable. They also include the cost of labor and transportation to get caregivers to the clients' homes. Case assessments performed by the government social workers for each applicant are also part of the service costs.

We consider the overall cost of homecare per patient to be C_{homecare} . The overall cost is a sum of the total societal costs C_{societal} and total service costs C_{service} . Therefore,

$$C_{\text{homecare}} = C_{\text{societal}} + C_{\text{service}}$$

Societal costs are a result of clients waiting to receive homecare services. The longer the wait, the higher are the societal costs. These costs increase with every additional day of waiting. Societal costs are mainly due to the delay of waiting time in providing homecare. The total societal cost C_{societal} is a function of the waiting time of a client, and the societal cost incurred per waiting day by that client. Hence, C_{societal} is a linear function. If $t=0$, $C_{\text{societal}}=0$ Therefore,

$$C_{\text{societal}} = k * t$$

k is the societal cost per waiting day

t is the number of waiting days

Service costs are the resources the government spends to deliver the actual homecare service. The more money the government can spend the more customers it is able to serve. Hence, increased service costs or resources will reduce waiting times for homecare services. The total service cost C_{service} is a non-linear function. We assume the following function for C_{service} ,

$$C_{\text{service}} = m/t$$

m is a parameter of the service cost function

t is the number of waiting days

When t is normalized to 1, $C_{\text{service}} = m$

The model will provide the optimal waiting time for homecare services, and the minimum yet optimal amount of resources required. Therefore, by manipulating the mathematical formula we get

$$C_{\text{homecare}} = C_{\text{societal}} + C_{\text{service}}$$

$$C_{\text{homecare}} = k*t + m/t$$

The optimal solution (t^*) for time is

$$t^* = \sqrt{\frac{m}{k}}$$

The optimal solution for minimizing the resources needed by the government is

$$C_{\text{service}} = m / \sqrt{\frac{m}{k}} = \sqrt{mk}$$

We consider solving for C_{service} since the government doesn't have any direct control over societal costs C_{societal} . One way C_{societal} can be reduced is by increasing resources spent through C_{service} .

The two values that need estimation in the proposed mathematical model are k and m . The optimal solution for waiting time and resource allocation depends on these two parameters. To estimate values for k and m , real time data should be collected using surveys and interviews with people receiving homecare. Accurate data sourcing from the Department of Health and Wellness would also be required to estimate service costs and most recent waiting times.

4.2.1. Estimating k

The value of k corresponds to the societal costs incurred per client for every waiting day. People have different preferences and circumstances that affect their choice of service and corresponding location. Societal costs are a function of many factors. The most important determinants of total societal costs are the number of seniors waiting for homecare services, the income of these clients, their health conditions, the distance between their homes and healthcare providers, the services available and reputations of hospitals nearby as well as availability of family support.

The intangible nature of societal costs makes it hard to quantify them. Empirical studies are needed to collect relevant data. One way to collect data is conducting surveys and interviews with people who are receiving homecare, or who are waiting for homecare. Analyzing the gathered data and determining relationships between relevant factors would give an estimate of the societal costs.

One important societal cost factor to estimate is the effect of waiting times on the health of seniors. Surveys on the health conditions of people waiting for homecare services, can determine whether waiting times contribute to deteriorating health

conditions for seniors or not. Given that waiting time does deteriorate the health of clients, the surveys can provide an estimate on how much it costs the government to care for these people in hospitals and acute care facilities till homecare is made available.

Surveys on the sacrifices family members undertake to care for loved ones, provide an estimate on how much waiting for homecare service from the government can cost these informal caregivers. For instance, sometimes these family members quit their jobs to become fulltime caregivers, since the government is not providing adequate and timely homecare or nursing home support. In some situations people leave their homes and communities to move closer to healthcare services. Interviews and surveys can also provide an estimate of the costs these members incur when they move from place to place.

The most challenging part in estimating societal costs is quantifying the emotional distress that accompanies waiting. Clients and informal care givers waiting for homecare support are under emotional stress. People who leave their communities to receive healthcare services also suffer from emotional strain. It is difficult to put a price on people's psychological conditions. A possible way to do that is interview concerned people and determine which physical aspects of their lives have been affected by this stress. It is then easier to quantify the costs of emotional distress.

Once cost estimates of involved factors have been determined from the empirical study, we can establish the relationship between the overall societal costs and waiting times. We can then estimate the incremental cost incurred with every additional day of waiting. However, due to lack of empirical data we are unable to estimate an exact range for k .

4.2.2. Estimating m

The parameter m of the service costs is determined based on the nature and shape of the cost function. For the purpose of our research we assumed a non-linear function for the service costs. The parameter m is a function of various factors. The most important factors are the government's available budget, cost of delivering homecare per patient, number of homecare hours provided per client, current waiting times for homecare services, capacity of nursing homes, the demand for homecare and the demand for nursing homes.

Estimating m starts with gathering data on the mentioned factors. The budget for homecare services can be obtained from the Department of Health and Wellness's fiscal budget. The cost of delivering homecare services per client can be determined by calculating the average wage per hour for healthcare providers and the average number of hours each client gets. The reason for using the average cost and average number of hours is due to the fact that different clients require different types of care. Thus, the healthcare providers' wages and number of hours needed may differ from person to person. The wage per hour and number of hours are set by the government and can be obtained from the Department of Health and Wellness records.

Estimating the waiting time for homecare services, or nursing homes, is more challenging. There is no official documentation available that lists the actual waiting times for clients. A survey is needed to estimate the current average waiting times for homecare services in Nova Scotia. The list of nursing homes in Nova Scotia and their corresponding available beds is also obtainable from government records. Therefore, the percentage of vacant beds is easily computed.

Estimating the demand for homecare and nursing homes is more challenging. A lot of factors play in a person's decision to choose homecare over nursing homes, and vice versa. Demand is affected by the societal costs mentioned in the previous section. The location of healthcare providers and nursing homes is a determinant of demand. If clients live far from a nursing home, they would opt for homecare services. However if homecare services are scarce in a client's region, and that person doesn't have support from family members, nursing homes becomes the favorable option. Demand is also influenced by the resources the government spends on either homecare or nursing homes. Clients would be more inclined to choose the service that is offering more resources and hence shorter waiting times. Surveys and interviews can provide the data needed to estimate demand. The data can help determine the existing function between demand and societal concerns, as well as availability of resources.

Once all the relevant data is gathered and estimated, we can determine the relationship among the different factors of service costs C_{service} , and hence the shape of the function. As mentioned the parameter m is determined by the shape of the function. Therefore, after plotting the different variables of the factors and determining the relationships among them, the service costs function might have a shape other than the one proposed in our model. This might lead to a new function and new parameters other than m .

CHAPTER V

DISCUSSION OF THE MODEL

5.1 SENSITIVITY ANALYSIS

We perform a sensitivity analysis due to lack of empirical data to estimate k and m . The sensitivity analysis will allow us to understand the mechanism of the proposed model. It also demonstrates the relationships between waiting time t , m and k in our conceptual model (Pannell, 1997).

We have no data to help us estimate the possible ranges of k and m . Therefore, we choose a random range from \$50 to \$250, by increments of \$50, for the value of k . We choose a random range from 1 to 5 for the parameter m .

We first keep m constant while changing the value of k and solve for the optimal t^* and minimal C_{services} , given the different values in the range of k . The results are demonstrated in the following tables.

Table 1. Sensitivity Analysis for $m = 1$

k	m	C_{service}	t
50	1	7.07	0.14
100	1	10.00	0.10
150	1	12.25	0.08
200	1	14.14	0.07
250	1	15.81	0.06

Table 2. Sensitivity Analysis for $m = 2$

k	m	C_{service}	t
50	2	10.00	0.20
100	2	14.14	0.14
150	2	17.32	0.12
200	2	20.00	0.10
250	2	22.36	0.09

Table 3. Sensitivity Analysis for $m = 3$

k	m	C_{service}	t
50	3	12.25	0.24
100	3	17.32	0.17
150	3	21.21	0.14
200	3	24.49	0.12
250	3	27.39	0.11

Table 4. Sensitivity Analysis for $m = 4$

k	m	C_{service}	t
50	4	14.14	0.28
100	4	20.00	0.20
150	4	24.49	0.16
200	4	28.28	0.14
250	4	31.62	0.13

Table 5. Sensitivity Analysis for $m = 5$

k	m	C_{servie}	t
50	5	15.81	0.32
100	5	22.36	0.22
150	5	27.39	0.18
200	5	31.62	0.16
250	5	35.36	0.14

We now keep k constant while changing the value for m and solve for the optimal t^* and minimal C_{services} , given the different values in the range of k . The results are demonstrated in the following tables.

Table 6. Sensitivity Analysis for $k=50$

k	m	C_{service}	t
50	1	7.07	0.14
50	2	10.00	0.20
50	3	12.25	0.24
50	4	14.14	0.28
50	5	15.81	0.32

Table 7. Sensitivity Analysis for $k=100$

k	m	C_{service}	t
100	1	10.00	0.10
100	2	14.14	0.14
100	3	17.32	0.17
100	4	20.00	0.20
100	5	22.36	0.22

Table 8. Sensitivity Analysis for $k=150$

k	m	C_{service}	t
150	1	12.25	0.08
150	2	17.32	0.12
150	3	21.21	0.14
150	4	24.49	0.16
150	5	27.39	0.18

Table 9. Sensitivity Analysis for $k=200$

K	m	C_{service}	t
200	1	14.14	0.07
200	2	20.00	0.10
200	3	24.49	0.12
200	4	28.28	0.14
200	5	31.62	0.16

Table 10. Sensitivity Analysis for $k = 250$

K	m	C_{service}	t
250	1	15.81	0.06
250	2	22.36	0.09
250	3	27.39	0.11
250	4	31.62	0.13
250	5	35.36	0.14

The results of the first sensitivity analysis demonstrate that as k changes by increments of \$50 and m remains constant, the optimal waiting time t^* is reduced to half if the government spends double the amount of resources on $C_{services}$. This result held true for all values of m .

However, the results of second sensitivity analysis demonstrate that as k is fixed and m changes from 1 to 5, by increments of 1, the optimal waiting time t^* is doubled even as the government spends double the amount of resources on $C_{services}$. This result held true for all values of k .

CHAPTER VI

CONCLUSION

6. *LIMITATIONS AND AREAS FOR FUTURE RESEARCH*

One limitation of this research is absence of empirical data needed to test the robustness of the conceptual mathematical model. However, the process of acquiring data is constrained by our lack of resources and time. Therefore, we propose a method to collect relevant data and estimate values for the variables in the proposed model.

Another limitation is the assumption that with adequate supply of homecare services, demand for nursing homes will decrease. Our model is based on this assumption that people will shift to homecare if given a chance, thus reducing the length of the queue in nursing homes. This raises implications for future areas of research. An empirical study should be carried out to determine people's preferences and what factors affect the choice of homecare or nursing homes. Another area to research once peoples' preferences are recognized is the demand shift. A model needs to be developed to quantify the percentage of demand shifting from nursing homes to homecare services. Once the demand shift has been quantified, further research is needed to build a model that would quantify the reduction in waiting times at nursing homes, based on the demand shift.

In conclusion, this research provides a framework for future studies. It provides an overview of healthcare situation in Nova Scotia, specifically for continuing care. This research also identifies challenges faced by nursing homes and homecare support. It recognizes the relationships between factors of the healthcare system and proposes a conceptual model that could solve the current waiting time issues in continuing care.

CHAPTER VII

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