Application of interRAI Assessments in Disaster Management: Identifying Vulnerable Persons in the Community

by

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A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirements for the degree of

Doctor of Philosophy

in

Public Health and Health Systems

Waterloo, Ontario, Canada, 2016

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Background: Several studies have shown the increased vulnerability and disproportionate mortality rate among frail community dwelling older adults as a result of disasters. Parallel to an escalating number of disasters, Canada is faced with an aging demographic and a policy shift emphasizing aging at home. This results in a greater vulnerability of this group of high needs community dwelling individuals to the effects of events that lead to interruption of home health care services and/or displacement. Despite the growing vulnerability it has proven to be difficult to identify those most vulnerable older adults and their characteristics. This makes it challenging for emergency managers, first responders and health care providers to develop targeted preparedness, response and recovery strategies aimed at the most vulnerable older adults living at home. Relatively recent developments in electronic health records provide an unprecedented opportunity to use comprehensive assessment information collected as part of routine clinical practice in the home care sector to identify vulnerable community dwelling older adults. In Ontario, the Resident Assessment Instrument for Home Care (RAI-HC) is the mandated primary assessment tool for long-stay home care clients.

Objective: The three specific objectives of this dissertation are to examine:

1. The application of the New Zealand Priority Algorithm used during the Christchurch earthquake to the Ontario Home Care Client database.
2. Determinants of Emergency Response Level (ERL) designation within CCACs.
3. The person-level factors that contribute to increased vulnerability of home care clients to power interruptions through examining the health effects of the power outage that occurred as a result of the December 2013 Ice Storm including emergency department (ED) visits, hospitalization and service utilization.

Conceptual Framework: The person-environment fit model is used as the conceptual framework for this dissertation. This model views individual vulnerability as a product of the interaction between individual competence, adaptive behavior and the strength of the environmental stress (the emergency or disaster). Where the demands of an emergency or disaster exceed the ability of the older adult to cope, a person- environment misfit may lead to negative health outcomes.

Methodology: All research questions were addressed using RAI-HC datasets in combination with other datasets. Chapter three used the RAI-HC database by selecting unique home care clients with assessments closest to December 31st 2014 (N=275,797). For chapter four Emergency Response Level (ERL) codes were provided by the Hamilton Niagara Haldimand Brant (HNHB) and Toronto Central (TC) Community Care Access Centre (CCAC) and matched with a RAI-HC assessment in both CCACs (N=70,292 and N=8,996 respectively). In addition, linkages were made with data regarding death, hospitalization and long term care (LTC) admission. Lastly, chapter five uses information on Toronto Hydro power outages and an estimation of outage areas based on outage mapping in addition to the HC database. The exposure group (N=10,748) was compared to two comparison groups. Group one included clients with HC assessments in the same period and receiving services during the same week but were unaffected by the hydro outage (N=12,072). The second comparison group was comprised of clients residing in the same area as the hydro outage one year prior to the storm (N=10,886). Service utilization was collected from the Client Health Related Information System (CHRIS). Statistical analyses were done using SAS version 9.4 and methods used include frequency tabulation, bivariate logistic regression, multivariate logistic regression as well as Kaplan-Meier survival plotting and Cox proportional hazards ratios calculations.

Results: When comparing four decision support algorithms (University of Waterloo, Canterbury, Vulnerable Persons at Risk (VPR) and VPR Plus) to identify high priority clients, the VPR and VPR Plus were most predictive of mortality, LTC admission and hospitalization. The high priority groups were significantly more impaired than lower priority clients with both the VPR and VPR Plus. They had higher levels of health instability, experienced more falls, required more assistance with Activities of Daily Living (ADL), were more cognitively impaired and had higher levels of depression ratings. When comparing the chosen algorithms, the VPR and VPR Plus, with ERL levels assigned by care coordinators the analysis showed considerable overlap in predictive variables. The ERL was highly predictive of mortality and LTC admission, but less predictive of hospitalization. C-stats of logistic regression modeling with ERL and VPR/VPR Plus in predicting mortality showed that the VPR and VPR Plus models were a better or equal fit as models with the ERL. Finally, when examining the characteristics of clients that were affected by the 2013 power outage with the two comparison groups, a significant difference was found for the non-exposed group in the year of the outage in relation to numbers of nursing and personal support worker (PSW) visits, hospital admission and emergency department (ED) visits as well as mortality, LTC admission and hospitalization rates. The analysis showed that clients in the non-affected areas in the year of the outage were more likely to decline in Depression Rating Scale (DRS), Changes in Health, End-Stage Disease, Signs and Symptoms Scale (CHESS) and Instrumental Activities of Daily Living (IADL). This is consistent with the higher rates of LTC admission and hospitalization within six months after the outage for non-exposed clients as well as higher frequency of nursing and PSW visits during and 30 days after the outage. In contrast to the expectation that exposed clients would do worse during and after the outage, the analysis showed that exposed clients showed in fact less health decline than non-exposed clients. However, when looking at those clients that would have been considered high and medium risk clients based on the VPR and VPR Plus, the analysis showed that those clients in areas with hydro outages were more likely to die and to be admitted to long term care (LTC) than the high and medium risk clients living in unaffected areas.

Conclusions: The analyses in this dissertation have shown the usefulness of information collected as routine clinical practice using interRAI assessment tools. The current system of designating Emergency Response Levels (ERL) by care coordinators is highly dependent on consistent updating of the ERLs in the system whenever a new home care assessment is completed. The analyses showed that this is not consistently done, and may render the ERL code obsolete overtime. The VPR and VPR Plus have been shown to be valid and reliable alternatives to ERL codes and they are kept up to date as new assessments are completed on home care clients. Incorporating these decision support algorithms into the RAI-HC assessment system software enables an automatic and up to date vulnerability assessment of clients. This can make it possible for emergency managers, first responders and health care providers to use a comprehensive priority system before, during and after emergency, ultimately preventing unnecessary death or health deterioration.

Acknowledgements

The work on this thesis has been very challenging at many times and I owe a good number of people a great deal of thanks. Without them I would have never been able to finish this work.

I would like to start by expressing my deep gratitude to Dr. Hirdes. His technical and editorial advice was essential to the completion of this thesis. He has guided me through tough and complicated analyses during times where I was unable to see the forest through the trees. His Dutch words of encouragement and gestures of mini violins made me smile and ensured that I left his office more motivated than ever. Dank je wel!

I would also like to thank my committee members Dr. George Heckman and Dr. Phillip Bigelow for their continuous support.

Miceala Jantzi and Jonathan Chen deserve a special heartfelt thank you as well. As the SAS gurus of the department, they have cheerfully walked me through some very challenging code and have always been happy and willing to help me work through my SAS difficulties. I would also like to like to thank Julie Koreck. She has supported me through times when I believed that this thesis would never come to an end and ensured that I had an appointment with my supervisor Dr. John Hirdes for those times when I most needed it. Julie is the life raft for many graduate students.

I would like to show appreciation to the senior management at the Greater Toronto Airport Authority (GTAA). They have granted me the time to fulfill many of the degree requirements. I would also like to express my gratitude to the Toronto Central CCAC and Hamilton Niagara Haldimand Brant CCAC. This dissertation would not have been possible without their willingness to share their data. I would like to acknowledge that this dissertation is a result of the collaboration and support of both the World Health Organization and the Canadian Red Cross.

Many loving thanks to my parents, brother, sister-in-law and friends back home in The Netherlands. The distance did not stop them from showing support all the way. My mom's "I wish you luck" helped me through those tough exams. Special thanks to my oma Ger and 96-year-old Jo, who inspired me to do this work.

Lastly, I would like to thank my wife Leslie Eckel. She has been a motivation all along the way. Many times she has reminded me why the heck I am doing this again and offered counsel and loving words at each turn of the road. Her suggestions and support cleared the path towards completion of this dissertation. And of course thank you to my kids Sidney and William, who patiently put up with my lack of time and occasional moodiness. To them I would like to say: "Kids, it's finally over!"

Thank you all.

Dedication

This thesis has been lovingly dedicated to my dear wife Leslie. Her sense of willpower and resourcefulness with which she responds to the many challenges in life has helped me to seek this in myself.

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List of Abbreviations

AAH – Aging at Home

AC - Acute Care

ADL - Activities of Daily Living

BC – British Columbia

CAP - Clinical Assessment Protocol

CCAC - Community Care Access Centres

CDC - Centers for Disease Control and Prevention

CE – Central East

CHAM - Champlain

CHESS - Changes in Health, End-stage disease and Symptoms and Signs

CHRIS - Client Health Related Information System

CI – Confidence Interval

C-MIST – Communication, Medical care, maintaining functional Independence, Supervision and Transportation

CPS - Cognitive Performance Scale

CSS - Community Support Services

CW – Central West

DF – Degrees of Freedom

DRS - Depression Rating Scale

ED – Emergency Department

EFS - Edmonton Frail Scale

EM-DAT – Emergency Database

EMS - Emergency Medical Services

EOC - Emergency Operations Centre

ERL - Emergency Response Level

ESC – Erie St. Clair

ETA - Ecology Theory of Aging

FI – Frailty Index

FSW - Forward Sortation Areas

GDS - Geriatric Depression Scale

GIS - Geographic Information Systems

HC – Home Care

HNHB - Hamilton Niagara Haldimand Brant

IADL - Instrumental Activities of Daily Living

IMS - Incident Management System

IV – Intravenous

LHIN - Local Health Integration Networks

LTC – Long Term Care

LTCF – Long Term Care Facilities

M – Mean

MAPLe - Method for Assigning Priority Levels

MB - Manitoba

MDS - Minimum Data Set

MH - Mental Health

MH – Mississauga Halton

MMSE – Mini-Mental State Examination

MoCA - Montreal Cognitive Assessment

NACRS - National Ambulatory Care Reporting System

NE – North East

NS – Nova Scotia

NSM - North Simcoe Muskoka

NW – North West

NZ – New Zealand

OACCAC - Ontario Association of Community Care Access Centres

OFMEM - Office of the Fire Marshal and Emergency Management

OR – Odds Ratio

ORE - Office Of Research Ethics

PSW - Personal Support Worker

PTSD - Post-Traumatic Stress Disorder

RAI – Resident Assessment Instrument

REC - Research Ethics Committee

RSO – Revised Statutes of Ontario

SAS - Statistical Analysis System

SD – Standard Deviation

SE – South East

SHELTER - Services and Health for Elderly in Long TERm care

SW – South West

TFS – Toronto Fire Services

TC – Toronto Central

UW – University of Waterloo

VPP - Vulnerable Population Protocol

VPR - Vulnerable Persons Registry

VPR – Vulnerable Persons at Risk (interRAI)

WHO – World Health Organization

WW – Waterloo Wellington

YT – Yukon Territory

Chapter 1: Introduction

1.1 Disasters and Vulnerable Populations

Canada is the second largest country in the world, covering 9,984,670 square kilometers. It has the longest coastline (over 200,000 kilometers) and fifteen distinct ecozones (Lindsay, 2009). Due to its relative sparseness of population, fewer people are exposed to different types of hazards (Lindsay, 2009), but regardless Canada is not spared from risk. In fact, there has been an increase in reported natural emergencies and disasters in Canada (Canadian Disaster Database, 2015; EM-DAT, 2016). Canada has experienced-and will continue to experience- a full range of meteorological, geological and other natural hazards as well as unintended and intentional events (Lindsay, 2009).

In 1998, severe freezing rainstorms affected Quebec and other parts of North America. In Quebec these storms affected almost 5 million people, causing major power outages and damage to infrastructure and the natural environment (World Health Organization, 2008). The wild fires in British Columbia (2003), hurricane Juan in Nova Scotia (2003), and the Goderich, Ontario Tornado in 2011 are more recent examples of widespread emergencies caused by the forces of nature that affected large numbers of Canadians.

In June 2013, the province of Alberta was struck by major flooding in the city of Calgary and surrounding communities. Four lives were lost, thousands were displaced from their homes, and major damage to property and infrastructure resulted (Alberta Watersmart, 2013). In the same year, parts of Toronto flooded due to heavy rainfall. In December of 2013 a massive ice storm caused hundreds of thousands of power outages throughout Ontario and Quebec. Thousands of Toronto residents were without power for days while outside temperatures fell far below zero. On Christmas Eve, well over 1,000 people slept in warming centres (Moore & MacKrael, 2013). There were numerous reports of seniors in high-rise buildings unable to reach the ground floor after the power outage disabled the elevators (Moore & MacKrael, 2013). The ice storm damaged hydropower lines throughout Ontario and Quebec and caused widespread travel delay (CBC News, 2013). Hydro one, which serves 1.3 million customers in Ontario including Guelph, Newmarket and Orangeville, had 120,000 customers who were without power at its peak (CBC News, 2013; Office of the Premier, 2013).

Most recently, in June 2016, Fort McMurray in Alberta was threatened by a large wildfire. The wild fire led to the mandatory evacuation of the entire town and surrounding areas, which constituted over 80,000 people. This made the Fort McMurray wild fire disaster the largest evacuation in Canada (Fritz, 2016).

There has been much research conducted in the field of disasters and emergency management, including research on the characteristics of collective and personal vulnerability to adverse outcomes. In recent years disaster research has gained much momentum, but it contends with major ethical and methodological problems (Evans, 2010). Victims often have no interest in participating in research, researchers are often not permitted to enter a disaster area, and follow-up studies are often very difficult to arrange (Gibbs & Montagnino, 2007; Gutman, 2007). This makes it challenging to address a question that has been a major topic of interest in disaster research: what makes an individual more vulnerable to adverse disaster outcomes? If these vulnerabilities were known beforehand, emergency managers and health care personnel could work together to mitigate these factors prior to and during disasters and response efforts could focus on those most vulnerable populations (Jenkins, Levy, Rutkow, & Spira, 2014).

Age is one of the factors that has long been recognized to be associated with one's likelihood of withstanding a disaster event (Fernandez, Byard, Lin, Benson, & Barbera, 2002; Peek, 2010). In previous disasters and large-scale emergencies, the population of older adults showed disproportionately high rates of mortality, increased morbidity and decreased quality of life (Ngo, 2001). In a summary report based on a series of unpublished case studies of individual disasters the World Health Organization (WHO) stated that of the approximately 1,200 people that died as a result of Hurricane Katrina, 71% were persons over the age of 60 (World Health Organization, 2008). Of the elderly persons affected by Katrina, most lived independently, and many were disabled and mobility-restricted (Cahalan & Renne, 2007). Further, in the first year following the hurricane the elderly had the highest mortality rate (Adams, Kaufman, van Hattum, & Moody, 2011; Stephens et al., 2007).

In Canada, the Quebec Ice Storm resulted in the deaths of 30 people 50% of whom were adults 65 years and older (Gutman, 2007; World Health Organization, 2008). During the 2003 heat wave in Europe, older adults over the age of 75 accounted for 70% of the deaths (Hémon & Jougla, 2004; Pirard et al., 2005; World Health Organization, 2008). Lack of mobility, pre-existing medical conditions, lack of air conditioning equipment, housing conditions (e.g., lack of thermal isolation), absence of family and professional care staff during peak holiday season, and poor coordination between emergency, health and social services were among the factors attributed to this high fatality rate (Larrieu et al., 2008; Pirard et al., 2005; Vandentorren et al., 2006; World Health Organization, 2008).

However, age alone does not make a person vulnerable to a disaster as the population of older adults is highly heterogeneous (Durant, 2011). Age interacts with many personal variables that may result in the heightened vulnerability of some individuals over others (Evans, 2010; Peek, 2010). It is a combination of disaster related and personal variables that makes an older adult more vulnerable (Elmore & Brown, 2007; Fernandez et al., 2002; Tuohy & Stephens, 2011). Age related physical and cognitive decline could directly influence personal vulnerability and result in adverse outcomes from a disaster (Smith, Tremethick, Johnson, & Gorski, 2009). Risk factors frequently identified in the literature include mental health disorders, cognitive impairment, chronic illness, decreased mobility, dependence on electrical medical technologies (e.g., oxygen machines), medication, special diets, dependency or reliance on others to provide basic social and economic needs, and visual and hearing impairments (Aldrich & Benson, 2008; Durant, 2011; Fernandez et al., 2002; Ford et al., 2006; Lamb, O'Brien, & Fenza, 2008; Mokdad et al., 2005; Person & Fuller, 2007; Smith et al., 2009; Tuohy & Stephens, 2011; Vandentorren et al., 2006). Although these impairments may be found in younger populations, the proportion of persons who are more vulnerable to disasters is higher among the population of older adults due to age-related changes in health and functional status (Durant, 2011; Lach, Langan, & James, 2005). Elderly individuals frequently have multiple disadvantages and they tend to be less tolerant of major traumas and disruptions of their environment and normal routines (Durant, 2011).

The global pace of population aging is accelerating rapidly due to declining birth rates and increased life expectancy. The world population is expected to grow by almost one billion people over the next 20 years, and the population aged 60 years and older is the fastest growing segment (United Nations, Department of Economic and Social Affairs, Population Division, 2013). As of July 1, 2011, the number of seniors (aged 65 and older) in Canada stood at just under 5 million, with 1.4 million aged 80 and older, and 7,600 individuals aged 100 and older (Statistics Canada, 2012). Seniors make up 14.4% of the Canadian population, but this percentage is expected to grow rapidly in the coming years as the baby boom generation reaches the age of 65. By 2036, seniors could represent between

23% and 25% of the total population (between 9.9 and 10.9 million people) (Statistics Canada, 2012).

Aside from demographic change, health and social policy can also affect an older adult's exposure to disasters. For example, the Ontario's Ministry of Health and Long-Term Care introduced an 'Aging at Home Strategy' (AAH) in August of 2007 (Ministry of Health and Long-Term Care, 2013). This strategy led to a shift in emphasis from an acute based model of care to one which leverages home and community care services in enabling older adults to live at home longer and healthier (Blair, 2013). As a result, escalating numbers of elderly persons with substantial needs reside in their own homes longer, and are dependent on formal home and community care services and informal networks to manage their activities of daily living.

The combination of population aging with policy shifts emphasizing aging at home means more high needs individuals will reside in their own homes longer, resulting in a greater vulnerability of this group to the effects of natural events such as winter storms and to interruption in home health care services (Banks, 2013). The concurrent increase in reported natural emergencies and disasters (Canadian Disaster Database, 2015; EM-DAT, 2016) makes it clear that the current standard emergency management framework needs to change to adequately respond to the needs of community dwelling vulnerable persons.

1.2 Study Rationale

Due to global climate change, the probability of extreme weather events such as snow storms, floods, wildfires and heat waves increases, often overwhelming the capacity of communities to respond to the needs of the population (Keim, 2008). Some clients with extensive needs are highly vulnerable to interruption in health care services and equipment, including home-based care (Banks, 2013). During winter storms power failures, supply chain and transportation failures, impassable roadways, and home care staffing shortages may cause interruption in home-based care, isolating clients from nursing care, medical treatments, delivery of medications and meals (Smith et al., 2009). Power outages can interrupt electronic devices such as oxygen generators. The informal and formal networks that the client relies upon may be unavailable during a disaster or major emergency, leaving the client without vital services and support. Furthermore, large-scale emergencies such as earthquakes and hurricanes as well as power outages can displace clients from their home for prolonged periods of time. This, in turn may contribute to problems such as lack of medications and health care.

Disasters such as the September 11, 2001 attack on the World Trade Centre and the devastating effects of Hurricane Katrina in 2005 have demonstrated that the needs of people with functional limitations are inadequately addressed in emergency planning and response efforts (Campbell, Gilyard, Sinclair, Sternberg, & Kailes, 2009). While there is a wealth of information regarding how to prepare for those most vulnerable adults, there is a dearth of literature that describes how these community dwelling vulnerable adults can be identified pre-disaster or how to identify those individuals that require priority attention during and after a disaster.

The urgency of identifying and registering the frailest older adults has been emphasized in many reports and articles (Baylor College of Medicine & American Medical Association, 2006; Bourgue, Siegel, Kano, & Wood, 2007; Fernandez et al., 2002; World Health Organization, 2008). In 2012, the Centers for Disease Control and Prevention (CDC) published a report regarding the identification of vulnerable older adults during all hazards emergencies. The CDC states that there has been no consensus reached on the most appropriate terminology to define the group most in need of special attention during an emergency, nor the strategies to be used to identify vulnerable adults (Centers for Disease Control and Prevention, 2012). The CDC concludes that none of the methods currently being used in the United States to identify older adults who may require assistance during an emergency have been evaluated. 'Our ability to accurately identify which older adults are – or will become – vulnerable is limited and is a primary obstacle to helping those in need during an emergency (Centers for Disease Control and Prevention, 2012, p. 15).

It is crucial for emergency managers to have an understanding of the diversity of the population they service and the potential hazards affecting those distinct populations. They must develop targeted prevention, mitigation, response and recovery strategies to maximize the safety of those most in need, including building disaster response capacity and develop processes and procedures (Kailes & Enders, 2007). Triage systems with the aim of helping those with the highest chance of survival require change and thorough consideration should be given where scare resources are to be allocated (Lach et al., 2005).

While there is general agreement that individuals living on their own are the most difficult to locate and assist in comparison to those persons living in an institutionalized health care setting (Cahalan & Renne, 2007), there is no consensus on the individual characteristics that define a community dwelling person as more vulnerable to the effects of a disaster (Centers for Disease Control and Prevention, 2012). This lack of consensus hinders the ability to identify the most vulnerable individuals living in their own home. Many have suggested the development of local registries of people with disabilities and chronic health issues, including current address as well as services likely to be needed in times of a disaster (Fox, White, Rooney, & Rowland, 2007). However, surveillance efforts to identify those vulnerable groups appear to be weak and impossible to maintain (Fox et al., 2007).

In Canada there are a few initiatives to identify older adults that may require assistance during an emergency. In Sault Ste. Marie, Ontario, residents meeting pre-established criteria may register in a Vulnerable Persons Registry (VPR) (Sault Ste. Marie Innovation Centre, 2014). This information is shared with local fire, police, paramedics, utilities and Canadian Red Cross. Although this initiative is promising, the numbers of older adults using this free service is limited. In July 2013, 196 people had registered out of a total population of 70,000 (Canadian Red Cross, 2013). The Canadian Red Cross currently has adopted this registry and hopes to implement the VPR across Ontario.

Many Community Care Access Centres (CCAC) have adopted an approach that includes a rating system whereby the care coordinators, categorize the level of assistance required by the client during an emergency by assigning an Emergency Response Level (ERL). While a step in the right direction, the assignment of the ERL is based on the subjective conclusions of the care coordinator, and there appears to be limited consistency between CCACs.

As in the United States, the Canadian initiatives seem to lack evidence based support for the methods used to identify the most vulnerable home care clients. Although there is a wealth of research identifying characteristics that predispose some populations to adverse health outcomes, determining the thresholds and prevalence of these vulnerabilities remains a challenge (Jenkins et al., 2014).

Relatively recent developments in electronic health records provide an unprecedented opportunity to use comprehensive assessment information collected as part of regular clinical practice in the home care sector to identify vulnerable community dwelling older adults. In Ontario, the Resident Assessment Instrument for Home Care (RAI-HC) is the mandated primary assessment tool for long-stay home care clients (Canadian

Home Care Association, 2013). The RAI-HC is a comprehensive, standardized instrument for evaluating the needs, strengths and preferences of clients of home care agencies (Gray et al., 2009; Hirdes et al., 1999; Landi et al., 2001; Morris et al., 1997).

A promising attempt to identify the individuals that require emergency assistance based on the RAI-HC was made in February 2011 in Christchurch New Zealand in response to a major earthquake (Downes, 2011). An algorithm was applied to the database containing records of home care clients in Christchurch assessed with the RAI-HC in order to identify community dwellings persons requiring a priority check-in. As the algorithm was applied to a database containing real time person level data, this application provided emergency responders with an up-to-date list of the most vulnerable home care clients in Christchurch. This ultimately resulted in a targeted response to hundreds of seniors and other vulnerable populations.

Using real time information gathered as standard clinical practice on home care clients is an encouraging method to identify those clients most in need of assistance during an emergency. This thesis will examine the applicability of the New Zealand algorithm to the home care population of Ontario Canada, using assessment information collected as standard clinical practice in the home care sector. The analysis may suggest that a separate registry is not required, considering the wealth of information that already exists in the interRAI assessment databases, which has been implemented in several countries. The thesis will define the unique vulnerabilities that are faced by the least resilient home care clients during emergencies and disasters and will use evidence-based tools to identify vulnerability factors. This will improve standards for evidence of effectiveness in disaster science and services (Bradt, 2009; Jenkins et al., 2014) and can enable emergency planners, health care and community support agencies and emergency responders to implement strategies before, during and after disasters targeted to those most vulnerable community dwelling adults. This thesis is an original contribution to emergency management research as it is one of the few studies to examine person-level characteristics contributing to disaster vulnerability.

The three specific goals of this dissertation are to examine:

1. The application of the New Zealand Priority Algorithm used during the Christchurch earthquake to the Ontario Home Care Client database.
2. Determinants of Emergency Response Level (ERL) designation within CCACs.
3. The person-level factors that contribute to increased vulnerability of home care clients to power interruptions through examining the health effects of the power outage that occurred as a result of the December 2013 Ice Storm including emergency department (ED) visits, hospitalization and service utilization.

Full ethics clearance for this research has been received through the University of Waterloo Research Ethics Committee (REC) (ORE#21109).

1.3 Search Strategy

A search of PubMed and Scopus was completed to identify relevant literature to be included in this dissertation. A number of keywords were used, including but not limited to "frail elderly" OR "elderly" OR "older adults" AND "disasters" OR "emergencies". Other combinations with the keywords "disasters" OR "emergencies" were used as well such as in combination with "vulnerable populations" OR "vulnerability" OR "individual vulnerability" and with vulnerability factors such as "cognitive impairment" OR "mental health" OR "disability". Specific articles on disasters were searched by using keywords such as

“European heat wave” OR “Hurricane Katrina” in combination with “older adults” OR “elderly”. Keyword, title and abstract information were used.

The abstracts of all articles were reviewed and when the articles were thought to contribute to the purpose of this dissertation, full articles were retrieved. In addition, a manual search of reference lists from all retrieved articles was done to identify secondary resources.

In addition, grey literature was identified by conducting internet searches using Google. This literature was included when review determined that the document was relevant to one or more chapters of the thesis.

Literature was never excluded based on publication date. All literature was organized into relevant topic areas including vulnerability and resiliency theory, elderly persons during disasters, disability during disasters, disaster management in health care, social and psychological factors and physical frailty.

2. Literature Review

2.1 Disasters and Emergencies: definitions

The Ontario Emergency Management and Civil Protection Act 1990 defines an emergency as: "a situation or an impending situation that constitutes a danger of major proportions that could result in serious harm to persons or substantial damage to property and that is caused by the forces of nature, a disease or other health risk, an accident or an act whether intentional or otherwise" (Emergency management and civil protection act, RSO 1990, c E.9, 1990). Disasters are emergencies that exceed the local capacity to respond and require regional, provincial, and potentially, federal involvement. The International Federation of Red Cross defines disasters as "a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources" (International Federation of Red Cross and Red Crescent Societies, 2016).

Major emergencies and disasters are not simply physical occurrences, but should be considered as a complex interaction between a potentially damaging event and the vulnerability of the community where the event occurs (Birkmann, 2006). Disasters only occur when a vulnerable population crosses with a natural hazard (Cannon, 2008) and the combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disaster.

Major emergencies and disasters are viewed in this thesis as an event that is simultaneously experienced by a collective, rather than by individuals. The core principle of major emergencies and disasters is that they are major stressful events. They may vary in size and duration, in numbers of deaths and injured, in severity of the aftermath as well as in the gravity of individual and collective outcomes.

2.2 Conceptual Framework

Interaction between person and environment is the topic of the general ecology theory of aging (ETA) developed by Lawton and Nahemow (1973). This theory defines a framework in which person-level characteristics and the environment interact (Lawton & Nehamow, 1973). The environment changes both constantly and rapidly requiring ongoing adaptation by the (older) person. The ability to adapt is dependent on the person level characteristics that include different aspects of personal competence of the aging person: biological health, functional health, cognition, time use (enriching activities) and social behavior (e.g., family networks) (Lawton & Nehamow, 1973; Lawton, 1983). The environment can impose environmental stress on the individual (environmental press) that, depending on the personal competences and the ability of the individual to adapt to the environment, may be overcome. This interaction between biological, psychological, and social resources and environmental characteristics is a dynamic process, and any environmental change may influence the individual's ability to cope.

When a person ages, a reduction in personal competence is often tends to occur. When environmental stress remains constant or increases, individual functioning is adversely affected. This may result in an increase in falls and inability to perform Instrumental activities of daily living (IADLs) and Activities of daily living (ADLs). A good fit between environment and competence can be achieved by either lowering the environmental stress or by raising the individual's competence (Lawton & Nehamow, 1973). There are four adaptive strategies. The first one involves a passive role of the individual and is aimed at changing the environment. Arranging assistance with ADLs or

IADLs through community support services (CSS) is one example of such a strategy. A second strategy involves more active participation from the individual in changing the environment, and might include, for example, making a house more accessible. The two remaining strategies aim to elevate the individual's competency level. An educational program is one example of a strategy where the individual is relatively passive, and self-therapy is an example of elevation of competence through the effort of the individual.

Table 2.1: Adaptive strategies of individuals to environmental stress

Aim	Passive	Active
Lowering environment stress	Support from Community Support Services (CSS)	Increasing accessibility of the home
Increasing individual competency	Educational program	Self-therapy, growth, rehabilitation

A disaster or emergency may adversely affect the environmental surroundings of an older adult, such as housing, physical environment and social structure. Where an older adult's ability to cope is compromised due to the lack of one or more personal competencies, the older adult may experience negative health outcomes as a result of the environmental press, in this case the disaster. This person-environment misfit is caused by the demands of the disaster and the inability of the older adult to cope. The misfit between person and environment can intensify when the emergency or disaster has accelerated a decline in personal competence (e.g., due to a fall during an earthquake). Even when the 'normal' environment is re-established the misfit may continue to exist as the personal competencies may have irreversibly declined. The fit between environment and competence that existed prior to the disaster may never be recovered, either because the environment has been damaged too much or the individual's competence has decreased (e.g., increased frailty). For some people with low competence level even the smallest change in environmental press (e.g., a small house fire) could lead to gross changes in quality of life (Lawton & Nehamow, 1973; Lawton, 1983).

In this dissertation, the person-environment fit model is the framework in which the individual vulnerability of an aging person is viewed in relation with disasters and emergencies. The degree of individual competence, adaptive behavior and level and the magnitude of the disaster (strength of environmental press) determine the extent of individual vulnerability.

2.3 Vulnerability in Disaster Research

The term 'vulnerability' has been employed as ambiguously in the disaster management sector as the term 'frailty' in the health literature. According to Birkmann (2006), there are over 25 different definitions, concepts and methods to classify vulnerability. The different meanings of the term arise mainly from the different orientations and practices (e.g., political, economic, physical science) (Cutter, Boruff, & Shirley, 2003). The term has become so vague that using it analytically has little value (Cannon, 2008) and it has proven to be difficult to operationalize the concept using specific indicators (Cutter et al., 2003).

Most emergency management research is focused on social, physical and environmental vulnerability, rather than individual vulnerability (Cornell, Cusack, & Arbon, 2012). The vulnerability in such studies is described in relation to the built or constructed environment in at-risk places, and social vulnerability as indicated by factors such as income, age distribution, ethnicity and cultural capital (Cutter et al., 2003; Durant, 2011; Wisner, Blaikie, Cannon, & Davis, 2004). In this view, the vulnerability definition contains notions of poverty and 'marginalization' and often focuses on stereotypical groups such as the elderly, the poor, women and children (Cannon, 2008). This view stereotypes whole categories of individuals without distinguishing between individuals within the group (Levine, 2004).

All elderly persons, all children, and all those who are poor are often considered vulnerable even though there is immense variability within these groups (Levine, 2004). These generalized views result in the definition of an impractically large population at risk of being harmed by types of hazards. Kailes and Enders (2007) calculated that over half of the population of the United States would be considered having special needs when using the standard definitions of emergency management agencies. This calculation includes children aged 15 and younger, elderly, institutionalized persons, and people with difficulties speaking English. When including other special needs categories such as zero-vehicle households and pregnant women, this number could easily approach 70% of the population (Kailes & Enders, 2007).

DeBruin (2004) suggests that a more productive strategy would involve a focus on the person-level characteristics that contribute to vulnerability instead of looking at vulnerable groups, as the label 'vulnerable' may not apply equally to all members of the group (DeBruin, 2004). Groups that are defined too broadly will result in imprecise planning and emergency response inefficiencies (Kailes & Enders, 2007). Of course vulnerability only exists when there is an external force that imposes a risk to that individual, group or community. Therefore, Watts and Bohle (1993) suggest defining vulnerability in terms of exposure, capacity and potentiality. The most vulnerable individuals or groups are those that are most exposed to risk, have limited coping capacity and who may suffer the most from the effects with limited recovery capability.

Although personal vulnerability is increasingly the subject of emergency management research, there seem to be no agreement about which characteristics make one person more vulnerable to disasters than others. The term is frequently used to highlight those people that are exposed to risk because of particular personal (or household, or community) characteristics that make them likely to suffer harm (Cannon, 2008). A definition of vulnerability that is in line with this view comes from Schroeder and Gefenas (2009, p. 117): "To be vulnerable means to face a significant probability of incurring an identifiable harm while substantially lacking ability and/or means to protect oneself". The external component of this definition refers to the need to be exposed to the possibility of harm in order to be vulnerable. The internal component of this definition is that someone is vulnerable when he or she is substantially unable to protect oneself (Schroeder & Gefenas, 2009).

The above definitions suggest that personal vulnerability is linked to the individual's capacities to anticipate and cope with the impact of a hazard or, in other words, his or her susceptibility to further harm, following an exposure to risks and shocks. For example, the person who is already ill may become more susceptible to additional illness and deprivations. According to Kottow (2004) these individuals require more than protection. He states that they have specific needs in specific circumstances, and that these needs must be addressed by applying specific care and measures (Kottow, 2004). However, this definition, as with all the previous definitions, does not identify why these individuals may have specific needs, nor address attributes, which may reduce vulnerability and enhance resiliency (Buckle, 1998).

Kailes and Enders (2007) attempted to define the vulnerable population by moving away from using the terms vulnerability and special needs. Instead, they adopted a function-based approach to operationalizing vulnerable populations. They propose a framework to assist people who may have additional needs before, during, and after an incident in the areas communication; medical care; maintaining functional independence; supervision; and transportation (C-MIST) (Kailes & Enders, 2007). People with functional needs that will not receive this C-MIST support may suffer severe consequences as a result of an emergency or disaster. Kailes and Enders (2007) suggest that by focusing on essential -sometimes overlapping- functional needs, a more accurate and flexible planning and response framework can be developed.

Table 2.2: Kailes and Enders' functional need requirements used to define vulnerable populations (Kailes & Enders, 2007)

Need Requirement	**Definition**
Communication	Limitations that interfere with the receipt of and response to information due to: • Hearing impairment • Vision impairment • Speech limitations • Cognitive impairment • Intellectual limitations • Limited English proficiency.
Medical Care	Individuals who require assistance with managing/administration of: • unstable, terminal or contagious conditions that require observation and ongoing treatment; • intravenous (IV) therapy, tube feeding, and/or regular vital signs; • dialysis, oxygen, and suction; managing wounds, catheters, or ostomies; • Individuals operating power-dependent equipment to sustain life.
Maintaining Independence	Individuals requiring support to be independent in IADLs and ADLs such as bathing, feeding, going to the bathroom, dressing and grooming.
Supervision	Individuals who before, during, and after an emergency may be unable to identify themselves; and when in danger, they may lack the cognitive ability to assess the situation and react appropriately.
Transportation	Individuals who cannot drive or who do not have a vehicle and may need support through accessible vehicles.

Despite providing examples of which populations may share types of functional needs (e.g., people with mental health problems), Kailes and Enders (2007) do not define the specific characteristics and thresholds needed to identify vulnerable individuals at the individual level, nor do they account for characteristics that enhance resiliency. However, thinking in functional terms does provide for an opportunity to address vulnerability in a practical way (Buckle, 1998).

2.4 Individual Vulnerability and Social Factors during Disasters

The literature mentions several micro-level characteristics that contribute to increased vulnerability to the effects of disasters. Many of these characteristics are associated with age. In this section of the dissertation, all possible micro-level factors that increase the risk of harm during a disaster are described.

2.4.1 Physical Frailty

There has been much spirited debate on the concept and measurement of frailty in older persons (Bergman et al., 2007; Bortz II, 2002; de Vries et al., 2011; Fried et al., 2001; Fried, Ferrucci, Darer, Williamson, & Anderson, 2004; Gobbens, Luijkx, Wijnen-Sponselee, & Schols, 2010; Grundy, 2006; Hogan, MacKnight, & Bergman, 2003; Levers, Estabrooks, & Ross Kerr, 2006; Mitnitski, Song, & Rockwood, 2013; Rockwood, Fox, Stolee, Robertson, & Beattie, 1994; Rockwood & Mitnitski, 2007). However, there is general consensus that this population of older adults represents a group that has a weakened resistance to stressors and are at high risk of adverse health outcomes including mortality, institutionalization and hospitalization. Frailty is commonly considered to be a physiologic loss of reserve capacity and reduced ability to resist stressors (Fried et al., 2001; Rockwood et al., 1994). With the aging of the population, the prevalence of frailty is expected to increase markedly (Ahmed, Mandel, & Fain, 2007).

The physical frailty state is characterized by physical symptoms including loss of muscle mass, decreased balance and immobility, increased weakness, slowed performance, unintentional weight loss, fatigue, low activity, decreased cognitive ability as well as various biological changes such as altered nutritional markers and increased inflammatory responses (Lang, Michel, & Zekry, 2009). Factors leading to this frailty state are interconnected and may lead to further deterioration of systems. Chronic under-nutrition, consolidated by age-related changes, may cause loss of bone and skeletal muscle mass. Degenerative loss of skeletal muscle mass and muscle strength, known as sarcopenia, is regarded as one of the major components of frailty (Abate et al., 2007; Berrut et al., 2013; Heuberger, 2011; Levers et al., 2006; Zaslavsky et al., 2013). It is considered a serious risk factor as it may lead to loss of mobility, impairments in activities of daily living (ADL) and instrumental activities of daily living (IADL), neuromuscular impairment, breathing problems, reduced energy intake, slowed motor skills, reduced nutrient intake and gait and balance disorders (Bortz II, 2002; Cruz-Jentoft & Michel, 2013; Mühlberg & Sieber, 2004).

Frail older adults may have difficulties coping with disaster-induced stress, and be more adversely affected by disasters than non-frail older adults (Elmore & Brown, 2007; Fernandez et al., 2002; Tuohy & Stephens, 2011). Existing symptoms may worsen and new physical, mental or cognitive problems may emerge as a result of the disaster. The frail older adult with chronic health conditions that require medical treatments, nursing care or delivery of medication and meals, may be adversely affected when the existing support infrastructure collapses (Smith et al., 2009). Frailty in the older adult and the resulting vulnerability to progressive disability with the addition of another stressor (such as an emergency) may result in a domino effect that increases mortality (Heuberger, 2011).

Further, a multitude of problems that can contribute to adverse health outcomes may emerge when a frail older adult is evacuated to a shelter. Potential problems include inaccessibility of toilets, poor bedding, excessive noise and temperatures, separation from family, medication and medical equipment shortages, lack of training regarding psychological support, long food lines and lack of continuity of health services (Lach et al., 2005; Powell, Plouffe, & Gorr, 2009). The consequences of displacement of a frail older adult have been compared with the effects of a prolonged hospitalization, and include new or worsening disability, or even death (Gill, Allore, Gahbauer, & Murphy, 2010; Rothman & Brown, 2007). The hospitalized frail older adult may, without proper intervention, suffer from skin and muscle breakdown, sensory deprivation, altered sleep patterns, and increased risk for deconditioning, delirium, confusion and falls, ultimately leading to institutionalization (Gillis & MacDonald, 2005; Rothman & Brown, 2007). The same effect is witnessed after displacements during disasters. In Louisiana, for example, over 1300 adults living in the community prior to hurricane Katrina now live in nursing homes after the storm displaced them from their homes (Campbell, 2007b).

The risk of falls is very high among frail older adults (Cefalu, 2011; Gill et al., 2010; Lamoth et al., 2011). Major risk factors for falling are gait and postural instability, as well as cognitive impairments (Lamoth et al., 2011). The ability of some frail older adults to engage in avoidance of structures and to navigate in an unfamiliar environment may be compromised, especially for those with mobility, motor skills and vision challenges (Banks, 2013; Lach et al., 2005). This can lead to serious falls and injuries (Uscher-Pines, Vernick, Curriero, Lieberman, & Burke, 2009). Among those who died from falls or complications of falls during Hurricane Andrew, 80% were at least 60 years of age (Ngo, 2001). Twelve months after Hurricane Katrina, over 7,000 older adults 65 years or older had still not returned home. These displaced victims had 1.53 greater odds of sustaining a hip fracture, and 1.24 greater odds of sustaining other fractures even after adjusting for other risk factors (Uscher-Pines et al., 2009). This may be caused, in part, by the type of housing (such as mobile homes), environmental unfamiliarity, as well as a lack of assistive aids (such as walkers) and hazards that contribute to falls (Uscher-Pines et al., 2009). Frail older adults in high-rise buildings during a power outage may be particularly vulnerable to falls as elevators are no longer an option and stairs are the only means of entering or exiting the building.

Disasters often cause damage to structures and other dangerous conditions, and may necessitate the evacuation of large portions of the population. The frail older adult may not be able to seek cover quickly enough during a sudden disaster such as an earthquake or tornado (Smith et al., 2009) or may have trouble gaining access to needed relief supplies, personnel or services (Rothman & Brown, 2007).

Prolonged inactivity due to the unavailability of assistance - in either a shelter or during shelter-in-place- increases the risk of further physical decline. Decreased activity may increase the onset of new chronic diseases, new or worsening disability, or initiation of frailty (Fried et al., 2004; Gill et al., 2010).

When the nutritional status of frail older adults is threatened by an interruption of food intake or supply this may lead to (further) sarcopenia (Heuberger, 2011; Levers et al., 2006) and other complications such as impaired wound healing (Rothman & Brown, 2007). Nutritional dependent conditions such as renal disease and intestinal conditions may worsen when an older frail adult is in a shelter without sufficient food choices (Banks, 2013) or in shelter-in-home without proper home care services to ensure nutritional food intake (Behr & Diaz, 2013).

Frail older adults are also highly susceptible to dehydration, a potent risk factor for confusion and falls (Lach et al., 2005; Rothman & Brown, 2007). Dehydration is a risk factor of particular concern for frail older adults since it may lead to delirium (Inouye, Studenski, Tinetti, & Kuchel, 2007). Certain medications can contribute to dehydration, and the frail older person may not have sufficient liquid intake (lack of awareness, memory deficits, incontinence). Water may not be readily available during disasters further confounding the risk (Rothman & Brown, 2007).

Severe heat and cold present a great risk for frail older adults. Frail older adults are less able to regulate body temperature due to changes in body structure. These changes include decreased water content and loss of subcutaneous tissue, and may be compounded by medications (Lamb et al., 2008). During the 1995 Chicago heat wave 372 of the over 500 deaths were frail older adults (Whitman et al., 1997). Most of the elderly that died were socially isolated individuals with medical conditions with no access to air conditioning (Whitman et al., 1997). The European heat wave of 2003 reveals even more astounding numbers. Of the 14800 deaths that occurred during the heat wave in France 70% were among persons 75 years and older, and 20% among people aged 94 years and over (Pirard et al., 2005).

Caring for frail older adults is challenging, especially under extreme circumstances such as those posed by major emergencies and disasters. They have an increased burden of symptoms and may be medically complex. They may have cognitive impairments, mood disorders and be socially dependent. They are characterized by a reduced reserve capacity and under extreme stress such as an emergency or disaster they may have difficulties coping and may be more adversely affected than non-frail older adults. Existing symptoms may worsen and some new physical, mental or cognitive problems may emerge as a result of the major emergency or disaster.

2.4.2 Cognitive Impairments

Cognitively impaired individuals have reduced ability to process information, communicate and understand. Consequently, they are less capable of responding accordingly to an impending emergency or disaster. Under adverse conditions, they may have exacerbated difficulty with communication, comprehending dangers, complying with safety procedures as well as understanding risk communication, weather warnings, evacuation orders, and offers of assistance (Eisenman, Cordasco, Asch, Golden, & Glik, 2007; Lach et al., 2005; Pekovic, Seff, & Rothman, 2007).

Cognitive impairment increases the risk of falls (Inouye et al., 2007). It can also lead to altered behaviours such as forgetting to eat, drink, lack of self-care, aggression, increasing apathy and inability to maintain a healthy diet (Robertson, Savva, & Kenny, 2013; Rothman & Brown, 2007), leading to further decline.

2.4.3 Physical Disability

The term disability is defined by the World Health Organization (WHO) as follows: "An umbrella term for impairments, activity limitations and participation restriction; it denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal)" (World Health Organization, 2001, p. 213). Disability can be manifested in various ways, including limitations in cognition, mobility, vision, hearing, activities of daily living (ADL) (for example bathing, toileting and feeding) or independent activities of daily living (IADL) (e.g., managing money) (Campbell et al., 2009).

In the event of a major emergency or disaster, a disability of any type can hinder the person's ability to bring him/herself to safety. People with impaired mobility may not be able to quickly evacuate or seek cover during a sudden disaster impact such as an earthquake or tornado (Smith et al., 2009) or gain access to needed relief supplies, personnel or services (Rothman & Brown, 2007). Damage to structures and other dangerous conditions may make it physically impossible for persons with mobility or visual impairments to evacuate independently. People with hearing and visual impairments may also have a limited understanding of warnings and directions (Banks, 2013). After Hurricane Katrina, sensory impairments prevented some frail elderly persons in evacuation centres from reading signs indicating where help could be located, or from hearing announcements over the public address system (Baylor College of Medicine & American Medical Association, 2006).

Further, those people that require assistance with ADLs and IADLs may become isolated when home care and community support agencies are unable to provide the support services. These risks are greatest for people with severe disabilities (Campbell et al., 2009).

2.4.4 Chronic Illness, Medications and Power Driven Equipment

In several studies examining the relationship between disease processes and disasters, it is concluded that the presence of disease influenced the post disaster morbidity and mortality. It is well accepted that people with long term health conditions and chronic illnesses are adversely affected during disasters and that their condition(s) will worsen (Evans, 2010). For example, during the two weeks following Hurricane Andrew, half of those disaster victims who died from cardiovascular causes were 60 years of age and older, and the number of cardiovascular deaths among this group doubled each day (Ngo, 2001). Further, non-traumatic illness accounted for 55.5% of all hospital admissions within two weeks of the Kobe earthquake in 1995 (Evans, 2010). On the day of the Northridge, California earthquake in 1994 the number of sudden deaths related to cardiac causes increased fivefold (Ngo, 2001). In fact, half of the 101 deaths during this earthquake were cardiac related.

Greenough et al. (2008) conducted a survey of 499 evacuees accommodated in 18 different American Red Cross shelters in Louisiana 2 weeks after Hurricane Katrina hit New

Orleans. Among the survey questions were questions focused on acute and chronic burden of disease and health care access. Of the 499 respondents, over half (55.6%) had a pre-existing chronic illness and of those almost half (48.4%) did not have access to any medications to treat the condition. Immediate medical attention was needed for more than one third (34.5%), showing a range of symptoms including dehydration (12.0%), dyspnea (11.5%), injury (9.4%), and chest pain (9.7%).

The inaccessibility of prescribed medications is an important factor that may lead to a deterioration of a previously well-controlled chronic illness (Evans, 2010; Greenough et al., 2008). People with comorbidities commonly require a number of medications and treatment regimes. People that rely on multiple medications are at particular risk for medication withdrawal. Symptoms of drug withdrawal can include agitation, hallucinations, hypertension or seizure (Rothman & Brown, 2007). An interruption in the supply of medications and medical supplies, lack of access to healthcare providers, and disruption of daily eating and health care routines, all may lead to a further decline in health status (Arrieta, Foreman, Crook, & Icenogle, 2009; Banks, 2013). Problems such as storing insulin, monitoring glucose levels, inadequate oxygen and portable tank supplies, incapability to provide dialysis, insufficient patient knowledge of medications and lack of medication supply were frequently reported during and after Hurricane Katrina (Arrieta et al., 2009). Further, the addition of new medications as a result of disaster related injury exposed evacuees to increased risk of adverse outcomes due to drug interactions, including kidney or liver damage, bleeding or confusion (Rothman & Brown, 2007).

People with chronic illnesses who appear to be at particular risk for adverse health outcomes include those with cardiovascular diseases, types 1 and 2 diabetes mellitus and respiratory diseases (Evans, 2010). The response to acute stress, the lack of medications and the increased workload associated with self-rescue and reconstruction increases the risk for cardiovascular patients (Evans, 2010). People with types 1 and 2 diabetes mellitus are at risk of disruption of glycemic control when lack of insulin and changes in nutrition are outcomes of the disaster or emergency (Evans, 2010; Greenough et al., 2008). Maintaining proper nutritional intake is especially of concern in shelters where people are offered foods that are high in fat and salt, and lack the appropriate nutritional value (Evans, 2010).

There are a number of risk factors for exacerbations of underlying respiratory illnesses cited in the literature including increased physical activity, environmental exposure to cold, mold spores and other airborne particulate matter, disruption of medication regimes and dehydration (Evans, 2010). It has also been shown that acute respiratory illness can increase 4-fold in crowded shelters (Shoaf, 2014).

Lastly, people dependent on electrically powered life-saving devices such as mechanical ventilators, oxygen compressors and dialysis machines are very vulnerable to power outages, especially outages that are long in duration (Prezant et al., 2005).

2.4.5 Mental Health

A major disaster can cause a disruption of every aspect of life (Brown, 2007). The psychological effects of disasters can be immediate or delayed, and are sometimes short term but can be very persistent (Ngo, 2001; Shoaf, 2014). The stress of locating family members, the loss of possessions, and the burden of filling out forms commonly results in loss of self-esteem, feelings of anger or helplessness, depression, anxiety and denial and shock (Brown, 2007; Lamb et al., 2008; Ngo, 2001). Older adults may display a variety of reactions to trauma, including withdrawal and social isolation, physical reactions such as sleep disorders and hypo- or hyperthermia, and emotional reactions such as depression, fear of institutionalization and anxiety with unfamiliar surroundings (Evans, 2010; Pekovic et al., 2007).

Individuals with pre-existing mental health problems are particularly vulnerable to additional stressors and long-term psychological decline (Brown, 2007; Gibson & Gutman, 2013). Evacuations or moves from one facility to another may become quickly disorientating and confusing (Pekovic et al., 2007). They may wander, have poor impulse control, or resist medical care or assistance with ADLs and IADLs (Pekovic et al., 2007). Any mental health problem, including depression and anxiety, may impair the ability or urge to respond to disasters, including following directions (Brown, 2007; Cloyd & Dyer, 2010).

According to many researchers, under detected depression and anxiety is common among older adults (Brown, 2007; Préville, Côté, Boyer, & Hébert, 2004; Szczerbinska, Hirdes, & Zyczkowska, 2012). Older adults may consider the disorders as a stigmatizing condition subject to denial and be less likely to report a mood disorder (Arrieta et al., 2009; Préville et al., 2004). Few elderly disaster victims seek out assistance from agencies providing counseling and other mental health services due to the stigma associated with these services (Ngo, 2001) and fear of institutionalization (Pekovic et al., 2007). For this reason, many psychological disorders after disasters remain undetected and untreated.

There has been a wealth of literature written on the subject of Post-Traumatic Stress Disorder (PTSD) as a consequence of disasters and major emergencies. PTSD is an anxiety problem that develops in some people after extremely traumatic events. People with PTSD may re-experience the event via intrusive memories, flashbacks and nightmares; avoid anything that reminds them of the event; and have anxious feelings they did not have before that are so intense their lives are disrupted (American Psychological Association, 2014). PTSD has been the main focus of mental health research on the aftermath of a disaster (Gibbs & Montagnino, 2007). For example, Van Kamp et al. (2006) assessed self-reported physical and mental health among those affected by the explosion of a fireworks storage facility in a residential area in Enschede, The Netherlands two to three weeks after the disaster. They concluded that physical and mental health problems were strongly associated with the shocking experiences during and shortly after the disaster (van Kamp et al., 2006).

Despite the research, it remains unclear which individual predictors can be attributed to PTSD. In 2002, Livanou and colleagues (2002) examined the incidence of PTSD and depression in 1,027 earthquake survivors after the August 1999 earthquake in Turkey. They report estimated rates of PTSD at 63% and major depression rate of 42% (Livanou, Basoglu, Salcioglu, & Kalender, 2002). They found overlapping predictors for PTSD and depression, but noted differences as well. Severe PTSD symptoms were related to greater fear during the earthquake, female gender, lower educational level, loss of friends, shorter time since the earthquake, and material loss. Severe depression symptoms were also related to female gender, lower educational level and loss of a family member, longer time since the earthquake and past psychiatric illness.

Several other researchers have found victim characteristics that make them more vulnerable to PTSD and depression. Cherry et al. (2014) examined the long-term psychological outcomes in older adults after Hurricanes Katrina and Rita and the 2010 British Petroleum Deepwater Horizon oil spill. They concluded that individuals with low income and low social support are at greater risk (Cherry et al., 2014). The researchers argued that age alone was not a significant predictor of psychological outcomes.

2.4.6 Social Factors

Social Isolation

The same things that provide for a high quality of life in the best of circumstances are what make someone safe during a disaster (Campbell, 2007b). The richness of connections to family, friends, community, church and health care services provide a protective buffer from harm (Campbell, 2007b; Tuohy & Stephens, 2011). The more connections one has the greater the likelihood that assistance will be available when needed. If the informal support network is unable to respond during an emergency, formal service providers provide a safety net, provided that these services can continue (Campbell, 2007b). If these services and the traditional social structures of family and neighbourhood support are unavailable, older adults may become more socially isolated and be left to care for themselves during a disaster (Tuohy & Stephens, 2011).

Social isolation may have severe consequences for the health and well-being of the (frail) older adult. Their ability to cope independently may exceed their resources and the disaster may leave them at risk for adverse health outcomes including death, as well as further isolation, neglect, exploitation and violence (Ngo, 2001). In the event of an evacuation, it is often the case that the older resident is unable to evacuate without help due to immobility and lack of resources -including transportation and assistance-, leaving them 'stranded' in their homes exposed to the impending hazard (Cloyd & Dyer, 2010).

Increased social isolation may further contribute to a lack of information and understanding about the disaster situation, and inability to recognize the threat (Tuohy & Stephens, 2011). Social isolation may prevent elderly persons from receiving important warnings or asking for help, rendering them virtually invisible from rescue and recovery efforts (Eisenman et al., 2007; Tuohy & Stephens, 2011). During the 2007 floods of North

Island township of Kaitaia, New Zealand, community dwelling individuals experienced more negative outcomes than those living in rest homes where 24-hour support was provided (Tuohy & Stephens, 2011). Tuohy and Stephens (2011) attribute the relatively poorer outcomes to the community dwelling individuals' lack of receipt of warning and timely information, and their inability to cope when resources fell short.

Emotional Attachment

Many studies have shown the unwillingness of elderly to leave their home. It is likely that the fear of the unknown plays a large factor (Banks, 2013) as well as the emotional attachment to their homes and belongings (Campbell, 2007b; Lach et al., 2005). During Hurricane Katrina, many people refused to evacuate due to fear of loss of belongings (Campbell, 2007b). Campbell (2007) suggests that they treasured personal objects that provide them with symbolic meanings and personnel identity. These objects may symbolize perceived control, mastery of aspects of the environment and a sense of belonging (Campbell, 2007b; Tuohy & Stephens, 2011). Further, the exclusion of pets from evacuation vehicles and shelters has also led to the unwillingness of many older adults to evacuate (Banks, 2013; Buttke et al., 2013; Langan & Christopher, 2012; McCann, 2011; World Health Organization, 2008). The evacuation of owner and pet remains an unresolved issue.

Socio-Economic Conditions

Disaster vulnerability is directly increased by poverty through its association with poorly constructed housing and the location of cheap(er) housing in high-risk geographical areas, (such as flood plains) as well as the lack of access to transportation and inability to pay high insurance premiums (Evans, 2010; Ngo, 2001). When New Orleans was under an evacuation order, many were unable to afford transportation or purchase the essentials needed to flee the city, leaving them stranded when the storm hit (Elder et al., 2007; Vink, Takeuchi, & Kibler, 2014). There is a higher prevalence of poverty among people with disabilities (Campbell et al., 2009) and people with lower income are more at risk for physical frailty (Gobbens, van Assen, Luijkx, Wijnen-Sponselee, & Schols, 2010).

A further concern is the risk of elder abuse, exploitation and neglect during and after disasters. During hurricane Katrina, many older adults became victims of theft when medications, pocket money, relief payments and other belongings were stolen (Cloyd & Dyer, 2010). Shelters should therefore have appropriate security to protect older adults who are vulnerable to theft, scams and sexual assaults (Baylor College of Medicine & American Medical Association, 2006). Every effort should be made to protect vulnerable older adults from any scams and fraud in the aftermath (Cloyd & Dyer, 2010).

Gender

There are socially determined differences that may put women more at risk of suffering negative health consequences following a disaster. In several case studies conducted by the WHO, gender played a substantial role in terms of dependency on others for information, support and access to services (Powell et al., 2009; World Health Organization, 2008). Gobbens et al. (2010) found that women tend to live alone more often than men and this social isolation may put women more at risk. Further, women generally have less access to resources and may find themselves at a disadvantage during the recovery period when attempting to get loans or other forms of financial assistance (Wisner & Luce, 1993). For this reason, gender plays an important role in the assessment of social vulnerability to disasters (Powell et al., 2009).

Conclusion

These examples demonstrate the importance of considering social vulnerabilities when planning for disasters. Social conditions, such as socio-economic status, living arrangements and the availability of informal support networks can directly influence the capacity to cope during and after disasters. It is therefore important to not only target the physical, cognitive and mental limitations of older adults, but to also pay close consideration to social vulnerabilities in an effort to mitigate the effects of emergencies and disasters on the health and well-being of older adults.

2.5 Home and Community Care in Ontario

Home care in Ontario is provided by service provider organizations under contract by Community Care Access Centres (CCAC). These services include nursing, therapies, homemaking, personal support services and other related services. There are 14 CCACs in the province ensuring access and quality of home and community care services (Canadian Home Care Association, 2013). Funding and oversight for CCACs is provided by 14 not-for-profit Local Health Integration Networks (LHIN). LHINs work with local health providers and community members to determine the health service priorities of each region. CCACs determine eligibility for services such as nursing, personal support and occupational therapy, develop treatment goals and monitor provision of services.

In 2012, 2.2 million Canadians received home care services (Sinha & Bleakney, 2014), comprising 8% of the Canadian population aged 15 years or older. 40% of the care receivers were 65 years or older. In 2015 home care services were provided to over 700,000 Ontarians through CCACs (Auditor General of Ontario, 2015; Ontario Association of Community Care Access Centres, 2014b), which is approximately 5% of persons of a total population of 13,792,100 (Statistics Canada, 2015).

In 2014, 2,137,100 (15.6%) of the population in Ontario was 65 years or older (Statistics Canada, 2014). 349,000 seniors received home care in 2013/2014, which is

16.3% of the population 65 years and older (Ontario Association of Community Care Access Centres, 2014a).

In addition to home care provided through contracted service providers arranged by CCACs, additional community support services (CSS) are provided to clients by a network of CSS agencies. These services are provided to help clients maintain their safety and independence while living at home. In 2012 in Ontario there were 644 agencies that provided these services and that are funded by LHINs with an estimated workforce of over 24,000 staff and 100,000 volunteers (Ontario Community Support Association, 2010; Sinha, 2013). Services provided through these agencies range from personal support services and homemaking to meals delivery and transportation. The sector provides services to over one million people each year, across the province (Ontario Community Support Association, 2015).

2.6 interRAI Assessments

interRAI assessments instruments are developed and implemented by an international collaborative of researchers and clinicians from over 30 countries, with the overarching aim of improving the quality of life of vulnerable persons (interRAI, 2015). This collaborative network is committed to improving services for vulnerable populations including older persons, persons with disabilities and those affected by mental illness (Carpenter & Hirdes, 2013). Researchers in this group have developed instruments for various health care settings including acute care, palliative care, long term care facilities, mental health and home care. This dissertation uses data collected through the RAI Home Care instrument (RAI-HC).

In Ontario, the RAI-HC is the mandated primary assessment tool for long-stay home care clients (Canadian Home Care Association, 2013; Morris, Fries, & Bernabei, 2009;

Morris et al., 1997). The instrument contains over 300 items and provides a comprehensive description of the needs and characteristics of the home care client population in Ontario. It is administered by Community Care Access Centre (CCAC) case managers/care coordinators at six-month intervals on all long-stay clients receiving service, or expected to receive service, for a period exceeding 60 days, and on clients who may require placement into a long-term care home (Canadian Home Care Association, 2013). The RAI-HC assessment instrument focuses on addressing the needs of adults of all ages living in community dwellings with complex and disabling physical and mental illnesses (Gray et al., 2009) and covers multiple domains of function, health, social support and service use (Morris et al., 1997).

The RAI-HC is part of a suite of instruments including assessments for long-term care facilities (LTCF), acute care (AC) and mental health (MH) (Carpenter & Hirdes, 2013; Hirdes et al., 1999). Core assessment items focus on issues such as communication and vision, physical functioning, cognition, psychosocial well-being and health conditions (Carpenter & Hirdes, 2013). All instruments in the interRAI suite are designed to trigger Clinical Assessment Protocols (CAPs) when needed and produce observations and outputs to assist clinicians in care planning and further assessment (Gray et al., 2009; Morris et al., 1997). The RAI-HC includes 30 CAPs to flag potential problem areas for persons receiving homecare such as pain, health promotion, social isolation, elder abuse and falls (Hirdes et al., 1999; Morris et al., 2010). For all interRAI instruments a series of outcome measures have been developed, including the Cognitive Performance Scale (CPS) (Morris et al., 1994), Depression Rating Scale (DRS) (Burrows, Morris, Simon, Hirdes, & Phillips, 2000), Activities of Daily Living (ADL) (Morris, Fries, & Morris, 1999) and the Changes in Health, End-stage disease and Symptoms and Signs (CHESS) score (Hirdes, Frijters, & Teare, 2003).

The CPS assigns clients into one of seven cognitive performance categories (Morris et al., 1994). The status ranges from intact (0) to very severely impaired (6). The DRS is a measure for depressive symptoms. Scores of 3 or greater indicate moderate or severe depressive disorders (Burrows et al., 2000; Szczerbinska et al., 2012).

The ADL hierarchy scale is a six-point scale measuring the ability to perform ADLs. It is based on the items personal hygiene, toilet transfer, locomotion and eating (Morris et al., 1999). The scores range from independent (0) to total dependence (6). The CHESS is a measure of health stability and predicts mortality (Hirdes et al., 2003). Scores range for 0 (no instability) to 5 (highest level of instability).

Finally, the MAPLe score is an algorithm that predicts nursing home placement, caregiver distress and for being rated as requiring alternative placement to improve outlook (Hirdes, Poss, & Curtin-Telegdi, 2008; Mitchell et al., 2015). The algorithm is intended to inform the prioritization of services. Scores range from low to very high risk.

2.6.1 Validity & Reliability

The validity and reliability of the RAI items, CAPs and scales have been reported extensively (Armstrong, Stolee, Hirdes, & Poss, 2010; Foebel et al., 2013; Hirdes et al., 2003; Hirdes et al., 2008; Hirdes, Poss, Mitchell, Korngut, & Heckman, 2014; Hjaltadáttir, Hallberg, Ekwall, & Nyberg, 2011; Jones, Perlman, Hirdes, & Scott, 2010; Landi et al., 2000; Morris et al., 1994; Morris et al., 1999; Onder et al., 2012).

To test inter-rater reliability of the Minimum Data Set for Home Care (MDS-HC) dual assessments were performed on 241 randomly selected home care clients in five countries (Morris et al., 1997). An average weighted kappa coefficient of 0.74 and 0.70 indicated high reliability of HC items. Further, Hirdes et al. (2008) examined the inter-rater reliability of items of five instruments, including the interRAI HC by conducting paired assessments on

783 individuals across 12 nations. Assessors were blinded to the other's assessment. They concluded that over 60% of items scored kappas greater than 0.70, also indicating a high reliability. Weighted kappa values varied among instruments from 0.63 to 0.73 (Hirdes et al., 2008).

Finally, as part of the European SHELTER (Services and Health for Elderly in Long TERm care) study, the test-retest and inter-rater reliability of the interRAI LTCF instrument (MDS) was presented (Onder et al., 2012). The interRAI LTCF as well as the interRAI HC are part of the third generation suit of instruments (Bernabei, Landi, Onder, Liperoti, & Gambassi, 2008). Instruments that are included in this suit have core items (70%) that are considered to be important in all care settings. The researchers concluded that 197 of the 198 items met or went above acceptable test-retest and inter-rater reliability limits (kappas 0.75 – 0.92 and 0.64 – 0.91) (Onder et al., 2012).

The CHESS has been validated and was found to be a strong predictor of mortality in different care settings, including in specific diagnostic groups (Hirdes et al., 2003; Hirdes et al., 2014). The correlations between CHESS and the Edmonton Frail Scale (EFS) and the frailty index (FI) (Rockwood & Mitnitski, 2007) were low (EFS, $r = 0.39$; FI, $r = 0.35$) (Armstrong et al., 2010). The CHESS however was shown to perform well in predicting adverse events in comparison to the two other algorithms (Armstrong et al., 2010).

The CPS has been validated against the Mini-Mental State Examination (MMSE), the Test for Severe Impairment and the Montreal Cognitive Assessment (MoCA) (Gruber-Baldini, Zimmerman, Mortimore, & Magaziner, 2000; Jones et al., 2010; Landi et al., 2000; Morris et al., 1994). Scores of the scale corresponded closely with the scores of the three validation instruments. In 2015, the CPS has been tentatively adjusted to an eight-scale measurement (Morris et al., 2015). A validation of the revised scale took place with a self-reported dementia prognosis, IADL and ADL functional problems, living status and 5 measures of distress. The new scale was found to be higher correlated (-0.75) with the MSSE then the original CPS (-0.72). The new CPS score also corresponded with scores on the validation items (e.g., increased IADL and ADL dependence corresponded with CPS scores).

The DRS has been validated against the Hamilton Rating Scale and the Cornell Scale for Depression with coefficient of r=0.70 and r=0.69 (Burrows et al., 2000). In addition, the DRS was found to be as strongly associated with depression diagnoses as the Geriatric Depression Scale (GDS) in a nursing home sample (Koehler et al., 2005). The DRS was also found to be strongly associated with the CHESS, cognitive impairment, functional impairment and pain (Szczerbinska et al., 2012).

Inter-rater reliability was tested for the ADL items (Morris et al., 1999). All kappas were above the 0.75 threshold, which indicates a strong reliability. Landi et al (2000) found furthermore a strong correlation between the ADL hierarchy scale and the Barthel Index indicating acceptable validity (r=0.74) (Landi et al., 2000).

Finally, a study in Iceland tested the predictive power of the CHESS, DRS, CPS and ADL long scale for 3-year mortality using the MDS for nursing homes (Hjaltadáttir et al., 2011). The researchers concluded that the CHESS and ADL performance were significant predictors of mortality. A similar study in Hong Kong came to the same conclusion(Lee, Chau, Hui, Chan, & Woo, 2009). The MDS-ADL, MDS-CPS as well as the MDS-CHESS were shown to be significantly predictive in terms of survival time.

3. Identification of Priority Home Care Clients in Ontario Using RAI-HC Priority Algorithms

This chapter will address the first research question. It will describe characteristics of home care clients that would be considered a priority during a disaster when three distinct priority algorithms are applied. The chapter reviews the applicability of priority algorithms to the RAI-HC database in the province of Ontario.

3.1 The Canterbury New Zealand Earthquake

At 12:51 pm local time on the 22nd of February 2011 the city of Christchurch, New Zealand (NZ) was struck by a 6.2 magnitude earthquake. This was one of the over 4,000 aftershocks following the 7.1 magnitude Darfield Earthquake on September 4th 2010 (Hogg, Kingham, Wilson, Griffin, & Ardagh, 2014; Spittlehouse, Joyce, Vierck, Schluter, & Pearson, 2014). The February 22nd earthquake killed 185 people, injured over 8,000, and destroyed or damaged over 100,000 buildings (Hogg et al., 2014). Many buildings collapsed and rock fall, landslides and large scale cliff collapses occurred, resulting in over 40 billion NZ dollars of damage (Hogg et al., 2014; Spittlehouse et al., 2014). Infrastructure services such as freshwater, sewerage and storm water systems ceased to function (Hogg et al., 2014) and power supplies were cut off (Tuohy, Stephens, & Johnston, 2014). Many houses were rendered uninhabitable due to the extensive damage and liquefaction of the ground.

Fifteen percent of the Christchurch population is above 65 years of age, which is the highest percentage of all New Zealand. The earthquake had an immense effect on elderly people and the ability of health agencies to provide services to this vulnerable group. During the earthquake older adults experienced difficulties seeking protection due to their immobility and fear of falls (Tuohy et al., 2014). This risk of falling remained a concern for many older adults receiving home based community care eighteen months after the earthquake due to the resulting damage to their homes (Hendry & East, 2013). Many were displaced from their homes and placed in unsuitable accommodation (Goldstraw et al., 2012; Stuff, 2012).

The Princess Margaret Hospital experienced a substantial increase in demand as the injured elderly sought care at the hospital. This demand was further increased by the necessity for admissions due to the loss of over 600 residential care beds (Goldstraw et al., 2012). The nature of the injuries (e.g., broken hips), the damage to the homes, as well as the closure of rest homes led to the evacuation of patients to hospitals outside the city (Johnston, 2011). The earthquake ultimately led to the closure and evacuation of 516 elderly persons from 9 residential care facilities (Heppenstall, Wilkinson, Hanger, Dhanak, & Keeling, 2013).

In the days and weeks following the earthquake, the identification of those people that were at risk of adverse health outcomes posed a major challenge to emergency response teams in Canterbury. As all District Health Boards in New Zealand have implemented the RAI-HC (Downes, 2011; McDonald, 2012), the Chief Medical Officer for the Canterbury District Health Board, the local agency in the Christchurch area, and interRAI Canada researchers at the University of Waterloo collaborated to develop a quick triage algorithm that could be applied to the Canterbury RAI-HC database for clients that had been assessed in the last 14 months (Downes, 2011; McDonald, 2012; University of Waterloo, 2011). The algorithm employed health related items and clinical thresholds that contribute to risk of adverse outcomes, including levels of health instability, cognitive impairment and impairments in Activities in Daily Living (ADL). The algorithm also took into consideration the level of social isolation and the amount of support the individual may receive from informal caregivers. This algorithm generated a list of just under two thousand records.

The Canterbury team subsequently chose to categorize all clients into one of three priority groups (Downes, 2011). The highest risk group constituted those persons with moderate to very severe cognitive impairment, medical instability and ADL impairment as measured by the Cognitive Performance Score (CPS), Changes in Health, End-Stage Disease, Signs, and Symptoms Scale (CHESS) and Activities of Daily Living (ADL) Hierarchy (approximately 100 people). The second group was those people that scored moderate or higher in two of the three scales (approximately 250 people). Finally, the last group was those people that scored moderate or higher in one of the three scales (approximately 400 people).

The HC assessment was also used to pass on health information as the assessment travelled with the client throughout the evacuation process. Anyone involved with the client was subsequently aware of his or her needs.

3.2 Rational and Objectives

There are several pathways to minimizing a person's vulnerability and adverse outcomes from a disaster. Mitigation efforts may be targeted to minimize the threat of a hazard. Typical mitigation efforts include land use planning (e.g., no vulnerable people in flood prone areas), stringent building codes for houses in hazard prone areas and other structural enhancements aimed at reducing the vulnerability of individuals with disabilities, chronic conditions and functional limitations.

Stimulating personal preparedness efforts, organizational preparedness and contingency planning are well-proven strategies to maximize coping capacity of communities and individuals (Gibson et al., 2013). However, several studies have concluded that people with disabilities and chronic health problems are less prepared for a disaster (Eisenman et al., 2009). The relative absence of disaster supplies and communication plans increases their vulnerabilities (Eisenman et al., 2009). Findings that people of poor health are less prepared for a disaster should encourage public health and health professional groups to target this population for disaster preparedness, and make disaster-planning part of the overall health policies and programs (Eisenman et al., 2009).

The preparedness of emergency management organizations and first responders for the needs of people with disabilities and health problems is also limited (Fox et al., 2007; Gutman, 2007; Rooney & White, 2007). Many report the lack of preparedness of responders to address the needs of people with any type of disability, and that needs are often overlooked by disaster planners (International Federation of Red Cross and Red Crescent Societies, 2007; Nick et al., 2009). During Hurricanes Katrina and Rita many vulnerable people were stranded awaiting evacuation assistance, were refused shelter by unprepared organizations, or experienced difficulties in accessing emergency services because of pre-existing health conditions or vulnerabilities (Nick et al., 2009). Many first responders have little or no education in responding to the needs of people with disabilities, and lack guidelines and standard operating procedures as part of their planning efforts (Fox et al., 2007; Laditka, Laditka, Cornman, Davis, & Chandlee, 2008; Wingate, Perry, Campbell, David, & Weist, 2007).

The exercise of applying decision support algorithms to the Ontario home care population may highlight the sizeable numbers of community dwelling vulnerable adults that may require assistance before, during and after a disaster and their distinct functional needs. This may encourage emergency management professionals to seek ways to reduce this vulnerability and invest in emergency preparedness efforts for first responders and vulnerable individuals. Increased familiarity with the members of the community, their respective needs and the prevalence of vulnerability factors further enables emergency managers to plan for essential strategies such as the assignment of medical shelters, arranging special transportation means, developing communication strategies and recruiting psychological and social support volunteers.

It should be acknowledged that despite the relatively high needs of home care clients, it is not pragmatically useful to prioritize all home care clients at a single high risk level. A method for prioritizing emergency response efforts would allow for a targeted response founded on need and in consideration of available resources. As the algorithm used in Canterbury was developed in the direct aftermath of a disaster and under strict time restrictions, the algorithm was based on the expert opinion of researchers and health professionals. Even though the algorithm proved to be very useful after the earthquake, it was recognized further research is needed to refine and validate a decision support algorithm before widespread deployment is recommended.

This dissertation chapter aims to examine the implications of applying the Canterbury algorithm and variations to the algorithm to the Ontario Home Care Client database. Specifically this chapter will answer the following questions:

1. What proportion of long stay home care clients in Ontario would be considered priority clients during an emergency response?
2. What are the person-level characteristics of the high priority clients compared to low priority clients?
3. Are there any clients classified as low priority that would be expected to be priority clients based on the vulnerability items identified in the literature?
4. Which decision support algorithm is predictive of vulnerability status in 'normal' situations? This last question can be investigated by answering the following sub-questions:
    a. What are the survival rates of high priority clients compared to low priority clients?
    b. What are the rates of Long Term Care (LTC) admissions of high priority clients compared to low priority clients?

c. What are the rates of hospitalization of high priority clients compared to low priority clients?

3.3 Methods

3.3.1 Data Sources

Data used for this analysis come from the RAI-HC database in Ontario. The data are sent annually by the Ontario Association of Community Care Access Centres (OACCAC) to the University of Waterloo through a licensing agreement between interRAI and OACCAC that permits the sharing of de-identified assessment data.

3.3.2 Decision Support Algorithms

For this chapter three distinct decision support algorithms will be applied to the RAI-HC database: the algorithm sent by the University of Waterloo to Canterbury; the algorithm applied by the Canterbury District Health Board; and an algorithm that was designed for this dissertation, called the interRAI Vulnerable Persons at Risk (VPR) algorithm.

The University of Waterloo (UW) algorithm defines two groups, a high priority and a low priority group. The high priority clients are those clients that trigger one or more HC items in the impaired capacity column and either a social isolation item or a limited caregiver support item. These items further investigate the degree of individual competence to cope when the environment changes (e.g., due to a disaster), resulting in a person-environment misfit. This algorithm was developed by Dr. J. Hirdes of the University of Waterloo based on expert opinion and the literature and sent to Canterbury shortly after the earthquake.

The Canterbury algorithm distinguishes between two groups and uses the same strategy as the University of Waterloo algorithm. It is based on the original algorithm sent by the University of Waterloo, but the thresholds of some of the items are higher and some items are no longer used.

The VPR algorithm divides clients into three groups: low priority, medium priority and high priority. The highest risk group consists of those clients that trigger three or more of the impaired capacity items as well as one item in either the limited caregiver support or social isolation categories. The medium priority group consists of those clients that only trigger three or more of the impaired capacity items and not the caregiver support or isolation items. The low priority group are those clients that do not fulfill the requirements above.

This VPR algorithm was developed by testing the algorithm's association with the RAI-HC item "Client or primary caregiver feels that client would be better off in another living environment" (RAI item O2b). This variable is useful because it would be considered to be an objective rating of the person-environment fit for the current setting the person lives in. If that environment is considered to be a problem in normal circumstances, then it would certainly pose major challenges in the context of a disaster or large-scale emergency. Table 3.2 shows the odds ratios of the VPR items with this variable.

The different RAI-HC items and thresholds used in all three decision support algorithms are presented in Table 3.1.

Table 3.1: RAI-HC Items and thresholds used in the three decision support algorithms to identify vulnerable persons in large-scale emergencies and disasters

HC Item	University of Waterloo Algorithm	Canterbury Algorithm	VPR Algorithm
Impaired Capacity			
- Cognitive Performance Scale (CPS) †	CPS 2+	CPS 3+	CPS 2+
- Frailty/health instability measured by CHESS score ‡	CHESS 2+	CHESS 3+	CHESS 3+
- Vision impairment §	D1 = 2+	D1 = 2+	D1 = 3+
- Impairment in Activities in Daily Living (ADL) ¶	ADL Hierarchy 2+	ADL Hierarchy 3+	ADL Hierarchy 3+
ADL-self performance #: Transfer Locomotion in home Toilet use	 H2b = 2+ H2c = 2+ H2h = 2+	 Not used Not used Not used	 H2b = 3+ H2c = 3+ H2h = 3+
IADL Difficulty ††: - Medication management - Meal preparation	 H1db = 1 or 2 H1ab = 1 or 2	 H1db = 2 H1ab = 2	 H1db = 2 H1ab = 2
Social Isolation			
- Who lived with at referral	CC6 = 1 (lived alone)	CC6 = 1 (lived alone)	CC6 = 1 (lived alone)
- Isolation ‡‡	F3a = 2 or 3	Not used	F3a = 3
- Has primary helper §§	G1eA = 2	G1eA = 2	G1eA = 2
- Shows withdrawal from activities ¶¶	E1h = 1 or 2	E1h = 2	E1h = 2
- Has reduced social interaction ¶¶	E1i = 1 or 2	E1i = 2	E1i = 2
Limited Caregiver Support			
- A caregiver is unable to continue caring activities ##	G2a = 1	Not used	G2a = 1
- Primary caregiver is not satisfied with support received from family and friends ##	G2b = 1	Not used	G2b = 1
- Any signs of caregiver distress##	G2c = 1	G2c = 1	G2c = 1
- Client openly expresses conflict with family/friends ##	F1b=1	Not used	F1b=1

† The CPS score ranges from 0 (intact) to 6 (very severe impairment), where a score of 0 to 2 is defined as no to mild impairment, 3 to 4 defined as moderate impairment and 5 to 6 as severe impairment (Gruber-Baldini et al., 2000; Jones et al., 2010; Landi et al., 2000; Morris et al., 1994).

‡ The CHESS score (Changes in Health, End-stage disease and Symptoms and Signs) predicts mortality and is a measure of instability in health and uses RAI items such as weight loss, change in ADL status and dehydration (Hirdes et al., 2003; Hirdes et al., 2014). The scores range from 0 (no instability) to 5 (for the highest level of instability).

§ 2 stands for moderate impaired, 3 for highly impaired and 4 for severely impaired (no vision or sees only lights, colors or shapes).

¶ The ADL Hierarchy can range from 0 (independent) to 6 (total dependence) and uses the ADL items personal hygiene, toilet transfer, locomotion and eating (Morris et al., 1999).

Items address the client's physical functioning in routine personal activities of daily life (ADL) during the last three days. Scores range from 0 (independent) to 6 (total dependence). Transfer includes moving to and between surfaces, e.g., bed, chair, wheelchair.

†† The IADL difficulty code refers to how difficult it is for the client to perform the activity on his/her own, with scores ranging from 0 (no difficulty,) 1 (some difficulty) and 2 (great difficulty).

‡‡ 2 is alone during the day for long periods of time and 3 is always alone.

§§ 2 is "has no helper".

¶¶ A score of 1 refers to behaviour was exhibited 1-2 of last 3 days. Score of 2 refers to the behaviours was exhibited on all of last 3 days. Withdrawal from activities and reduced social interaction may cause that the person may not be noticed as "missing".

1 is yes.

Table 3.2: Candidate variables for predicting whether client is better off elsewhere as compared to current setting, Ontario home care clients, 2013 – 2014 (N=275,854)

Variable	Response Set	Point Estimate	95% CI
CPS	0-1 2+	1.00(ref) 4.48	 4.40 – 4.57
CHESS	0-2 3+	1.00 (ref) 1.84	 1.81 – 1.87
Vision	Adequate (0) – Moderately Impaired (2) Highly/severely impaired (3+)	1.00 (ref) 1.48	 1.44 – 1.52
ADL Hierarchy	0-2 3+	1.00(ref) 3.00	 2.94 – 3.05
Transfer	Independent – Supervision (0-2) Limited Assistance – Total Dependence (3+)	1.00 (ref) 2.56	 2.51 – 2.60
Locomotion	Independent – Supervision (0-2) Limited Assistance – Total Dependence (3+)	1.00 (ref) 2.92	 2.86 – 2.97
Toilet Use	Independent – Supervision (0-2) Limited Assistance – Total Dependence (3+)	1.00 (ref) 3.10	 3.04 – 3.15
Managing Medication	No – Some Difficulty (0-1) Great difficulty (2)	1.00 (ref) 4.30	 4.23 – 4.38
Meal Preparation	No – Some Difficulty (0-1) Great difficulty (2)	1.00 (ref) 3.31	 3.25 – 3.39

3.3.3 Sample

The data for this chapter include all RAI-HC data in Ontario collected from January 1st 2013 to December 31st 2014 (N=275,854). Only unique RAI-HC assessments, closest to December 31st 2014, are used to estimate proportions of Ontario home care clients with the algorithm-defined characteristics. Unique assessments are the unit of analysis to control for multiple assessments per client within the sample.

As illustration, available data from other provinces and territories are used as far as they were made available to the University of Waterloo. RAI-HC data collected between January 1st 2012 and December 31st 2013 were included in the analysis. Only unique RAI-HC assessments, closest to December 31st 2013, were used to estimate proportions of high and low risk home care clients in the provinces. As there were only 2010 assessments available for the province of Nova Scotia, these data were included instead.

3.3.4 HC Outcome

Descriptive characteristics for RAI-HC clients (e.g., demographics and health characteristics) are obtained from the RAI-HC data. Comparisons of the characteristics of high and low priority individuals are used to illustrate the differences between groups. Variables of interest include age, gender, marital status as well as measures for social isolation and caregiver support.

Measures for cognitive status (Cognitive Performance Scale (CPS)), functional status (ADL-hierarchy), Changes in Health, End-Stage Disease, Signs and Symptoms Scale (CHESS), Instrumental Activities of Daily Living (IADL) Capacity, Depression Rating Scale (DRS) and the Method for Assigning Priority Levels (MAPLe) are used to describe the health status of clients. The CPS measures a person's cognitive status (Gruber-Baldini et al., 2000; Jones et al., 2010; Landi et al., 2000; Morris et al., 1994), while DRS measures depressive symptoms (Burrows et al., 2000; Szczerbinska et al., 2012). The ADL hierarchy measures the ability to perform ADLs (Landi et al., 2000; Morris et al., 1999). The MAPLe predicts nursing home placement, caregiver distress and for being rated as requiring alternative placement (Hirdes et al., 2008; Mitchell et al., 2015).

The CHESS is a measure of health instability and decline in the ability to function (Hirdes et al., 2003; Hirdes et al., 2014). Finally, the IADL Capacity scale measures how well a person can perform IADL tasks and focuses on capacity rather than performance (Morris, Berg, Fries, Steel, & Howard, 2013). It is based on five items: meal preparation, ordinary housework, managing finances, managing medications, and shopping.

Further clinical characteristics considered include morbidity, disease diagnoses, medication use, communication capabilities, falls, wheelchair use, oxygen use, dialysis and transportation.

Due to copyright restrictions a copy of the RAI-HC is not included in this dissertation, but is available on request.

3.3.5 Statistical analysis

All statistical analyses were carried out using Statistical Analysis System (SAS) version 9.4. The algorithms were coded in SAS in order to identify high/medium priority and low priority clients based on each of the three coding rules. The data were then stratified by high/medium priority and low priority to identify the different characteristics of each group. The priority (UW, NZ, VPR) variable was assigned as the dependent variable and bivariate analysis with chi-square was conducted to identify client characteristics associated with the dependent variable. Frequencies and percentages are reported for all binary and categorical variables with corresponding p-levels. Given the large sample size, all comparisons between high and low priority clients were expected to achieve statistical significance. Although p-values are reported, it is the clinical significance that is of greatest importance in this study. Whereas statistical significance shows whether the difference between the high priority group and low priority group are real and not due to chance, clinical significance measures the magnitude of the difference in clinical practice

(Leung, 2001). In other words, does the statistical significant effect also represent a biological or clinical significant effect (Skelly, 2011)? There is no standard approach for the assessment of clinical significance (Kieser, Friede, & Gondan, 2013). Clinical relevance in the thesis is judged based on relative differences between groups.

For the survival rates, 6 month Kaplan-Meier survival plots were calculated using the LIFETEST procedure in SAS. The same test was used for rates of LTC admissions and hospitalization of high priority clients compared to low priority clients. Cox proportional hazards ratios are also calculated using the PHREG procedure.

3.4 Results

3.4.1 Descriptive Demographic and Clinical Characteristics

There were 275,797 unique clients that were assessed by the RAI-HC in Ontario between January 1st 2014 and December 31st 2014. Based on the University of Waterloo (UW) algorithm, a total of 211,976 (76.8%) high priority clients and 63,878 (23.2%) low priority clients were identified. The Canterbury algorithm identified 115,464 (41.9%) high priority and 160,390 (58.1%) low priority clients. Finally, the VPR algorithm identified 71,306 (25.9%) clients that are the highest priority, 23,533 (8.5%) clients that are medium priority clients and 181,015 (65.6%) low priority clients.

The mean age of the entire HC population is 78.6 (SD=13.7). The highest mean age (M=81.4, SD=12.8) can be found amongst the highest priority group selected based on the VPR algorithm. This mean age is comparatively higher than the mean age of the high priority groups identified by the University of Waterloo (M=79.1, SD=13.4) and Canterbury (M=80.4, SD=12.8) algorithms as well as higher than the mean age of the low priority groups identified by all three algorithms (M=77.0, 77.4, 77.3 respectively SD=14.6, 14.2, 13.6). All mean differences are statistically significant except between the Canterbury low priority mean and the VPR low priority as well as between the Canterbury high priority compared to the VPR medium priority.

Table 3.3: Mean age, SD and median age, by priority for the three decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	Algorithm 1: University of Waterloo		**Algorithm 2: Canterbury**		**Algorithm 3: VPR**		
	Low Priority n= 63,878	**High Priority n= 211,976**	**Low Priority n= 160,390**	**High Priority n= 115,464**	**Low priority n= 181,015**	**Medium Priority n= 23,533**	**High Priority n= 71,306**
Mean Age (SD) **95% CI**	77.0 (14.6) 76.9 – 77.1	79.1 (13.4) 79.1 – 79.2	77.4 (14.2) 77.3 – 77.5	80.4 (12.8) 80.3 – 80.4	77.3 (13.6) 77.3 – 77.4	80.3 (15.2) 80.1 – 80.5	81.4 (12.8) 81.3 – 81.5
Median Age **Q1 – Q3**	80.8 70.4 – 87.2	82.5 72.9 – 88.4	81.1 70.3 – 87.4	83.4 75.0 – 89.0	80.8 70.1 – 87.2	84.4 75.8 – 90.0	84.3 76.9 – 89.6

Note: SD = Standard Deviation; Q=Quantiles

Descriptive characteristics of both the high and the low priority groups based on all three algorithms are presented in Table 3.4. High priority clients in all three algorithm groups are more likely to be female, unmarried and living alone than low priority clients. It is of interest to note that while the high priority groups in the first two algorithms are more likely to not have a primary caregiver, this is not the case for the VPR algorithm. A higher proportion (3.7%) of low priority clients in the VPR algorithm group do not have a primary caregiver compared to the high priority clients (1.9%).

Table 3.4: Demographic characteristics of low, medium and high priority clients, by the three decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	Algorithm 1: University of Waterloo % (n)		**Algorithm 2: Canterbury % (n)**		**Algorithm 3: VPR % (n)**		
	Low Priority n= 63,878	**High Priority n= 211,976**	**Low Priority n= 160,390**	**High Priority n= 115,464**	**Low Priority n= 181,015**	**Medium Priority n= 23,533**	**High Priority n= 71,306**
Age †							
18-64 yrs.	17.4 (11,085)	14.1 (29,888)	17.5 (28,010)	11.2 (12,963)	17.4 (31,473)	12.4 (2,920)	9.2 (6,580)
65-74 yrs.	16.7 (10,658)	14.6 (31,005)	16.1 (25,814)	13.7 (15,849)	16.9 (30,548)	11.1 (2,612)	11.9 (8,503)
75-84 yrs.	32.3 (20,618)	31.6 (67,060)	31.7 (50,797)	32.0 (36,881)	32.1 (58,096)	28.8 (6,774)	30.0 (22,808)
85+ yrs.	33.7 (21,506)	39.6 (83,977)	34.8 (55,733)	43.1 (49,750)	33.6 (60,862)	47.7 (11,222)	46.9 (33,399)
Gender							
Female	58.6 (37,457)	63.9 (135,502)	62.6 (100,362)	62.9 (72,597)	64.4 (116,600)	61.1 (14,379)	58.9 (41,980)
Marital Status							
Married	53.4 (34,094)	32.5 (68,972)	42.9 (68,834)	29.7 (34,242)	36.1 (65,298)	41.0 (9,655)	39.4 (28,113)
Living Arrangement ‡							
Living alone	9.3 (5,848)	41.2 (86,268)	19.4 (30,696)	53.7 (61,420)	38.8 (69,467)	0.0	32.2 (22,649)
No primary caregiver §	1.3 (813)	3.4 (7,161)	1.9 (3,039)	4.3 (4,935)	3.7 (6,627)	0.0	1.9 (1,347)

† Frequency missing = 57
‡ Frequency missing = 3,435
§ Frequency missing = 1
All differences are significant at the 0.05 probability level

Tables 3.5 and 3.6 show the clinical characteristics for each of the three algorithm groups. Based on the distribution it is clear that the high priority groups identified by all three algorithms are a much more impaired population than the low priority group. High priority clients are more likely to have poorer cognitive status, increased health instability and show more symptoms of depression. Almost a quarter of the high priority clients in the UW algorithm score 3 or higher on the Depression Rating Scale (DRS), compared to slightly more than one tenth of the low priority clients. This number increases when the VPR algorithm is used where one third of the clients in the highest priority group score a DRS rating of 3 or higher.

The VPR algorithm also captures the highest proportion of the most impaired clients based on the MAPLe and CHESS scores. Almost half of the highest priority clients have a CHESS score of 3 or higher. This is compared to a little less than one quarter of UW algorithm high priority clients and one third of the high priority clients identified by the Canterbury algorithm.

The highest priority group shows a considerable proportion of MAPLe 4 and 5 clients (76.3%). The medium priority group identified by the VPR algorithm shows a similar proportion (68.0%), compared to 55.0% of the high priority group in the UW algorithm and 63.3% of the high priority group in the Canterbury algorithm. All four high/medium priority groups show proportions that are significantly higher than the low priority groups.

In the high priority sample for all three decision support algorithms, the majority (59.3%, 67.1%, 79.3% respectively) showed ADL decline in the past 60 days, with the VPR algorithm showing the greatest proportion (79.3%). 58.1% of the highest priority group and 58.3% of the medium priority group identified by the VPR algorithm had an ADL hierarchy score of 3 or higher, compared to only 6.7% of the low priority clients identified by that algorithm. The Canterbury algorithm shows a proportion of 32.7% of the high priority clients compared to 18.9% of the low priority clients with an ADL hierarchy score of 3 or higher. Finally the UW algorithm shows the least difference between the high priority clients and low priority clients in ADL hierarchy score. Roughly 25% of the priority clients compared to 22% of the low priority clients have an ADL hierarchy score of 3 or higher.

A substantial proportion of the two groups of priority clients identified by the VPR algorithm are fully IADL dependent (52.3% respectively 52.7%), compared to 9.3% of the low priority group. Again, the differences between low priority and high priority group are much smaller when the other two algorithms are applied. 24.7% of the priority clients and 22.3% of the low priority clients identified by the UW algorithm have a full IADL dependency, compared to 32.6% of the priority clients and 18.0% of the low priority clients identified by the Canterbury algorithm.

Table 3.5: Clinical characteristics of low, medium and high priority clients based on CPS, CHESS and DRS, by three decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	Algorithm 1: University of Waterloo % (n)		**Algorithm 2: Canterbury % (n)**		**Algorithm 3: VPR % (n)**		
	Low Priority n= 63,878	**High Priority n= 211,976**	**Low Priority n= 160,390**	**High Priority n= 115,464**	**Low Priority n= 181,015**	**Medium Priority n= 23,533**	**High Priority n= 71,306**
CPS							
Intact (0)	38.4 (24,512)	23.0 (48,650)	34.3 (55,069)	15.7 (18,093)	38.6 (69,797)	4.6 (1,092)	3.2 (2,273)
Borderline intact (1)	16.6 (10,589)	16.2 (34,398)	18.1 (28,973)	13.9 (16.014)	22.9 (41,450)	3.6 (844)	3.8 (2,693)
Mild impairment (2)	28.6 (18,295)	39.9 (84,655)	34.1 (54,688)	41.8 (48.262)	31.4 (56,783)	50.4 (11,857)	48.1 (34,311)
Moderate impairment (3)	8.0 (5,101)	12.0 (25,471)	7.2 (11,504)	16.5 (19,068)	5.3 (9,624)	18.6 (4,368)	23.3 (16,580)
Moderate/severe impairment (4)	1.7 (1,061)	2.2 (4,611)	1.4 (2,241)	3.0 (3,431)	0.5 (978)	4.5 (1,052)	5.1 (3,642)
Severe impairment (5)	4.5 (2,895)	5.4 (11,367)	3.6 (5,743)	7.4 (8,519)	1.3 (2,383)	12.0 (2,829)	12.7 (9,050)
Very severe impairment (6)	2.2 (1,425)	1.3 (2,824)	1.4 (2,172)	1.8 (2,077)	0.0 (1)	6.3 (1,491)	3.9 (2,757)
CHESS							
Not unstable (0)	30.8 (19,649)	17.0 (35,966)	24.9 (39,942)	13.6 (15,673)	24.8 (44,825)	18.4 (4,339)	9.1 (6,451)
CHESS = 1	34.4 (21,946)	28.2 (59,731)	33.3 (53,466)	24.4 (28,211)	35.8 (64,726)	22.6 (5,311)	16.3 (11,640)
CHESS = 2	21.8 (13,910)	30.4 (64,526)	27.6 (44,184)	29.7 (34,252)	30.3 (54,923)	22.7 (5,348)	25.5 (18,165)
CHESS = 3	10.3 (6,695)	17.8 (37,690)	10.9 (17,507)	23.2 (26,778)	8.0 (14,407)	27.1 (6,387)	32.9 (23,491)
CHESS = 4	2.5 (1,615)	6.1 (12,885)	3.0 (4,814)	8.4 (9,686)	1.1 (2,065)	8.3 (1,943)	14.7 (10,492)
CHESS = 5	0.3 (163)	0.6 (1,178)	0.3 (477)	0.8 (864)	0.0 (69)	0.9 (205)	1.5 (1,067)
DRS †							
No symptoms	67.7 (43,272)	45.5 (96,369)	56.9 (91,303)	41.9 (48,339)	54.8 (99,186)	58.9 (13,858)	37.3 (26,598)
DRS 1 or 2	21.5 (13,748)	27.8 (58,884)	25.0 (40,088)	28.2 (32,544)	25.4 (45,943)	26.0 (6,113)	28.9 (20.576)
Possible depression (DRS 3+)	10.7 (6,857)	26.8 (56,722)	18.1 (28,998)	30.0 (34,581)	19.8 (35,885)	15.1 (3,562)	33.8 (24,132)

† Frequency missing = 1

All differences are significant at the 0.05 probability level

Table 3.6: Clinical characteristics of low, medium and high priority clients based on MAPLe, ADL hierarchy and IADL capacity by three decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	Algorithm 1: University of Waterloo % (n)		**Algorithm 2: Canterbury % (n)**		**Algorithm 3: VPR % (n)**		
	Low Priority n= 63,878	**High Priority n= 211,976**	**Low Priority n= 160,390**	**High Priority n= 115,464**	**Low Priority n= 181,015**	**Medium Priority n= 23,533**	**High Priority n= 71,306**
MAPLe							
Low (1) – mild (2)	27.1 (17,285)	12.6 (26,643)	24.8 (39,738)	3.6 (4,190)	24.3 (43,917)	0.0 (5)	0.0 (6)
Moderate (3)	34.1 (21,763)	32.5 (68,787)	32.6 (52,316)	33.1 (38,234)	36.5 (66,149)	32.0 (7,527)	23.7 (16,874)
High (4) – very high (5)	38.9 (24,830)	55.0 (116,546)	42.6 (68,336)	63.3 (73,040)	39.2 (70.949)	68.0 (16,001)	76.3 (54,426)
ADL hierarchy							
Independent (0)	50.6 (32,292)	42.8 (90,735)	54.1 (86,785)	31.4 (36,242)	63.9 (115,676)	7.3 (1,722)	7.9 (5,629)
1	11.1 (7,091)	12.8 (27,081)	11.3 (18.087)	13.9 (16,085)	15.0 (27,229)	6.4 (1,513)	7.6 (5,430)
2	16.0 (10,200)	19.5 (41,391)	16.3 (26,197)	22.0 (25,394)	14.5 (26,160)	28.1 (6,603)	26.4 (18,828)
3	8.1 (5,198)	10.4 (21,957)	7.2 (11,558)	13.5 (15,597)	3.4 (6,064)	21.1 (4,956)	22.6 (16,135)
4	6.2 (3,982)	7.3 (15,532)	5.2 (8,335)	9.7 (11,179)	1.8 (3,198)	16.5 (3,872)	17.5 (12,444)
5	5.4 (3,420)	5.5 (11,664)	4.2 (6,737)	7.2 (8,347)	1.3 (2,384)	13.6 (3,195)	13.3 (9,505)
6 (dependent)	2.7 (1,695)	1.7 (3,616)	2.3 (2,691)	2.3 (2,620)	0.2 (304)	7.1 (1,672)	4.7 (3,335)
ADL Decline							
Past 90 days	43.2 (27,623)	59.3 (125,678)	47.3 (75,778)	67.1 (77,523)	44.9 (81,203)	66.0 (15,532)	79.3 (56.566)
IADL capacity							
Independent (0)	7.2 (4,580)	0.8 (1,783)	3.8 (6,052)	0.3 (311)	3.5 (6,353)	0.0 (3)	0.0 (7)
1	8.4 (5,361)	1.9 (4,006)	5.4 (8,617)	0.7 (750)	5.2 (9,341)	0.0 (2)	0.0 (24)
2	7.3 (4,651)	8.2 (17,393)	12.1 (19,348)	2.3 (2,696)	12.0 (21,800)	0.2 (47)	0.3 (197)
3	1.2 (792)	1.4 (2,993)	1.7 (2,778)	0.9 (1,007)	2.0 (3,545)	0.3 (59)	0.3 (181)
4	14.7 (9,373)	17.7 (37,609)	22.8 (36,484)	9.1 (10,498)	24.8 (44,907)	1.7 (405)	2.3 (1,670)
5	39,0 (24,883)	45.2 (95,895)	36.3 (58,207)	54.2 (62,571)	43.2 (78,194)	45.1 (10,620)	44.8 (31,964)
6 (dependent)	22.3 (14,238)	24.7 (52297)	18.0 (28,904)	32.6 (37,631)	9.3 (16,875)	52.7 (12,397)	52.3 (37,263)

All differences are significant at the 0.05 probability level

Table 3.7 shows further clinical characteristics of high priority compared to low priority clients. In all three decision support algorithms, the proportions of clients having four or more comorbidities was higher amongst high priority clients than amongst low priority clients. The difference was accentuated when applying the VPR algorithm. Almost 14% of the highest priority group has four or more comorbidities as compared to slightly more than 6% amongst the low priority group. Differences between high priority and low priority groups regarding cardiovascular diseases and diabetes are not clinically significant.

Table 3.7: Other clinical characteristics of high, medium and low priority clients, by three decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	Algorithm 1: University of Waterloo % (n)		**Algorithm 2: Canterbury % (n)**		**Algorithm 3: VPR % (n)**		
	Low priority n= 63,878	**High Priority n= 211,976**	**Low priority n= 160,390**	**High Priority n= 115,464**	**Low priority n= 181,015**	**Medium Priority n= 23,533**	**High Priority n= 71,306**
Morbidity and medications							
≥ 4 comorbidities	6.5 (4,154)	9.32 (19,762)	7.1 (11,387)	10.9 (12,529)	6.3 (11,462)	11.3 (2,662)	13.7 (9,792)
Cardiovascular diseases	73.0 (46,604)	76.2 (161,522)	74.1 (118,914)	77.3 (89,212)	73.9 (133,743)	76.6 (18,016)	79.1 (56,367)
Diabetes	27.7 (17,677)	27.3 (57,815)	27.7 (44,368)	27.0 (31,124)	27.3 (49,335)	27.1 (6,379)	27.7 (19,778)
Medications ≥ 9	52.1 (33,273)	55.9 (118,456)	53.5 (85,806)	57.1 (65,923)	52.0 (94,030)	60.2 (14,173)	61.0 (43,526)
Communication							
Difficulties making self understood †	7.4 (4,727)	7.3 (15,418)	5.4 (8,674)	9.9 (11,471)	1.5 (2,783)	19.8 (4,652)	17.8 (12,710)
Difficulty understanding others ‡	7.4 (4,729)	8.4 (17,833)	5.8 (9,289)	11.5 (13,273)	2.0 (3,556)	19.9 (4,675)	20.1 (14,331)
Hearing §	14.1 (8,976)	18.3 (38,738)	14.5 (23,286)	21.2 (24,428)	13.1 (23,731)	23.6 (5,541)	25.9 (18,442)
Other							
Falls (last 90 days) ≥ 2	15.0 (9,556)	21.7 (45,935)	16.9 (27,092)	24.6 (28,399)	15.5(28,023)	23.6 (5,547)	30.7 (21,921)
Wheelchair Use ¶	15.1 (9,673)	14.5 (30,665)	13.0 (20,867)	16.9 (19,471)	7.8 (14,099)	32.1 (7,548)	26.1 (18,691)
Oxygen Use	5.3 (3,398)	6.1 (12,898)	5.5 (8,803)	6.5 (7,493)	4.9 (8,916)	7.1 (1,671)	8.0 (5,709)
Dialysis	1.8 (1,142)	1.4 (3,054)	1.6 (2,567)	1.4 (1,629)	1.6 (2,883)	1.4 (332)	1.4 (981)
Transportation #	42.7 (27,264)	47.3 (100,182)	43.2 (69,319)	50. 3 (58,127)	42.5 (76,865)	57.4 (13,496)	52.0 (37,085)

† Based on RAI-HC expression item: client is sometimes understood or rarely/never understood
‡ Based on RAI-HC comprehension item: client sometimes understands or rarely/never understands others
§ Hears in special situations only or is highly impaired (C1 ≥ 2)
¶ Inside the home
# Based on RAI-HC item transportation which indicates whether someone other than the client drives the vehicle (performed by others)
All differences are significant at the 0.05 probability level

The clinical importance of the number of medications in contributing to disaster vulnerability is questionable. Regardless of the algorithm applied, the difference between high and low priority clients regarding medication use is small. When applying the VPR algorithm, a large proportion of both the highest priority clients (61.0%) and the low priority (52.0%) clients take more than nine prescription and over the counter medications (in the last seven days).

Upon examining communication issues, the most substantial differences are noted when applying the VPR algorithm. The highest priority clients are more likely to have difficulties making themselves understood (17.8%), understanding others (20.1%) and hearing others (25.9%) as compared to low priority clients.

In all three decision support algorithms, high priority clients are more likely to have two or more falls in the past 90 days with the most substantial differences noted when applying the VPR algorithm. The proportion of high priority clients having two or more falls in the past 90 days is double (30.7% vs 15.5%) the proportion of low priority clients when applying the VPR algorithm.

It is important to note that regardless of which algorithm is applied, approximately half of the priority clients are dependent on others to drive a vehicle. Nonetheless, the differences between high and low priority clients are small.

There are no significant differences between high priority and low priority clients regarding wheelchair use inside the home when applying the UW and Canterbury algorithms. However, when applying the VPR algorithm, the difference becomes clinically significant as the proportion of high priority wheelchair users is more than triple the proportion of low priority wheelchair users.

The proportion of high priority clients receiving oxygen treatment is comparable with the low priority group with the largest difference found when applying the VPR algorithm. 8.0% of the highest priority group is receiving or should be receiving (scheduled, not yet received) oxygen therapy. In the low priority group the prevalence of individuals receiving (or scheduled, not yet received) oxygen therapy is 4.9%. There were no significant differences found regarding dialysis. In fact, when applying the VPR algorithm the proportion of clients that is receiving or should be receiving dialysis is higher amongst low priority clients (1.6%).

It should be noted that the disaster health literature shows a higher vulnerability of those reliant on wheelchair use as well as those requiring oxygen and/or dialysis treatment. This raises the question whether those clients should always be considered high priority clients. Clients that use a wheelchair inside the house make up 14.6% (40,338) of the client population. This percentage remains almost the same when looking at wheelchair use outside the house (14.1%; 38,791). Over half (53,7%) of the clients that use a wheelchair inside, also use the wheelchair outside. Most (43.8%) of the remaining clients that are wheelchair dependent inside the house did not go outside, or used a scooter (1.3%). Wheelchair use inside the house seems like a good indication of dependency outside.

When adding clients that are wheelchair (inside), oxygen or dialysis dependent to the highest priority group when applying the VPR algorithm, this group increases in size to 38.1% of the total client population. There are 40,338 wheelchair users (14.6%), 16,296 client that require oxygen treatment (5.9%) and 4,196 clients requiring dialysis (1.5%).

Table 3.8: Distribution of clients by high, medium and low priority groups for two variations of the VPR decision support algorithm, Ontario home care clients, 2013 – 2014 (N=275,854)

Algorithm	**Low priority % (n)**	**Medium Priority % (n)**	**High Priority % (n)**
Original VPR	65.6 (181,015)	8.5 (23,533)	25.9 (71,306)
VPR Plus (VPR with wheelchair, oxygen use and dialysis in highest priority group)	56.6 (156,256)	5.3 (14,617)	38.1 (104,981)

3.4.2 Differences in CCACs

Table 3.9 presents the distribution of priority clients over the 14 CCACs. On examining the three algorithms the highest proportion of all individuals with high priority status is found in the Central East CCAC (12.7%; 13.8%; 14.4%; 13.4%). When applying the VPR algorithm high and medium priority clients in this region account for almost 39% of the total number of clients served by this CCAC (n=34,626).

The Toronto Central CCAC (TCCCAC) region is one of the most populated areas and provides services to 6,403 high priority clients based on the VPR algorithm. This represents 27.7% of the home care client population in Toronto Central (n=23,158). This number increases when applying the VPR Plus algorithm. The highest priority clients represent 37.7% (8,718) of the Toronto CCAC client base. When applying the UW algorithm, high priority clients account for approximately 84% of the clients. This proportion declines to half of the clients when applying the Canterbury algorithm.

The North Simcoe Muskoka (NSM) CCAC has the highest proportion of highest priority clients compared to the total number of clients in any single CCAC. Based on the VPR respectively VPR plus algorithms, the NSM CCAC services 3,499 and 4,947 highest priority clients (31.4% and 44.4% of all NSM clients, respectively).

Table 3.9: Distribution of medium and high priority clients over CCACs (column percentages), by four decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

CCAC Region	**Total # clients**	**University of Waterloo**	**Canterbury**	**VPR**		**VPR Plus**	
		High Risk n=211,976 % (n)	**High Risk n=115,464 % (n)**	**Medium Risk n=25,533 % (n)**	**High Risk n=71,306 % (n)**	**Medium Risk n=14,617 % (n)**	**High Risk n=104,981 % (n)**
Hamilton Niagara Haldimand Brant (HNHB)	13.2 (36,457)	12.4 (26,170)	11.2 (12,962)	13.2 (3,099)	10.3 (7,327)	12.5 (1,823)	11.9 (11,277)
Central East (CE)	12.6 (34,626)	12.7 (26,841)	13.8 (15,984)	13.3 (3,135)	14.4 (10,259)	13.9 (2,032)	13.4 (14,054)
Central	12.2 (33,633)	12.4 (27,016)	12.6 (14,504)	10.6 (2,502)	13.5 (9,630)	10.9 (1,591)	12.3 (12,860)
South West (SW)	8.7 (23,889)	8.6 (18,263)	8.1 (9,306)	7.7 (1,810)	8.5 (6,032)	7.2 (1,053)	8.9 (9,291)
Toronto Central (TC)	8.4 (23,158)	9.2 (19,430)	10.1 (11,696)	6.8 (1,609)	9.0 (6,403)	7.1 (1,043)	8.3 (8,718)
Champlain (CHAM)	7.9 (21,915)	8.4 (17,693)	9.0 (10,365)	9.9 (2,325)	9.1 (6,497)	9.8 (1,435)	8.8 (9,252)
Mississauga Halton (MH)	6.1 (16,807)	5.6 (11,839)	5.2 (6,001)	8.4 (1,974)	5.2 (3,735)	9.0 (1,314)	5.5 (5,719)
North East (NE)	5.5 (15,040)	5.7 (11,987)	6.2 (7,114)	3.9 (917)	5.6 (4,011)	3.9 (572)	5.7 (5,943)
Waterloo Wellington (WW)	5.2 (14,330)	5.1 (10,767)	4.6 (5,321)	5.4 (1,258)	4.5 (3,199)	5.1 (751)	4.9 (5,159)
South East (SE)	5.2 (14,445)	5.2 (10,915)	4.5 (5,203)	5.1 (1,207)	4.8 (3,393)	5.0 (733)	4.9 (5,177)
Erie St Clair (ESC)	4.9(13,379)	4.3 (9,157)	4.2 (4,860)	6.2 (1,454)	4.1 (2,939)	5.4 (789)	4.9 (5,164)
North Simcoe Muskoka (NSM)	4.0 (11,144)	4.3 (9,020)	4.8 (5,591)	3.8 (896)	4.9 (3,499)	3.7 (547)	4.7 (4,947)
Central West (CW)	4.0 (11,107)	3.8 (8,000)	3.3 (3,752)	4.7 (1,096)	4.2 (2,996)	5.3 (776)	4.0 (4,144)
North West (NW)	2.2 (5,924)	2.3 (4,878)	2.4 (2,805)	1.1 (251)	1.9 (1,386)	1.1 (158)	2.0 (2,114)

Table 3.10: Distribution of medium and high priority clients of total number of clients in each CCACs (row percentages), by four decision support algorithms, Ontario home care clients, 2013 – 2014 (N=275,854)

	University of Waterloo % (n)	Canterbury % (n)	VPR % (n)		VPR Plus % (n)	
CCAC Region	**High Risk**	**High Risk**	**Medium Risk**	**High Risk**	**Medium Risk**	**High Risk**
Hamilton Niagara Haldimand Brant (n=36,457)	71.8 (26,170)	35.6 (12,962)	8.5 (3,099)	20.1 (7,327)	5.0 (1,823)	34.1 (11,277)
Central East (n=34,626)	77.5 (26,841)	46.2 (15,984)	9.1 (3,135)	29.6 (10,259)	5.9 (2,032)	38.2 (14,054)
Central (n=33,633)	80.3 (27,016)	43.1 (14,504)	7.4 (2,502)	28.6 (9,630)	4.7 (1,591)	38.2 (12,860)
South West (n=23,889)	76.5 (18,263)	39.0 (9,306)	7.6 (1,810)	25.3 (6,032)	4.4 (1,053)	38.9 (9,291)
Toronto Central (n=23,158)	83.9 (19,430)	50.5 (11,696)	7.0 (1,609)	27.7 (6,403)	4.5 (1,043)	37.7 (8,718)
Champlain (n=21,915)	80.7 (17,693)	47.3 (10,365)	10.6 (2,325)	29.7 (6,497)	6.6 (1,435)	42.2 (9,252)
Mississauga Halton (n=16,807)	70.4 (11,839)	35.7 (6,001)	11.8 (1,974)	22.2 (3,735)	7.8 (1,314)	34.0 (5,719)
North East (n=15,040)	79.7 (11,987)	47.3 (7,114)	6.1 (917)	26.7 (4,011)	3.8 (572)	39.5 (5,943)
Waterloo Wellington (n=14,330)	75.1 (10,767)	37.1 (5,321)	8.8 (1,258)	22.3 (3,199)	5.2 (751)	36.0 (5,159)
South East (n=14,445)	75.6 (10,915)	36.0 (5,203)	8.4 (1,207)	23.5 (3,393)	5.1 (733)	35.8 (5,177)
Erie St Clair (n=13,379)	68.4 (9,157)	36.3 (4,860)	10.9 (1,454)	22.0 (2,939)	5.9 (789)	38.6 (5,164)
North Simcoe Muskoka (n=11,144)	80.9 (9,020)	50.2 (5,591)	8.0 (896)	31.4 (3,499)	4.9 (547)	44.4 (4,947)
Central West (n=11,107)	72.0 (8,000)	33.8 (3,752)	9.9 (1,096)	27.0 (2,996)	7.0 (776)	37.3 (4,144)
North West (n=5,924)	82.3 (4,878)	47.4 (2,805)	4.2 (251)	23.4 (1,386)	2.7 (158)	35.7 (2,114)

3.4.3 Distribution of VPR and VPR Plus Clients in Other Provinces in Canada

Table 3.11 presents the distribution of VPR clients in other provinces and in the Yukon Territory in 2013. Unfortunately for some provinces the data were incomplete resulting in small sample sizes. Therefore these provinces have been omitted. For Nova Scotia (NS) only data from 2010 were available.

Table 3.11: Distribution of low, medium and high priority persons among home care clients in five Canadian provinces and territories using the VPR and VPR decision support algorithms, 2013 (2010 for Nova Scotia)

	British Columbia N= 54,110 % (n)	**Manitoba N=12,434** % (n)	**Nova Scotia † N=3,902** % (n)	**Yukon N=307** % (n)	**Ontario N=275,854** % (n)
VPR					
Low	65.2 (35,284)	84.5 (10,512)	74.0 (2,886)	89.6 (275)	65.6 (181,015)
Medium	6.8 (3,689)	4.8 (591)	8.4 (328)	1.6 (5)	8.5 (23,533)
High	28.0 (15,137)	10.7 (1,331)	17.6 (688)	8.8 (27)	25.9 (71,306)
VPR Plus					
Low	58.0 (31,399)	75.8 (9,420)	66.5 (2,594)	75.9 (233)	56.6 (156,256)
Medium	5.0 (2,724)	3.5 (433)	6.9 (268)	1.6 (5)	5.3 (14,617)
High	36.9 (19,987)	20.8 (2,581)	26.7 (1,040)	22.5 (69)	38.1 (104,981)

† Data from 2010

The highest percentage of high-risk clients is found in British Columbia (BC). In this province, the high-risk clients constitute 28.0% of the BC client population compared to 25.9% of the clients in Ontario. The lowest proportion of high-risk clients is found in the Yukon Territory (8.8%).

3.4.4 Survival Rates

Figures 3.1-3.3 display the survival rates of the high/medium priority versus the low priority groups. The figures represent baseline data during 'normal' times. In chapter 5 the survival rates will be tested in disaster times (2013 Southern Ontario ice storm).

Figure 3.1: Kaplan-Maier Survival Curve for days to death by high and low priority clients using the University of Waterloo algorithm, Ontario home care clients, 2013 – 2014

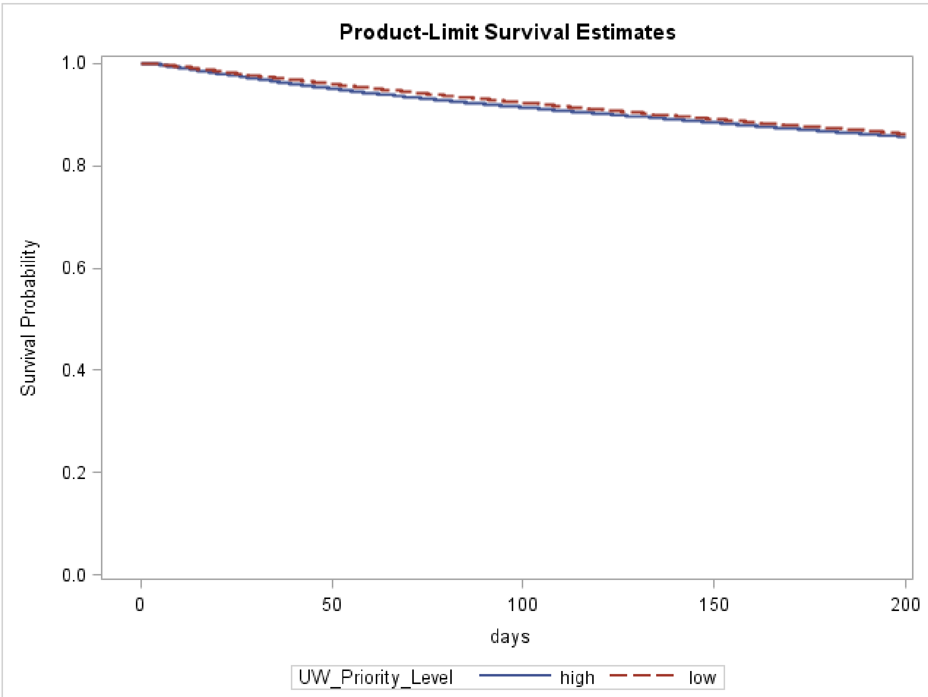


Figure 3.2: Kaplan-Maier Survival Curve for days to death by high and low priority clients using the Canterbury algorithm, Ontario home care clients, 2013 – 2014

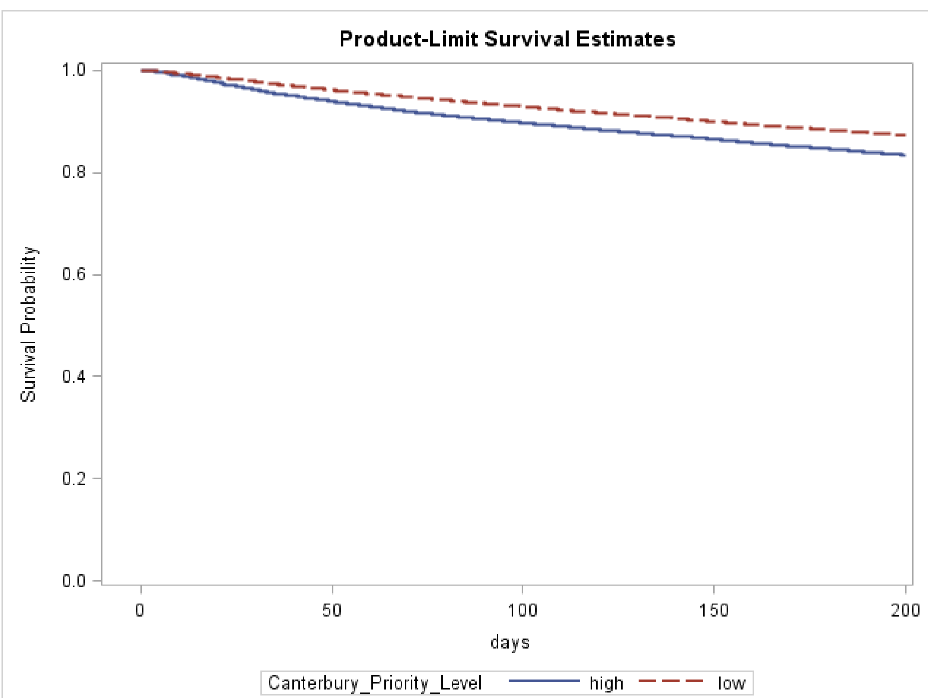


Figure 3.3: Kaplan-Maier Survival Curve for days to death by high, medium and low priority clients using the VPR algorithm, Ontario home care clients, 2013 – 2014

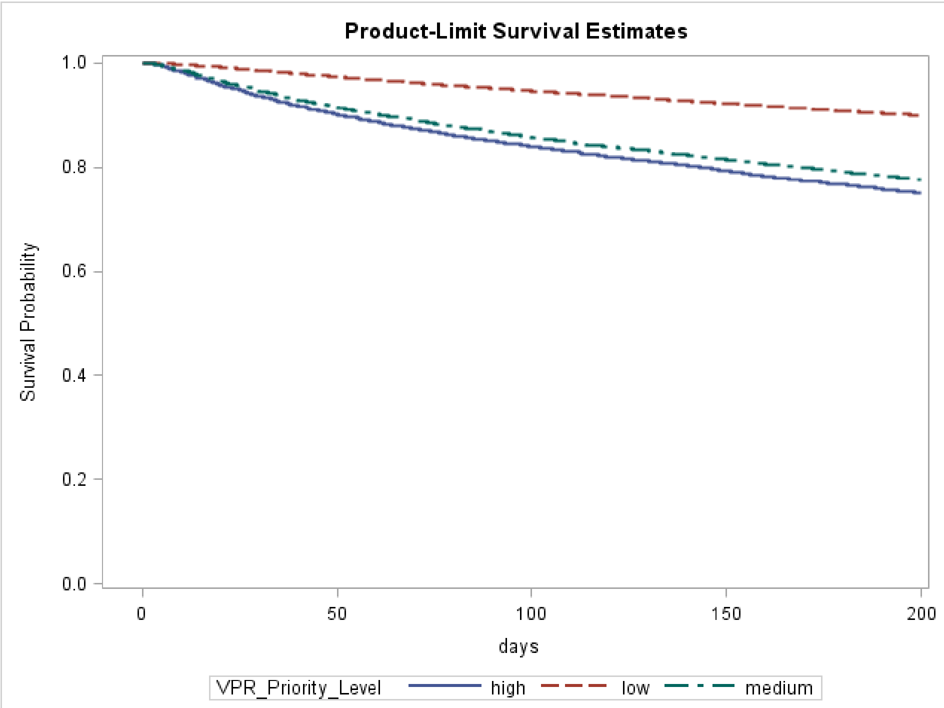
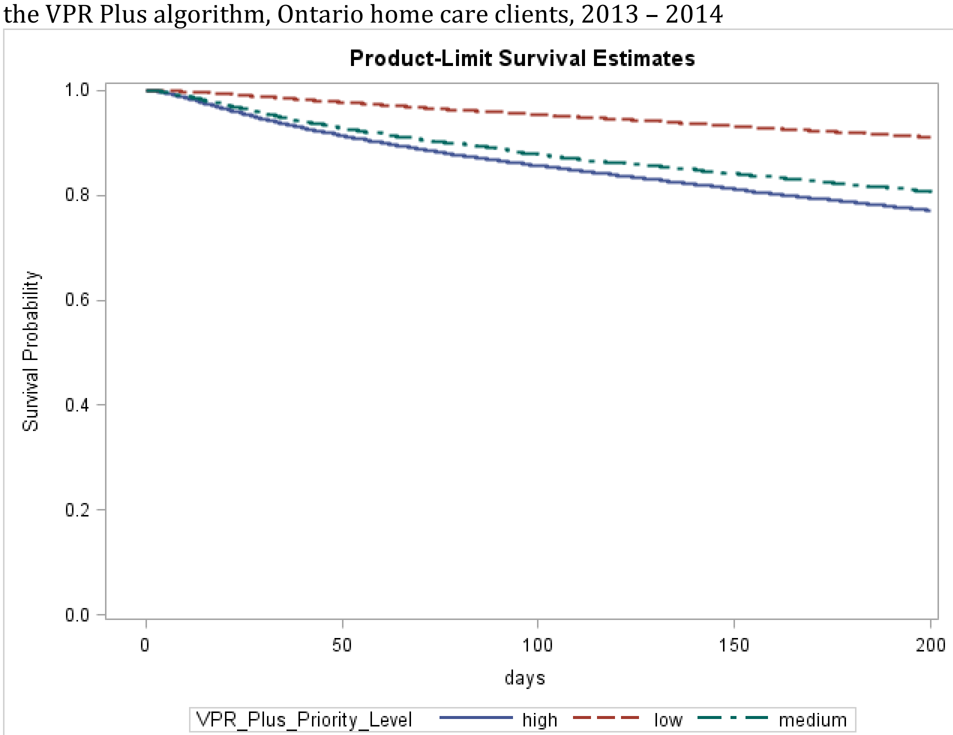


Figure 3.4: Kaplan-Maier Survival Curve for days to death by high, medium and low priority clients using the VPR Plus algorithm, Ontario home care clients, 2013 – 2014



When applying the University of Waterloo algorithm there is no difference in survival rate between priority and low priority groups (Figure 3.1). A larger difference is seen when applying the Canterbury algorithm (Figure 3.2). The high priority clients have notably lower survival rates than the low priority client. The largest difference is seen when applying the VPR algorithm (Figure 3.3) or VPR Plus algorithm (Figure 3.4). The differences between the highest priority group, medium priority group and low priority group are quite clear. The highest priority group has the lowest survival rate. Of all algorithms, the VPR or VPR Plus algorithms appear to be the most accurate predictor of death. For example, for someone in the highest priority group, the probability of surviving 100 days is slightly more than 80%. Conversely, for someone in the low priority, the probability of surviving the same time is more than 90%. The differences in probability increase when time goes by. The Log-Rank test shows a statistically significant difference for the VPR and VPR+ (X^2=6915.53 resp. X^2=6883.73; DF 2; p<.0001).

Table 3.12 shows the Cox proportional hazards ratio when adjusting for age, gender, marital status, CHESS and living status. The Cox proportional hazards ratios, when adjusting for age, gender, marital status, CHESS and living alone, show that the highest priority group is 1.65 times (p<0.0001) more likely to die than the low priority group when applying the VPR algorithm. This hazards ratio increases to 1.70 times when looking at the medium risk group (p<0.0001). The difference in hazards ratio between medium and high-risk groups is however not significant.

The hazards ratios increase when applying the VPR Plus algorithm. The high priority group is almost twice as likely to die compared with the lowest priority group. The medium priority group is 1.56 more likely to die.

When applying the UW algorithm, the Cox proportional hazards ratio is 0.93 (p<0.0001), indicating a small difference in risk between high priority and low priority groups. In fact, when applying this algorithm the low priority group seems to be at higher risk of dying. The hazards ratio increases to 1.12 ($p<0.0001$) when the Canterbury algorithm is applied, but this ratio is still substantially lower than the ratios shown for the VPR.

Table 3.12: Cox proportional hazards ratios for mortality with risk level, age, gender, marital status, CHESS and living status by four decision support algorithms, Ontario home care clients, 2013 – 2014 (N=237,777)

	University of Waterloo	Canterbury	VPR	VPR Plus
Risk Level (ref=low)				
Medium	-	-	1.70 (1.63 – 1.78)	1.56 (1.48 – 1.65)
High	0.93 (0.90 – 0.97)	1.12 (1.10 – 1.16)	1.65 (1.59 – 1.70)	1.99 (1.93 – 2.05)
Age (ref= 18-64)				
65-74	1.31 (1.25 – 1.38)	1.31 (1.25 – 1.38)	1.31 (1.24 – 1.38)	1.34 (1.27 – 1.41)
75-84	1.29 (1.24 – 1.36)	1.29 (1.23 – 1.35)	1.24 (1.19 – 1.30)	1.32 (1.26 – 1.39)
85+	1.77 (1.69 – 1.85)	1.76 (1.68 – 1.84)	1.63 (1.57 – 1.71)	1.78 (1.70 – 1.86)
Gender (ref=Female)				
Male	1.60 (1.55 – 1.64)	1.59 (1.54 – 1.63)	1.57 (1.52 – 1.61)	1.53 (1.49 – 1.58)
Marital status (ref=Not married)				
Married	1.06 (1.03 – 1.09)	1.06 (1.02 – 1.09)	1.08 (1.05 – 1.12)	1.08 (1.04 – 1.11)
CHESS (ref=0)				
CHESS 1	1.44 (1.37 – 1.51)	1.42 (1.35 – 1.50)	1.44 (1.37 – 1.51)	1.41 (1.34 – 1.49)
CHESS 2	2.28 (2.17 – 2.39)	2.23 (2.12 – 2.34)	2.21 (2.11 – 2.32)	2.14 (2.03 – 2.24)
CHESS 3	4.14 (3.94 – 4.35)	4.00 (3.77 – 4.16)	3.29 (3.13 – 3.46)	3.15 (2.99 – 3.31)
CHESS 4 – 5	9.58 (9.08 – 10.11)	9.02 (8.55 – 9.52)	6.99 (6.61 – 7.40)	6.59 (6.24 – 6.96)
Living Status (ref=not living alone)				
Living alone	0.77 (0.74 – 0.79)	0.72 (0.69 – 0.74)	0.84 (0.81 – 0.87)	0.83 (0.80 – 0.86)

All results are significant at the 0.05 probability level

3.4.5 LTC Admission Rates

Figures 3.5-3.8 display the long term care (LTC) admission rates of the high/medium priority versus the low priority groups.

The smallest differences of probability of LTC admission are found when the UW algorithm is applied. The highest rates for LTC Admission are again shown in the highest priority group when applying the VPR algorithm. This algorithm seems to be the best predictor for LTC admission as the probability for admission of the priority groups increases over time as compared to the low priority group. Again, the Log-Rank test shows a statistically significant difference between groups (X^2=19257.01; DF 2; p<.0001). The VPR Plus does not perform quite as well as the VPR with respect to LTC admission.

Figure 3.5: Kaplan-Maier Survival Curve for days to LTC admission by high and low priority clients using the University of Waterloo algorithm, Ontario home care clients, 2013 – 2014

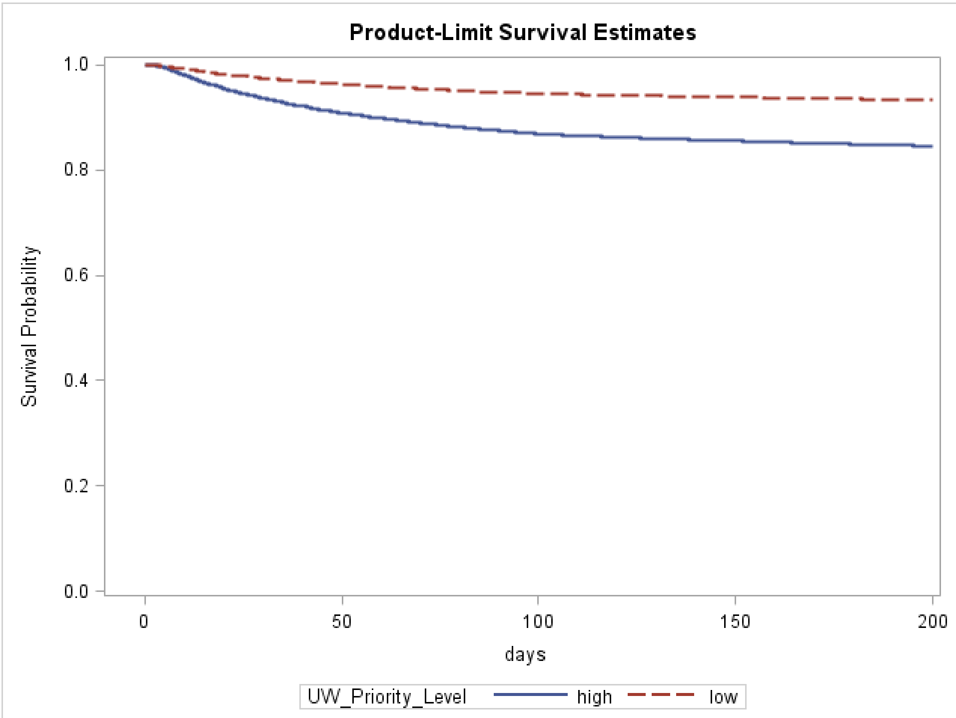


Figure 3.6: Kaplan-Maier Survival Curve for days to LTC admission by high and low priority clients using the Canterbury algorithm, Ontario home care clients, 2013 – 2014

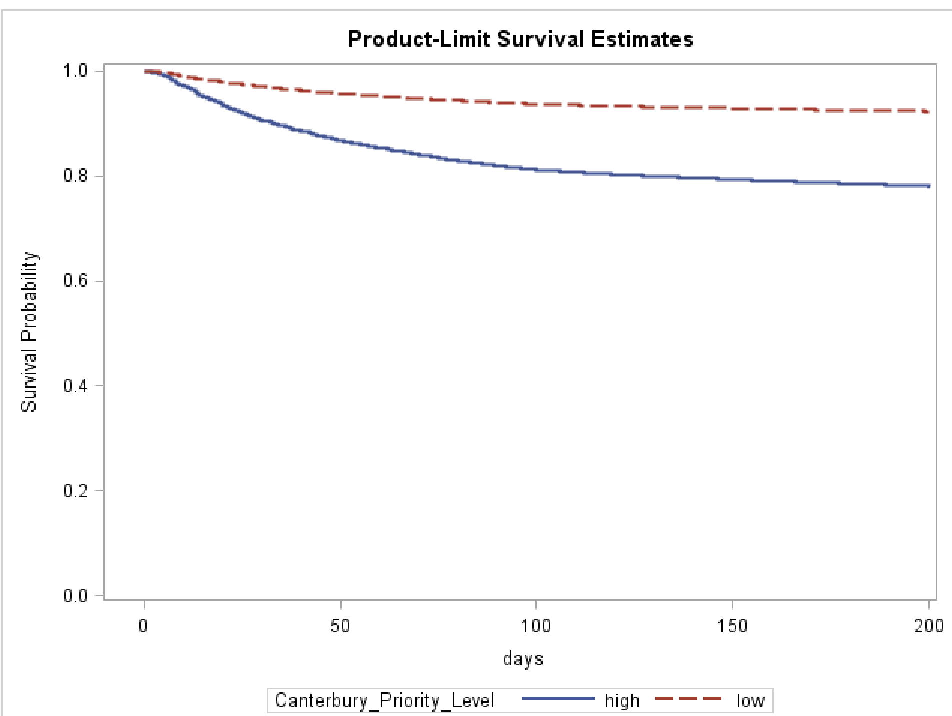


Figure 3.7: Kaplan-Maier Survival Curve for days to LTC admission by high, medium and low priority clients using the VPR algorithm, Ontario home care clients, 2013 – 2014

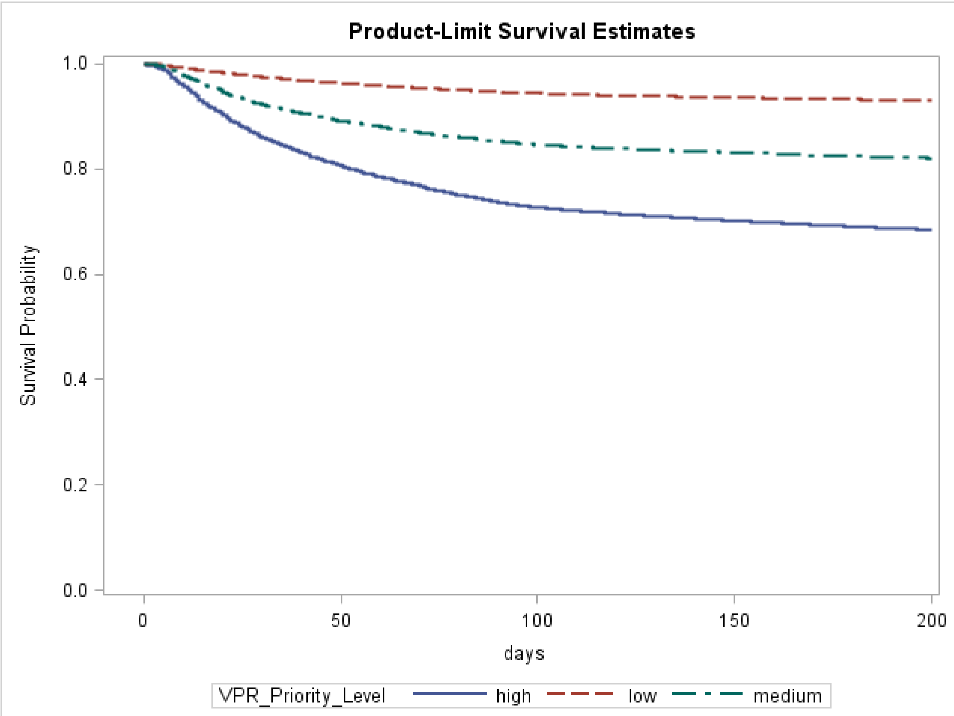


Figure 3.8: Kaplan-Maier Survival Curve for days to LTC admission by high, medium and low priority clients using the VPR Plus algorithm, Ontario home care clients, 2013 – 2014

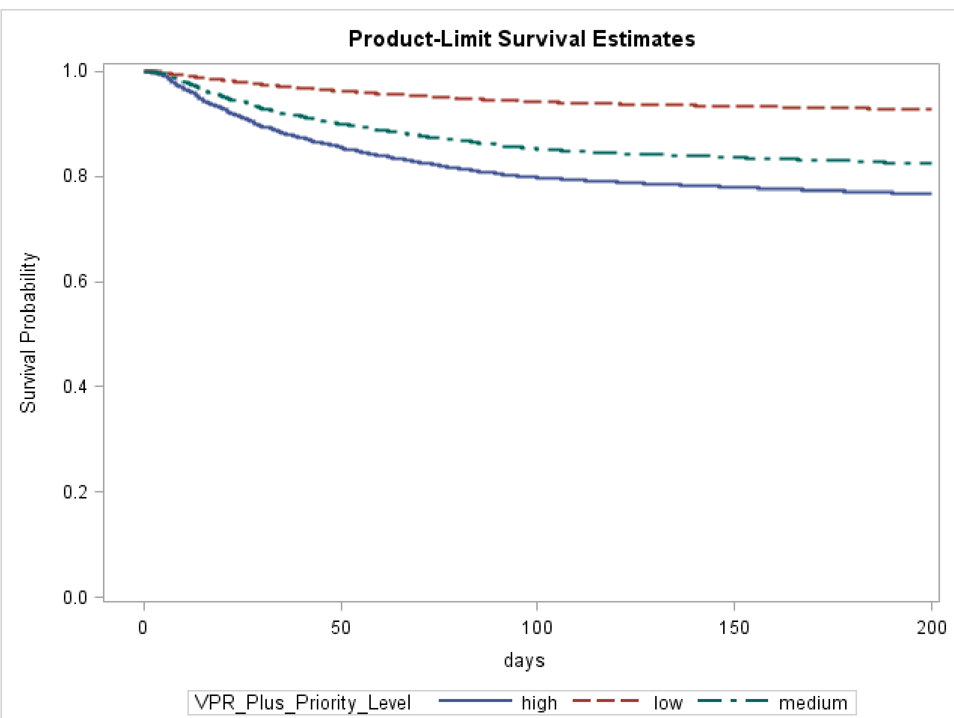


Table 3.13 shows the Cox proportional hazards ratios for LTC admission when adjusting for age, gender, marital status and MAPLe.

The Cox proportional hazards ratios, when adjusting for age, marital status and MAPLe, are 1.74 ($p<0.0001$) for the UW algorithm, 2.01 ($p<0.0001$) for the Canterbury algorithm and 2.94 ($p<0.0001$) and 2.59 ($p<0.0001$) respectively for the highest priority group in the VPR and VPR Plus algorithm. Again, the highest risk of LTC admission exists for the highest priority group within the VPR algorithm, as persons in this group are 2.94 times more likely to be admitted to LTC than persons in the low priority group, regardless of age, gender, marital status and MAPLe score.

Table 3.13: Cox proportional hazards ratios for LTC admission with risk level, age, gender, marital status and MAPLe by four decision support algorithms, Ontario home care clients, 2013 – 2014 (N=237,777)

	University of Waterloo	Canterbury	VPR	VPR Plus
Risk Level (ref=low)				
Medium	-	-	1.80 (1.72 – 1.87)	1.62 (1.53 – 1.70)
High	1.74 (1.68 – 1.81)	2.01 (1.96 – 2.06)	2.94 (2.86 – 3.02)	2.59 (2.52 – 2.66)
Age (ref= 18-64)				
65-74	2.34 (2.18 – 2.52)	2.27 (2.11 – 2.43)	2.42 (2.26 – 2.60)	2.55 (2.37 – 2.74)
75-84	3.43 (3.22 – 3.66)	3.30 (3.10 – 3.52)	3.40 (3.19 – 3.62)	3.79 (3.56 – 4.04)
85+	4.46 (4.19 – 4.74)	4.25 (4.00 – 4.53)	4.13 (3.88 – 4.39)	4.74 (4.45 – 5.04)
Gender (ref=Female)				
Male	0.99 (0.96 – 1.01) ^{ns}	0.97 (0.94 – 0.99)	0.96 (0.93 – 0.98)	0.95 (0.93 – 0.98)
Marital status (ref=Not married)				
Married	0.91 (0.89 – 0.94)	0.92 (0.90 – 0.96)	0.80 (0.78 – 0.82)	0.81 (0.79 – 0.84)
MAPLe (ref=MAPLe 1-2)				
MAPLe 3	21.23 (17.15 – 26.28)	17.51 (14.14 – 21.67)	16.31 (13.18 – 20.19)	16.59 (13.40 – 20.54)
MAPLe 4	55.15 (44.60 – 68.19)	45.53 (36.81 – 56.31)	37.28 (30.15 – 46.10)	41.74 (33.75 – 51.63)
MAPLe 5	117.97 (95.39 –145.88)	90.93 (73.50 – 112.49)	68.71 (55.54 – 84.99)	81.38 (65.77 – 100.68)

^{ns} = not significant at the 0.05 probability level

3.4.6 Hospitalization Rates

Figures 3.9-3.12 show the hospitalization rates for the high/medium priority versus the low priority groups. The UW algorithm shows the smallest difference between high and low priority groups in probability for hospitalization. The largest differences are found by applying the VPR algorithm. This algorithm appears to be the best predictor for hospitalization of priority clients versus low priority clients. The difference between the three groups is statistically significant as shown by the Log-Rank test (X^2= 3086.47; DF 2; p<.0.001). The VPR Plus slightly weakens the association.

Figure 3.9: Kaplan-Maier Survival Curve for days to hospitalization by high and low priority clients using the University of Waterloo algorithm, Ontario home care clients, 2013 – 2014

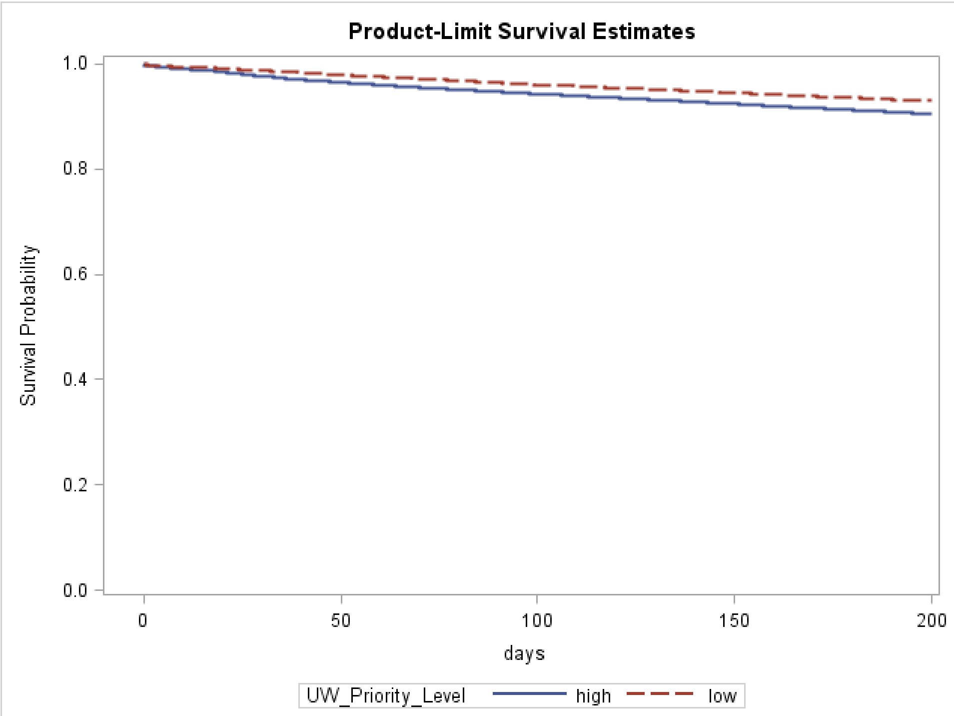


Figure 3.10: Kaplan-Maier Survival Curve for days to hospitalization by high and low priority clients using the Canterbury algorithm, Ontario home care clients, 2013 – 2014

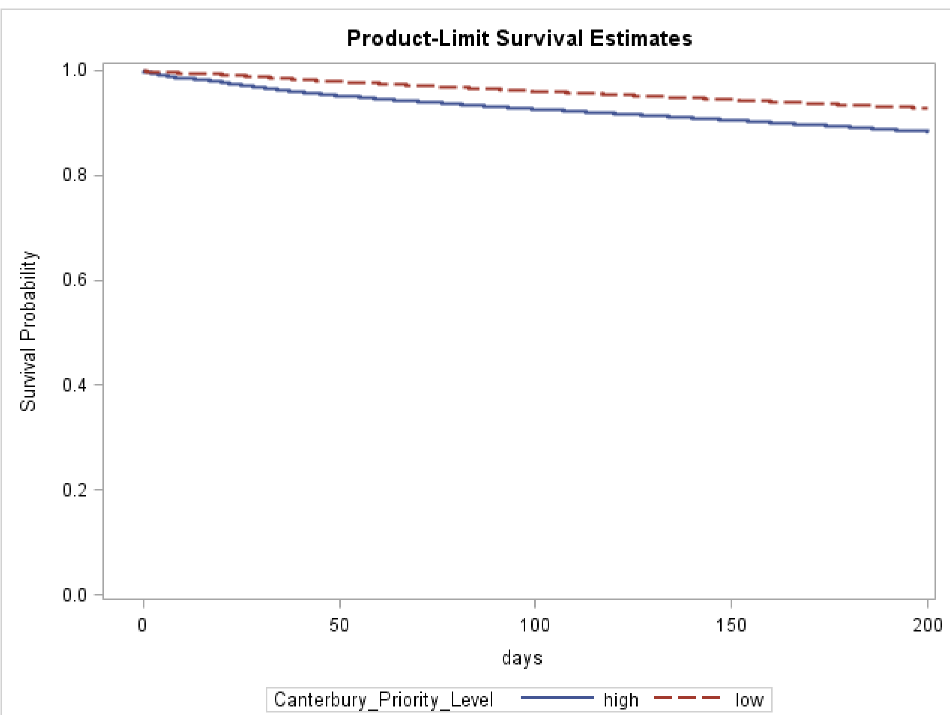


Figure 3.11: Kaplan-Maier Survival Curve for days to hospitalization by high, medium and low priority clients using the VPR algorithm, Ontario home care clients, 2013 – 2014

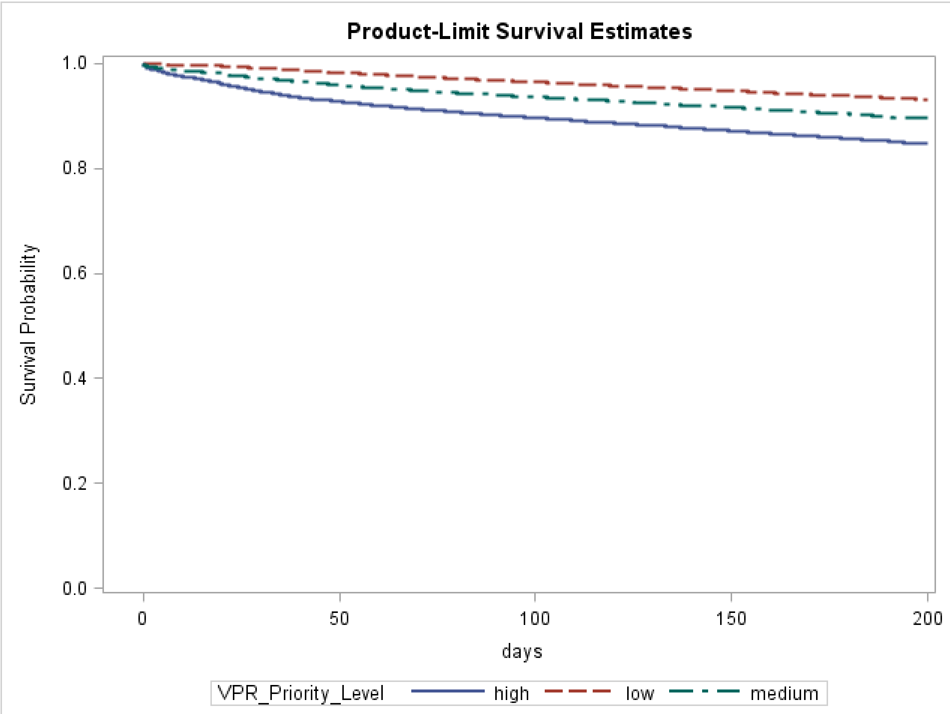


Figure 3.12: Kaplan-Maier Survival Curve for days to hospitalization by high, medium and low priority clients using the VPR Plus algorithm, Ontario home care clients, 2013 – 2014

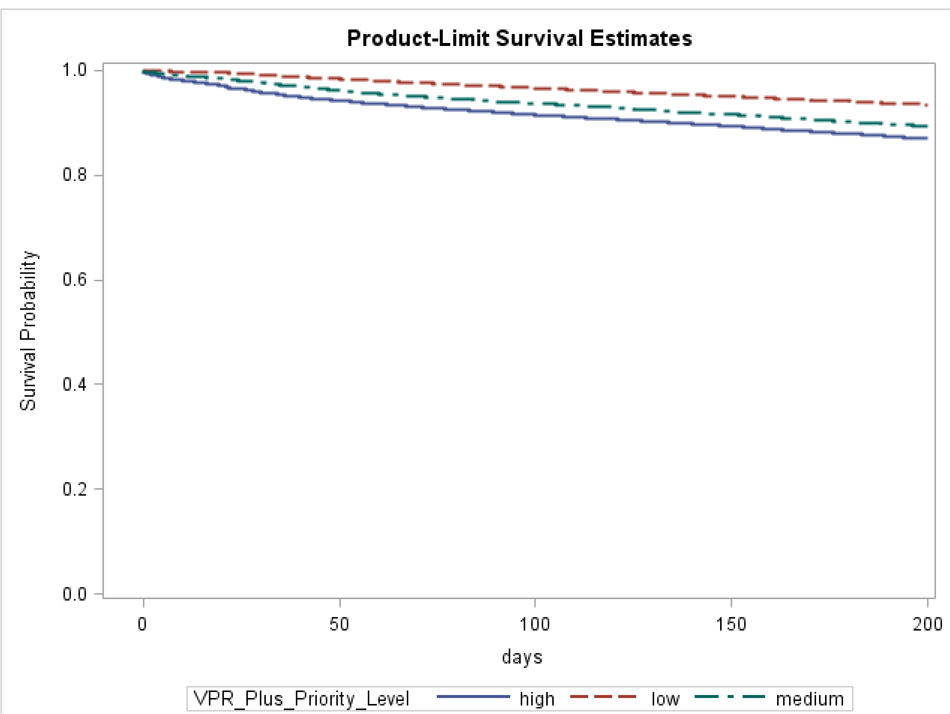


Table 3.14 shows the Cox proportional hazards ratios for hospitalization when adjusting for age, gender, marital status, CHESS and living status.

The Cox proportional hazards ratios, when adjusting for age, gender and CHESS (marital status and living status were non significant and therefore deleted from the model) show that the highest priority group of the VPR algorithm is 1.76 ($p<0.0001$) times more likely to be hospitalized than the low priority group. This ratio decreases to 1.30 ($p<0.0001$) for the medium risk group. The VPR Plus algorithm shows a hazards ratio of 1.62 ($p<0.0001$) for the high risk group and 1.26 ($p<0.0001$) for the medium risk group. The priority group in the Canterbury algorithm is 1.33 ($p<0.0001$) times more likely to be hospitalized than the low priority group. This ratio declines to 1.15 ($p<0.0001$) when applying the UW algorithm.

Table 3.14: Cox proportional hazards ratios for hospitalization with risk level, age, gender and CHESS by four decision support algorithms, Ontario home care clients, 2013 – 2014 (N=237,777)

	University of Waterloo	**Canterbury**	**VPR**	**VPR Plus**
Risk Level (ref=low)				
Medium	-	-	1.30 (1.24 – 1.37)	1.26 (1.19 – 1.35)
High	1.15 (1.11 – 1.20)	1.33 (1.29 – 1.37)	1.76 (1.69 – 1.82)	1.62 (1.57 – 1.67)
Age (ref= 18-64)				
65-74	1.28 (1.21 – 1.36)	1.27 (1.20 – 1.34)	1.28 (1.21 – 1.36)	1.31 (1.24 – 1.39)
75-84	1.34 (1.28 – 1.41)	1.32 (1.25 – 1.39)	1.30 (1.24 – 1.37)	1.38 (1.31 – 1.45)
85+	1.54 (1.47 – 1.62)	1.50 (1.43 – 1.57)	1.45 (1.38 – 1.	1.58 (1.50 – 1.65)
Gender (ref=Female)				
Male	1.45 (1.41 – 1.50)	1.45 (1.40 – 1.49)	1.40 (1.35 – 1.44)	1.39 (1.35 – 1.43)
CHESS (ref=0)				
CHESS 1	1.43 (1.36 – 1.51)	1.43 (1.36 – 1.51)	1.45 (1.38 – 1.53)	1.44 (1.36 – 1.51)
CHESS 2	2.05 (1.95 – 2.16)	2.03 (1.93 – 2.14)	2.04 (1.94 – 2.15)	2.03 (1.93 – 2.13)
CHESS 3	2.90 (2.75 – 3.06)	2.73 (2.59 – 2.88)	2.38 (2.26 – 2.52)	2.49 (2.36 – 2.63)
CHESS 4 – 5	4.57 (4.28 – 4.88)	4.25 (3.98 – 4.54)	3.39 (3.17 – 3.63)	3.65 (3.42 – 3.91)

All results are significant at the 0.05 probability level

3.5. Discussion

The purpose of this chapter was to present an overview of the characteristics of priority clients when three different decision support algorithms are applied to the home care client database in Ontario. This exercise provides a first glance into the size and characteristics of potential priority groups in the province, and sets the stage for the exploration of pro-active steps likely to reduce vulnerability during disasters for this high need group of home care clients. A sobering finding in this chapter is the substantial size of the high priority group, even when applying the most stringent algorithm (the VPR algorithm). Building an effective emergency response plan requires knowledge of the substantial volume of high priority clients together with their characteristics and needs. In a very real sense, all home care clients are relatively more vulnerable than average Canadians.

The high priority groups are significantly more impaired than the low priority groups, irrespective of which algorithm is applied. When applying either the Canterbury or VPR algorithm, the analysis shows that individuals within the priority group are more likely to have a higher level of health instability (CHESS), experience more falls, are more cognitively impaired, have higher levels of depression ratings, and require more assistance in both IADLs and ADLs. The literature supports the identification of these characteristics as common contributing factors to vulnerability during disasters.

Those individuals with a higher level of health instability may have substantial difficulties coping with effects of an emergency or disaster (Smith et al., 2009). Due to disaster related stress and disruption to daily care, their condition may rapidly deteriorate and lead to further frailty (Heuberger, 2011). Further, as formal and informal support systems often fail during emergencies and disasters, frail older adults are particularly challenged in bringing themselves to safety and gaining access to response and relief services (Smith et al., 2009).

The risk of falls is very high for frail older adults, even in the best of circumstances (Cefalu, 2011; Gill et al., 2010; Lamoth et al., 2011). More than half of the priority group identified by the VPR algorithm had two or more falls in the past 90 days. The risk of falls may increase during emergencies due to cognitive impairments (Cefalu, 2011; Gill et al., 2010; Lamoth et al., 2011), as well as compromises in the structural environment (Smith et al., 2009).

Cognitive impairment is another serious risk factor during emergencies and disasters and may lead to decreased response capabilities, difficulties communicating and understanding dangers as well as to an increased risk of falls (Eisenman et al., 2007; Lach et al., 2005; Pekovic et al., 2007). This analysis has shown that the priority groups are much more likely to have a higher CPS rating as compared to the low priority groups.

The analysis showed a priority group that is also highly dependent for ADLs and IADLs. As informal and formal support systems often fail during and after disasters, many frail older persons will be unable to manage necessary instrumental activities of daily living (IADL) such as meal preparation or medication administration. Of further concern are the high levels of depression in the priority group identified by the VPR algorithm. Pre-existing mental health problems increase an individual's risk for further psychological decline, leading to concerns such as wondering, assistance refusal and inability to respond to dangers (Brown, 2007; Cloyd & Dyer, 2010).

Comparative analysis across CCACs highlighted the regional variability of where priority clients reside. This information can help regional emergency managers as well as the provincial emergency management agency, the Office of the Fire Marshall and Emergency Management (OFMEM), assess service availability and resource allocation. Resource availability for emergency preparedness and response may result in different client trajectories during emergencies across LHINs.

The analysis has also shown that several RAI-HC items may not be predictive of priority status as the differences between high and low priority clients were shown to be not clinically significant. This was particularly the case for cardiovascular diseases and diabetes. The literature suggests increased vulnerability for these conditions (Ngo, 2001); however a substantial proportion (79.1% cardiovascular and 27.7% diabetes when applying the VPR algorithm) of the entire HC client base is affected by these diseases so they are not as useful to identify whether or not a client should be considered high priority. The same rational applies to medication use, since 85.0% of the HC clients use five or more medications and 55% nine or more medications. Morbidity and medication use are nonetheless important information pieces for aid workers as lack of medications may worsen the condition of an individual (Arrieta et al., 2009).

This same conclusion applies to vehicle use. Regardless of which algorithm is applied, approximately half of the priority clients are dependent on others to drive a vehicle. When clients are considered high priority based on health status and are living alone, responders should consider whether or not this individual is dependent on others to drive to safety.

Applying the different decision support algorithms has shown that, depending on which algorithm is applied, the size of the high priority group can vary greatly. It is of utmost importance that the algorithm that is applied is most predictive of adverse outcomes during and after emergencies. This analysis demonstrates that the VPR algorithms do the best job of predicting high priority clients during disasters by using the proxy variables of hospitalization, LTC admissions and mortality. However, the MAPLe and CHESS score in the cox proportional hazards models were very highly predictive of the proxy variables as well, and this raises the question why not use these scores instead of an algorithm. It should be noted that the models are predictive of death, LTC admission and hospitalization in normal day-to-day situations. This dissertation’s objective is to develop decision support algorithms in emergency situations by using variables that were identified as increasing the risk for vulnerable older adults in the literature.

This chapter has examined the potential usefulness of four different decision-support algorithms with the potential to improve response to the needs of vulnerable home care clients during all phases of emergency management. It is the first step towards the development of an algorithm that is the most predictive of vulnerability to emergencies and that can be used in other care settings such as palliative care, long term care and community mental health.

In the next two chapters the VPR and VPR Plus algorithms will be tested in further detail. Chapter 4 will provide an analysis of the algorithms as they relate to the Emergency Response Level (ERL) designation in two CCAC areas: Hamilton Niagara Haldimand Brant (HNHB) and Toronto Central (TC). Chapter five will explore the algorithms further by analyzing data from the 2013 Ontario ice storm.

4. Examining Determinants of Emergency Response Level Designation by CCACs

In order to achieve an effective response, the health care sector needs to be prepared for a range of different emergencies and their health effects. The health consequences of emergencies can vary with the type and magnitude of the event as well as the characteristics of the exposed population (Shoaf, 2014). The health effects can be a direct consequence of the impact of the disaster (e.g., earthquake injuries) or secondary. The secondary health effects are due to the worsened living conditions of surviving victims as a result of the event, as well as the capacity of the health care and public health sector to continue services (Shoaf, 2014). An event can precipitate the collapse of the existing health care infrastructure and increase the risk of illness.

Secondary health effects can be prevented by public health initiatives (e.g., clean drinking water) as well as re-establishing the services for those that require assistance before their needs become medically critical. It is often true that those people that require services as well as prescription medication resort to the hospital as a primary source of care instead of community based services (Prezant et al., 2005). As the surge in demand for health care is likely to increase, it is critical for health care organizations and emergency responders to coordinate the response in order to meet the increasing needs (Shoaf, 2014).

Jan and Lurie (2012) recommend the development of health information systems where health records are electronic and shared with all relevant agencies during emergencies. This information can be used to facilitate proper coordination between agencies regarding the care of people with substantial needs. However, it remains a challenge for agencies to identify those at risk older adults and implement appropriate response strategies to mitigate the effects of disasters on individual well-being (Jenkins et al., 2014).

Approximately 15 years ago, Community Care Access Centres (CCAC) developed a province-wide solution to ensure that all CCAC clients were assessed for risk level in the event of an emergency (Hill, 2015). Each CCAC client is assigned an Emergency Response Levels (ERL) along with the collection of routine assessment information. There were five risk levels developed:

1. ERL 1 Very High Risk
2. ERL 2 High Risk
3. ERL 3 Medium Risk
4. ERL 4 Low Risk
5. ERL 5 No Risk

To date most of the Community Care Access Centres (CCAC) in Ontario have implemented the ERLs, and have included the documentation of ERL codes in the Client Health Related Information System (CHRIS) since 2007. CCACs have adopted an approach whereby clients are assigned an Emergency Response Level (ERL) based on the assessment of the care coordinator. Some of the CCACs have expanded the range of codes to be more specific to the extent of assistance that is required. During several incidents, including the recent ice storm, these ERLs have been used to prioritize response among clients.

4.1 Rational and Objectives

To identify the most vulnerable clients, both the Toronto Central (TC) CCAC and Hamilton Niagara Haldimand Brant (HNHB) CCAC have developed and implemented Emergency Response Levels (ERL). These levels are assigned to each client receiving in-home services on admission by care coordinators. Codes are entered into the Ontario Association of Community Care Access Centres (OACCAC) Client Health Related Information System (CHRIS). The purpose of the ERL codes is to identify clients at risk of adverse health outcomes during and after emergencies.

The TC CCAC identifies five risk levels to identify clients that may require nursing or personal support within a certain timeframe (ERL code 1 – 5) as well as clients that are at risk due to certain health conditions or other limitations (e.g., codes heat, fall, cold, electric).

Table 4.1: Toronto Central (TC) CCAC Emergency Response Levels (ERL)

ERL Code	Description
ERL 1N	ERL 1 – Client requires nursing within 1 -12 hours
ERL 1P	ERL 1 – Client requires personal support within 1 -12 hours
ERL 2N	ERL 2 – Client requires nursing within 13 -24 hours
ERL 2P	ERL 2 – Client requires personal support within 13 -24 hours
ERL 3N	ERL 3 – Client requires nursing within 25 -72 hours
ERL 3P	ERL 3 – Client requires personal support within 25 -72 hours
ERL 4N	ERL 4 - Client can be placed on hold for up to five days
ERL 5N	ERL 4 - Client can be placed on hold for up to five days
ERL 5N	ERL 5 – None
ERL 5P	ERL 5 – None

The clients receiving the highest priority code (ERL 1) require nursing or personal support within 1-12 hours. During an emergency the TC CCAC uses these ERLs to produce a list of priority clients. Within the Incident Management System (IMS) it is the responsibility of the Business Intelligence On-Call Member to pull a list of clients that may be at risk, either based on postal code as directed by the location of the incident or based on the ERL codes (Toronto Central Community Care Access Centre, September 2013).

The HNHB CCAC uses similar ERLs, but does not use specific codes for risks such as heat, falls and oxygen (Hamilton Niagara Haldimand Brant CCAC, 2012).

Table 4.2: Hamilton Niagara Haldimand Brant (HNHB) CCAC Emergency Response Levels (ERL)

ERL Code	Description
ERL 1	Very high risk, must be seen within 1–12 hours, may require mechanical, ventilation, electrical equipment to sustain life, likely requires professional assistance in the event of an evacuation
ERL 2	High risk, must be seen within 13–24 hours, high needs with limited support network, may require non-professional assistance in the event of an evacuation
ERL 3	Moderate risk, must be seen within 25–72 hours, may be similar to a higher risk client but remain uncompromised because of a good support network
ERL 4	Low risk, may be placed on hold for up to 5 days, other supports to provide treatment/care
ERL 5	No risk, service can be placed on hold until the emergency situation is resolved

This dissertation chapter aims to examine the determinants of Emergency Response Level (ERL) designation within the TC and HNHB CCACs. Specifically this chapter will answer the following questions:

1. What proportion of long stay home care clients in TC CCAC and HNHB CCAC received which ERL designation, based on the results of the most recent home care assessment?
2. What person-level characteristics are associated with each of ERLs?
3. How do the determinants of level of risk by ERL code compare to those determinants identified in the literature?
4. What are the survival, LTC admission and hospitalization rates of each ERL code?
5. Based on the analysis, is it possible to develop candidate models as a prognostic tool for disaster service needs?
6. How do these models differ from the VPR algorithm?

4.2 Methods

4.2.1 Data Source

HC data used for this analysis come from the RAI-HC data sent by both CCACs. ERL codes are provided by the TC CCAC as per request by the University of Waterloo. Ethics clearance was given for secondary use of TC CCAC HC data by the University Of Waterloo Office of Research Ethics (ORE# 17771) and modified in October 2014 to include the ERL codes. The HNHB ERLs are provided by the HNHB CCAC as part of the routine quarterly HC data cut sent to the University of Waterloo (ORE# 16597).

In order to analyze survival rates, LTC admission and hospitalization rates, record linkages were made between the RAI-HC and ERL codes. To ensure confidentiality and anonymity, any personal identifiers were removed by the CCACs before sending the data to the University of Waterloo.

4.2.2 Sample

The sample consisted of long stay home care clients served by TC and HNHB CCACs that were assessed with the RAI-HC between 2003 (for HNHB)/2012 (for TC) and 2015. Only unique RAI-HC assessments were used to estimate proportions of HNHB and TC home care clients with the ERL designation. Unique assessments are the unit of analysis to control for multiple assessments within the sample.

The most recent ERL code for each person was selected from the database in order to identify the person-level characteristics associated with the ERL designation. The ERL codes were subsequently matched with a RAI-HC assessment that was conducted before or within 14 days after the ERL assignment. Further, the sample size was decreased by only including clients of which the ERL was assigned within 365 days of the last assessment. This resulted in a sample size of 70,292 unique HNHB and 8,996 unique TCCAC clients with an ERL designation.

To assess whether a client received a different ERL code when the health status has changed, the first and second HC was selected for clients that had an ERL code that was in effect at the time of both HC assessments or assigned maximum 30 days after. This resulted in 36,373 clients in the HNHB CCAC and 7,501 clients in the TC CCAC.

4.2.4 Statistical Analysis

Analyses were done using SAS version 9.4. Number of HC assessments per client as well as number of different ERLs per clients were calculated. Cross-tabulation was employed to show how the number of HC assessments relates to the number of ERL codes per client. In addition, change in health status was assessed by comparing the CPS, CHESS and ADL Hierarchy scores of the first assessment with the second, per client.

Descriptive analyses were employed to test and associate the prevalence of different RAI-HC items by ERL code. Frequencies and percentages are reported for each ERL level. Significance was tested with chi-square tests.

Bivariate logistic regression was used to test the associations between possible predictor variables and ERL designation. The ERL designation was made binary by collapsing the ERL levels into two groups (1, 2 and 3, 4, 5). Independent variables used were those identified as possibly being predictive or protective of adverse health outcomes during and after emergencies. Odds ratios with 95% confidence intervals are reported.

Based on the outcomes of bivariate analyses ($p<0.05$), covariates were selected for inclusion in the multivariate logistic regression model to predict emergency level designation. The c-statistic was used to compare goodness of fit. A c-statistic value of 0.70 is considered reasonable and 0.80 or higher as strong. The final model was compared to the VPR and VPR Plus algorithms.

For the survival rates, 6 month Kaplan-Meier survival plots were calculated using the LIFETEST procedure in SAS. The same test was used for rates of long term care (LTC) admissions and hospitalization of clients with an ERL designation of 1 or 2 compared to clients with an ERL of 3 to 5. Cox proportional hazards ratios were calculated using the PHREG procedure.

4.3 Results

4.3.1 Longitudinal analysis

Table 4.3 shows the number of HC assessments each unique client in the HNHB and TC CCAC received as well as the number of ERL codes.

There are 101,700 unique clients with one or more ERL assignments in the HNHB dataset. Almost half of the clients (47.7%) received only one ERL designation despite multiple HC assessments. More than 16 % of the clients have six or more HC assessments.

There are 16,521 unique clients with one or more ERL designations in the TC CCAC dataset. Over 85% of the clients had only one ERL code assignment, while over 80% of the clients had two or more HC assessments. One third of the clients had 6 or more assessments.

Table 4.3: Number of ERL code assignments and home care assessments, per unique client in the HNHB CCAC (2003 – 2015, N=101,700) and TC CCAC (2012 – 2015, N=16,521)

HNHB	**1** **% (n)**	**2** **% (n)**	**3** **% (n)**	**4** **% (n)**	**5** **% (n)**	**≥6** **% (n)**
ERL codes	47.7 (48,456)	34.0 (34,535)	15.3(15,599)	2.8 (2,871)	0.2(239)	-
HC Assessments	37.8 (38,406)	19.0 (19,294)	12.4 (12,604)	8.3 (8,474)	6.1 (6,158)	16.5 (16.764)
TC CCAC	**1** **% (n)**	**2** **% (n)**	**3** **% (n)**	**4** **% (n)**	**5** **% (n)**	**≥6** **% (n)**
ERL codes	85.5(14,129)	13.6(2,238)	0.9 (147)	7.0 (0.04)	-	-
HC Assessments	20.0 (3,310)	13.7 (2,258)	12.2 (2,016)	11.0 (1,824)	9.0 (1,488)	34.1 (5,625)

Table 4.4 shows the number of HC assessments by number of ERL codes. The table shows that most clients in both CCACs received multiple HC assessments, while the number of ERL codes maintained stable. Figure 4.1 and 4.2 visualize this in chart form. The analysis indicates that in both CCACs the ERL designation did not seem to change over time when a re-assessment was completed.

Of interest are those clients that received 4 or 5 different ERL codes while receiving less HC assessments. This would suggest that some care coordinators would update ERL codes independent from the HC assessment. In this case, the lack of a RAI-HC assessment could be considered a deficiency.

Table 4.5 shows whether a client received a different ERL code when their CPS, CHESS or ADL Hierarchy scores have changed. Only clients that had an active ERL or had an ERL assigned 30 days after the RAI-HC assessment were selected. It should be noted that there were 26,921 clients in the HNHB CCAC and 5,705 clients in the TC CCAC that did not have an ERL in effect or did not get one assigned within 30 days when one of the two or both HC assessment were done. Table 4.5 shows that there clearly are inconsistencies between health status change and ERL change. For example, over 23% in the HNHB and 43% in the TC CCAC of the clients that received a lower risk ERL code after the second HC actually showed decline in cognitive performance. The same trend is seen when comparing CHESS score changes. 25% (HNHB) and 37% (TC) of the clients receiving a lower risk ERL code, declined in CHESS.

Finally, of those clients that received a higher risk ERL almost 59% in the HNHB CCAC and 66% in the TC CCAC did not change in ADL hierarchy status. This would suggest that adjustments in ERL codes are made with little or no reference to cognitive, functional or medical changes detected by the RAI-HC.

Table 4.4: Number of ERL codes by number of home care assessments, per client in the HNHB CCAC (2003 – 2015, N=101,700) and TC CCAC (2012 – 2015, N=16,521)

Number of Home Care Assessments												
Number of ERLs	**1**		**2**		**3**		**4**		**5**		**>6**	
	HNHB n=38,406 % (n)	**TC n=3,310 % (n)**	**HNHB n=19,294 % (n)**	**TC n=2,258 % (n)**	**HNHB n=12,604 % (n)**	**TC n=2,016 % (n)**	**HNHB n=8,474 % (n)**	**TC n=1,824 % (n)**	**HNHB n=6,158 % (n)**	**TC n=1,488 % (n)**	**HNHB n=16,764 % (n)**	**TC n=5,625 % (n)**
1	59.1 (22,709)	87.7 (2,903)	47.3 (9,119)	87.6 (1,979)	42.2 (5,318)	87.1 (1,756)	40.1 (3,396)	87.1 (1,589)	39.1 (2,408)	84.1 (1,252)	32.8 (5,506)	82.7 (4,650)
2	31.1 (11.951)	11.9 (395)	36.2 (6,985)	11.9 (268)	37.2 (4,684)	12.2 (246)	35.0 (2,964)	11.9 (217)	33.3 (2,050)	15.1 (224)	35.2 (5,901)	15.8 (888)
3	8.7 (3,352)	0.3 (11)	14.4 (2,772)	0.5 (11)	17.6 (2,221)	0.7 (14)	20.4 (1,727)	0.9 (17)	22.5 (1,387)	0.8 (12)	24.7 (4,140)	1.5 (82)
4	1.0 (372)	0.03 (1)	2.0 (389)	0.0	2.8 (358)	0.0	4.2 (358)	0.8 (12)	4.5 (275)	0.0	6.7 (1,119)	0.1 (5)
5	0.1 (22)	0.0	0.2 (29)	0.0	0.2 (23)	0.0	0.3 (29)	0.0	0.6 (38)	0.0	0.6 (98)	0.0

Figure 4.1: Number of ERL codes assignments by number of home care assessments done per client in the HNHB CCAC

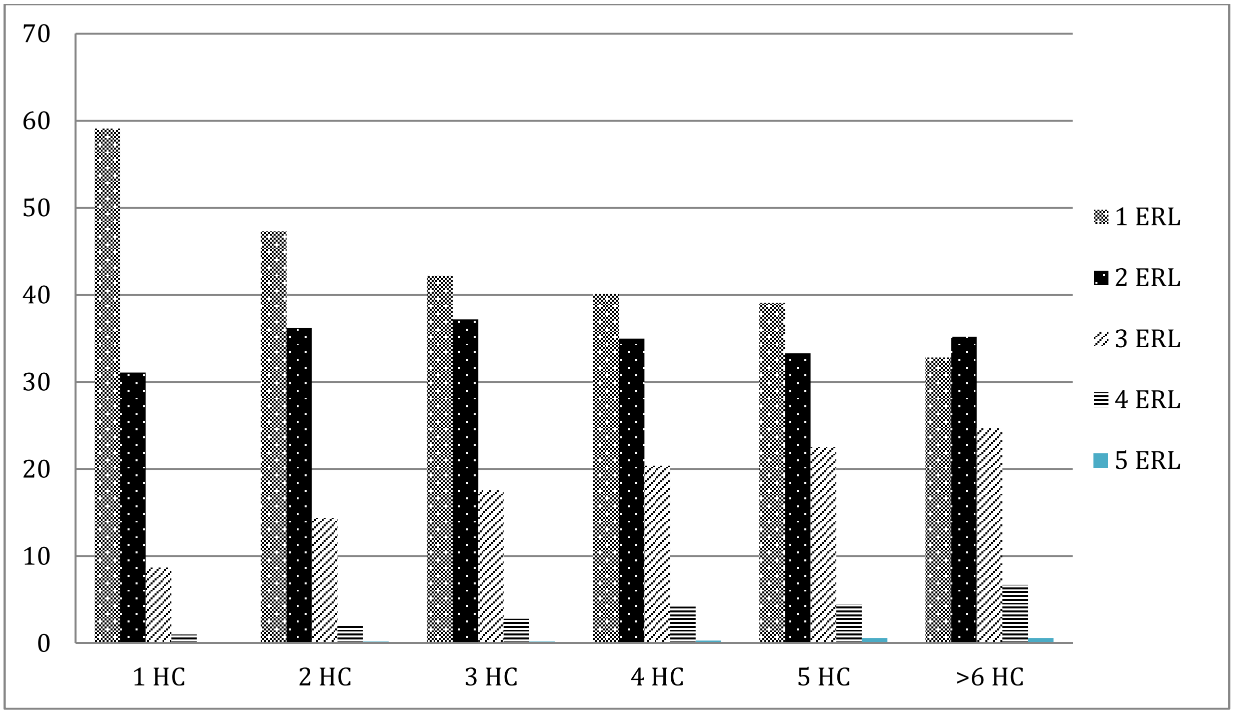


Figure 4.2: Number of ERL codes assignment by number of home care assessments done per client in the TC CCAC

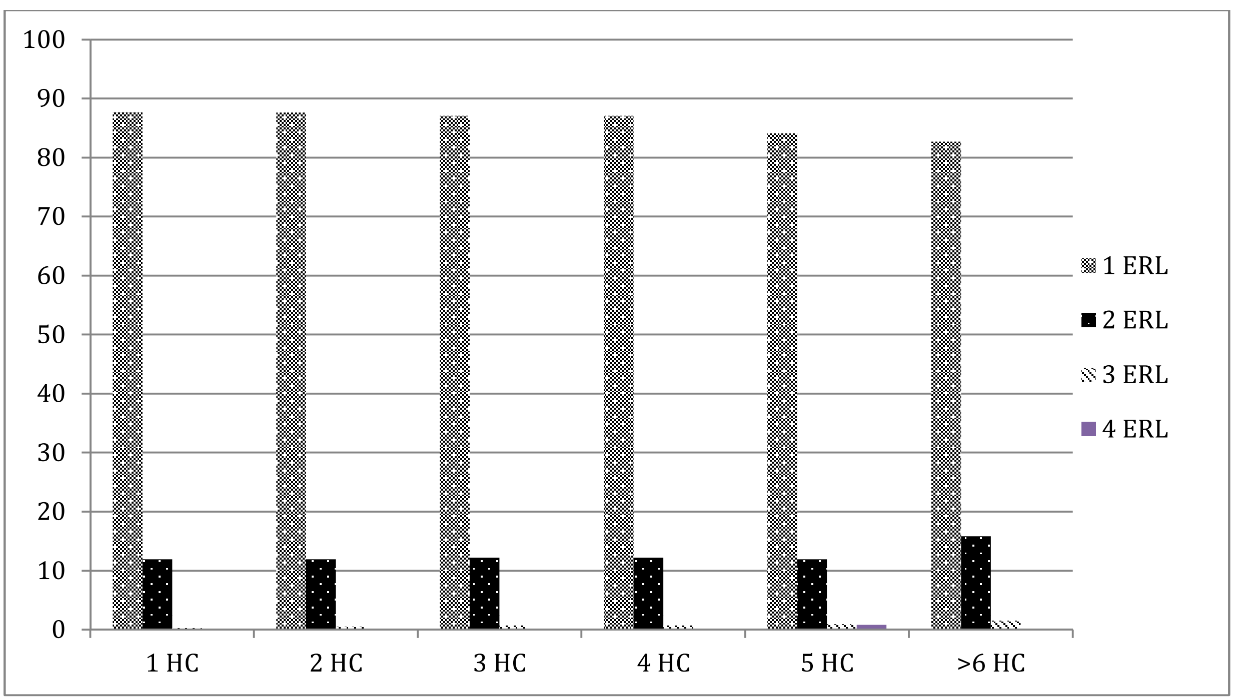


Table 4.5: ERL level change by change in CPS, CHESS and ADL Hierarchy levels between first and second assessment in the HNHB CCAC (2003 – 2015, N=36,373) and TC CCAC (2012 – 2015, N=7,501)

	ERL Level change					
	Better % (n)		**Same % (n)**		**Worse % (n)**	
	HNHB n=3,726	**TC n=16**	**HNHB n=27,341**	**TC n=7,456**	**HNHB n=5,306**	**TC n=29**
CPS difference						
Better	5.7 (214)	0.0	5.3 (1,456)	6.8 (510)	5.2 (277)	6.9 (2)
Same	71.1 (2,648)	56.3 (9)	78.9 (21,564)	73.5 (5,479)	67.5 (3,580)	62.1 (18)
Worse	23.2 (864)	43.8 (7)	15.8 (4,321)	19.7 (1,467)	27.3 (1,449)	31.0 (9)
CHESS difference						
Better	34.4 (1,281)	18.8 (3)	33.3 (9,091)	25.8 (1,926)	24.6 (1,303)	31.0 (9)
Same	40.3 (1,502)	43.8 (7)	47.3 (12,925)	51.0 (3,805)	38.6 (2,047)	37.9 (11)
Worse	25.3 (943)	37.5 (6)	19.5 (5,325)	23.1 (1,725)	36.9 (1,956)	31.0 (9)
ADL Hierarchy difference						
Better	11.4 (424)	18.8 (3)	9.7 (2,654)	9.0 (670)	7.9 (420)	3.5 (1)
Same	69.5 (2,591)	50.0 (8)	75.6 (20,667)	76.3 (5,689)	58.9 (3,124)	65.5 (19)
Worse	19.1 (711)	31.3 (5)	14.7 (4,020)	14.7 (1,097)	33.2 (1,762)	31.0 (9)

4.3.2 Socio-demographic and clinical characteristics by ERL Code

There were 70,292 unique RAI-HC assessments with an ERL designation selected in the HNHB area, and 8,996 within the TC area. Over 75% (52.937) of the ERL codes in HNHB and 74% (6,683) in TC CCAC were assigned within a 30 day period of the HC assessment.

Tables 4.6 and 4.7 present the descriptive characteristics of HC clients by ERL code in the TC and HNHB CCACs. Overall, the majority of clients in both CCACs are female and older than 75. The clients with an ERL 1 designation are clearly a more impaired group than clients with the other designations. In the HNHB CCAC 11.2% of the clients with an ERL score of 1 have a CPS score of 5-6. This decreases to 4.0% of the clients with an ERL score of 5. The same trend is shown for TC CCAC clients where almost 8% of the clients with a CPS 5-6 have an ERL score of 1 compared to 2.5% of the ERL 5 clients.

The CHESS, DRS and MAPLe score reinforce the same conclusion. A very prominent downwards trend is shown for the MAPLe score for TC CCAC clients. 61.0% of the clients with an ERL score of 1 have a MAPLe score of 4 or 5.

Another notable difference between clients with an ERL score 1 and 5 are between those that have an ADL hierarchy score of 5-6. 17.1% (HNHB) and 13.0% (TC) of the ERL 1 clients have an ADL score of 5-6. This proportion reduces to 3.0% and 1.9% of the ERL 5 clients, respectively.

In addition, whether a client is sometimes or rarely/never understood, sometimes or rarely/never understands others, uses a wheelchair, has a higher frequency of falls and has moderately to severe vision impairments were other characteristics of clients with an ERL 1 designation that stand out as compared to clients with an ERL 5 code.

There is no substantial association with ERL code designation and the number of medications a client uses. Oxygen use and dialysis were the only non-significant variables in the TC CCAC at the 0.01 probability level. There were no non-significant variables in the HNHB CCAC.

IADL capacity did not seem to substantially influence ERL designation. Over half of the clients with an ERL of 5 in both CCACs had an IADL capacity of 5-6, meaning these clients are highly dependent on assistance performing IADLs. The fact that CCACs do not provide assistance with IADLs may explain that this variable does not influence the ERL designation despite that IADL impairment can very well influence disaster resilience of their clients.

Logistic regression modeling will be used in the next paragraph in order to test which variables predict the assignment of an ERL designation of 1 or 2.

Table 4.8 shows the distribution of the VPR and VPR Plus in the HNHB and TC dataset.

Table 4.6: Socio-demographic and clinical characteristics of unique HNHB CCAC clients, by ERL designation, 2003 – 2015 (N=70,292)

Variable	Response Set	ERL=1 n=2,106 % (n)	ERL=2 n=4,467 % (n)	ERL=3 n=22,462 % (n)	ERL=4 n=19,372 % (n)	ERL=5 n=21,884 % (n)
Gender†	**Female**	62.3 (1,312)	58.9 (2,633)	60.8 (13,663)	62.5 (12,103)	61.4 (13,438)
Age, y ‡	**18-64**	12.5 (263)	18.3 (816)	14.9 (3,346)	16.1 (3,108)	16.7 (3,658)
	65-74	12.3 (258)	15.4 (689)	15.3 (3,441)	14.9 (2,885)	14.8 (3,238)
	75-84	32.1 (674)	30.4 (1,351)	33.7 (7,567)	34.7 (6,715)	34.1 (7,457)
	≥85	43.2 (908)	36.0 (1,608)	36.0 (8,080)	34.3 (6,641)	34.3 (7,506)
CPS §	**0**	28.3 (596)	37.5 (1,674)	39.8 (8,931)	43.2 (8,365)	40.3 (8,814)
	1-2	40.5 (853)	40.8 (1,823)	46.3 (10,406)	45.5 (8,811)	46.1 (10,098)
	3-4	20.0 (422)	14.1 (628)	9.9 (2,227)	7.9 (1,538)	9.6 (2,095)
	5-6	11.2 (235)	11.4 (343)	4.0 (898)	3.4 (658)	4.0 (877)
CHESS ¶	**0**	9.5 (200)	13.8 (617)	15.4 (3,453)	20.7 (4,009)	24.2 (5,297)
	1-2	57.5 (1,211)	55.6 (2,485)	60.7 (13,636)	62.1 (12,025)	59.8 (13,088)
	3+	33.0 (695)	30.6 (1,366)	23.9 (5,372)	17.2 (3,337)	16.0 (3,499)
DRS #	**0**	50.5 (1,063)	52.5 (2,345)	57.7 (12,964)	60.4 (11,705)	60.3 (13,201)
	1-2	26.1 (550)	26.0 (1,163)	24.7 (5,556)	23.8 (4,604)	23.0 (5,037)
	3+	23.4 (493)	21.5 (959)	17.5 (3,939)	15.8 (3,063)	16.6 (3,641)
MAPLe††	**1-2**	10.8 (227)	17.2 (768)	21.6 (4,854)	29.1 (5,644)	29.2 (6,389)
	3	30.5 (643)	34.5 (1,540)	35.6 (8,005)	31.6 (6,127)	28.5 (6,232)
	4-5	58.7 (1,236)	48.3 (2,160)	42.8 (9,603)	39.2 (7,601)	42.3 (9,263)
ADL Hierarchy ‡‡	**0**	26.4 (556)	37.7 (1,684)	49.7 (11,171)	63.7 (12,333)	63.4 (13,882)
	1 -2	29.3 (616)	28.6 (1,276)	30.2 (6,791)	24.7 (4,789)	23.1 (5,049)
	3-4	27.3 (575)	24.0 (1,070)	15.8 (3,558)	10.0 (1,933)	10.5 (2,305)
	5-6	17.1 (359)	9.8 (438)	4.2 (941)	1.6 (316)	3.0 (646)
IADL Capacity §§	**0**	2.0 (42)	1.9 (86)	23.1 (605)	3.9 (763)	5.2 (1,127)
	1 -2	6.4 (135)	11.0 (490)	26.5 (3,264)	20.0 (3,873)	20.7 (4,539)
	3-4	12.3 (258)	16.2 (725)	21.4 (4,798)	25.1 (4,869)	22.5 (4,915)
	5-6	79.3 (1,671)	70.9 (3,167)	61.4 (13,795)	50.9 (9,867)	51.7 (11,303)
Comorbidities	**≥ 4**	64.8 (1,365)	57.0 (2,547)	54.6 (12,256)	50.2 (9,715)	50.3 (11,007)
Falls (last 90 days)	**≥ 2**	27.9 (587)	22.6 (1,009)	21.7 (4,862)	20.4 (3,949)	18.9 (4,143)
Medications	**≥ 9**	62.4 (1,314)	55.0 (2,456)	53.2 (11,947)	49.2 (9,538)	49.0 (10,725)
Difficulties making self understood	**Sometimes or rarely/never**	8.4 (177)	6.8 (302)	4.0 (903)	3.2 (619)	4.0 (871)
Difficulty understanding others	**Sometimes or rarely/never**	10.2 (215)	8.3 (370)	4.8 (1,084)	3.9 (763)	4.7 (1,032)
Vision impairment	**Moderately to severely**	13.9 (293)	11.5 (515)	8.7 (1,962)	7.5 (1,454)	8.1 (1,777)
Wheelchair use in door		24.2 (510)	18.5 (825)	11.4 (2,567)	6.9 (1,341)	8.2 (1,788)
Oxygen Use		8.6 (181)	9.4 (418)	5.5 (1,237)	3.6 (695)	3.4 (735)
Dialysis		4.7 (99)	3.2 (141)	1.8 (402)	1.3 (250)	1.1 (232)

† Missing=1
‡ Missing = 83
§ 0=cognitive intact; 1-2=borderline to mild cognitive impairment; 3-4=moderate to moderately sever cognitive impairment; 5-6=severe to very severe cognitively impaired
¶ 0=no health instability; 1-2=some health instability; 3+=moderate to high health instability; Missing=2
# 0=no indication of depression; 1-2=some indicators of depression; 3+=indicators of probable depression; Missing=9
†† predicts nursing home placement, caregiver distress and for being rated as requiring alternative placement. Low (1) – mild (2), moderate (3), high (4) – very high (5)
‡‡ 0=no impairment; 1-2=some functional impairment; 3-4= moderately functionally impaired; 5-6=dependent; Missing=4
§§ 0=no difficulty; 1-2=some difficulty; 3-4 =limited to extensive assistance; 5-6-maximal assistance/total dependence
All differences are significant at the 0.01 probability level.

Table 4.7: Socio-demographic and clinical characteristics of unique TC CCAC clients, by ERL designation, 2012 – 2015 (N=8,996)

Variable	Response Set	ERL=1 N=671 % (n)	ERL=2 N=1,315 % (n)	ERL=3 N=2,763 % (n)	ERL=4 N=3,281 % (n)	ERL=5 N=960 % (n)
Gender	**Female**	60.1 (403)	63.0 (829)	63.2 (1,745)	67.9 (2,231)	71.4 (685)
Age, y †	**18-64**	8.1 (54)	11.6 (152)	13.7 (378)	11.9 (389)	11.3 (108)
	65-74	12.8 (86)	15.2 (200)	15.3 (421)	15.2 (499)	12.3 (118)
	75-84	37.2 (250)	34.2 (450)	34.4 (950)	37.0 (1,215)	38.8 (372)
	≥85	41.8 (280)	39.0 (513)	36.7 (1,012)	35.9 (1,180)	37.7 (362)
CPS ‡	**0**	16.5 (111)	25.3 (332)	35.0 (965)	43.5 (1.429)	45.1 (432)
	1-2	53.1 (356)	53.9 (709)	48.0 (1,326)	46.3 (1,520)	43.2 (414)
	3-4	22.5 (151)	15.1 (198)	13.6 (375)	8.3 (272)	9.3 (89)
	5-6	7.9 (53)	5.8 (76)	3.4 (94)	1.9 (62)	2.5 (24)
CHESS §	**0**	11.7 (78)	16.9 (221)	16.4 (450)	21.3 (694)	21.8 (207)
	1-2	60.6 (403)	60.2 (788)	64.6 (1,775)	65.4 (2,127)	67.0 (636)
	3+	27.7 (184)	23.0 (301)	19.0 (522)	13.3 (431)	11.3 (107)
DRS ¶	**0**	41.7 (277)	49.2 (644)	51.9 (1,426)	58.1 (1,890)	58.0 (551)
	1-2	29.8 (198)	27.7 (365)	26.3 (723)	23.6 (766)	26.4 (251)
	3+	28.6 (190)	23.0 (301)	21.8 (598)	18.3 (596)	15.6 (148)
MAPLe#	**1-2**	6.0 (40)	11.1 (146)	15.3 (422)	24.9 (818)	31.5 (302)
	3	33.1 (222)	38.7 (509)	42.4 (1,170)	42.3 (1,389)	37.8 (363)
	4-5	61.0 (409)	50.2 (660)	42.4 (1,171)	32.9 (1,080)	30.7 (295)
ADL Hierarchy ††	**0**	22.8 (153)	36.5 (480)	45.9 (1,266)	61.6 (2,023)	69.7 (668)
	1 -2	38.0 (255)	37.5 (493)	36.7 (1,014)	29.2 (958)	23.2 (222)
	3-4	26.2 (176)	18.7 (246)	14.1 (389)	7.6 (249)	5.3 (51)
	5-6	13.0 (87)	7.3 (96)	3.3 (91)	1.6 (54)	1.9 (18)
IADL Capacity ‡‡	**0**	0.0 (0)	0.2 (3)	1.0 (27)	0.8 (27)	1.9 (18)
	1 -2	5.4 (36)	8.4 (110)	9.1 (253)	15.1 (496)	15.3 (147)
	3-4	9.7 (65)	14.8 (194)	20.9 (578)	25.4 (835)	26.4 (253)
	5-6	85.0 (570)	76.7 (1,008)	69.0 (1,905)	58.7 (1,928)	56.5 (542)
Comorbidities	**≥ 4**	55.0 (369)	47.5 (625)	45.1 (1,246)	38.9 (1,277)	39.0 (374)
Falls (last 90 days)	**≥ 2**	22.4 (150)	19.2 (253)	17.9 (495)	14.8 (486)	10.0 (96)
Medications	**≥ 9**	46.1 (309)	44.1 (580)	42.7 (1,179)	38.2 (1,256)	38.7 (371)
Difficulties making self understood	**Sometimes or rarely/never understood**	9.1 (61)	6.7 (88)	3.9 (108)	2.1 (69)	3.3 (32)
Difficulty understanding others	**Sometimes or rarely/never understands others**	10.6 (71)	7.1 (93)	4.6 (126)	2.3 (75)	3.3 (32)
Vision	**Moderately to severely impaired**	14.5 (97)	13.8 (182)	10.5 (290)	8.5 (279)	7.6 (73)
Wheelchair use in door		20.1 (135)	13.8 (182)	9.8 (270)	4.8 (158)	3.7 (35)
Oxygen Use ns		3.3 (22)	3.1 (41)	2.5 (69)	2.6 (85)	1.7 (16)
Dialysis ns		1.2 (8)	2.1 (27)	1.6 (45)	1.0 (33)	0.8 (8)

† Missing=7
‡ 0=cognitive intact; 1-2=borderline to mild cognitive impairment; 3-4=moderate to moderately sever cognitive impairment; 5-6= severe to very severe cognitively impaired; Missing=8
§ 0=no health instability; 1-2=some health instability; 3+=moderate to high health instability; Missing=2
¶ 0=no indication of depression; 1-2=some indicators of depression; 3+=indicators of probable depression; Missing=72
# predicts nursing home placement, caregiver distress and for being rated as requiring alternative placement. Low (1) – mild (2), moderate (3), high (4) – very high (5)
†† 0=no impairment; 1-2=some functional impairment; 3-4= moderately functionally impaired; 5-6=dependent; Missing=7
‡‡ 0=no difficulty; 1-2=some difficulty; 3-4 =limited to extensive assistance; 5-6-maximal assistance/total dependence; Missing=1
ns = non significant at the 0.01 probability level. All other differences are significant at the 0.01 probability level

Table 4.8: Distribution of unique clients with different levels of VPR and VPR Plus designation within the HNHB (2003 – 2015, N=70,292) and TC datasets (2012 – 2015, N=8,996))

VPR	HNHB %(n)	TC %(n)
0	75.7 (53,238)	76.1 (6,848)
1	7.9 (5,535)	8.6 (770)
2	16.4 (11,519)	15.3 (1,378)
VPR Plus		
0	66.8 (46,921)	69.2 (6,227)
1	5.4 (3,814)	6.5 (581)
2	27.8 (19,557)	24.3 (2,188)

4.3.3 Logistic Regression Model for Predicting ERL Designation 1-2

Logistic regression was used to estimate the model predicting the assignment of an ERL designation of 1-2 as compared to the assignment of ERL designation 3-5. Tables 4.9 – 4.11 provide the list of candidate variables for the bivariate logistic regression model. The tables show the odds ratio as well as the 95% confidence intervals of each variable at the bivariate level. A total of 70,292 HNHB clients and 8,996 TC CCAC clients were included for the analysis.

Table 4.9: Candidate variables for predicting ERL designation 1-2 as compared to ERL designation 3-5, HNHB 2003 – 2015 (N=70,292); TC 2012 – 2015 (N=8,996)

		HNHB		TC	
Variable	**Response set**	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
Gender	**Male**	1.00 (ref)		1.00 (ref)	
	Female	0.94	0.89-0.99	0.82	0.74-0.91
Age, y	**18-65**	1.00 (ref)		1.00 (ref)	
	65-74	0.93	0.84-1.02 ns	1.17	0.96-1.43 ns
	75-84	0.87	0.81-0.94	1.17	0.99-1.39 ns
	≥85	1.06	0.98-1.14 ns	1.32	1.11-1.57
Marital Status	**Married**	1.00 (ref)		1.00 (ref)	
	Never married/Separated/ Divorced/ Widowed	0.98	0.93-1.03 ns	1.04	0.93-1.16 ns
Living Arrangement	**Living alone**	1.00 (ref)		1.00 (ref)	
	Living with others	1.08	1.02-1.14	1.57	1.40-1.77
Primary helper available	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.74	1.39-2.18	0.99	0.82-1.20 ns
Caregiver unable to continue caring activities	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.65	1.54-1.77	1.33	1.15-1.54
Primary caregiver is not satisfied with support received from family or friends	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.51	1.34-1.70	2.00	1.63-2.55
Caregiver expresses feelings of distress, anger or depression	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.61	1.52-1.71	2.13	1.89-2.39
Withdrawal	**No withdrawal exhibited**	1.00 (ref)		1.00 (ref)	
	Withdrawal from activities exhibited at least once the past 3 days	1.47	1.36-1.59	1.28	1.12-1.46
Has reduced social interaction	**No reduced social interaction exhibited**	1.00 (ref)		1.00 (ref)	
	Reduced social interaction exhibited at least once the past 3 days	1.38	1.29-1.47	1.30	1.15-1.47
Isolation	**Is never alone or about one hour**	1.00 (ref)		1.00 (ref)	
	Is alone long periods of time or always	0.69	0.65-0.72	0.91	0.83-1.01 ns
CPS	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.05	0.99-1.11 ns	2.08	1.85-2.35
	3-4	2.06	1.91-2.23	3.03	2.57-3.56
	5-6	2.73	2.47-3.02	4.57	3.57-5.85
CHESS	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.49	1.38-1.61	1.19	1.03-1.37
	3+	2.64	2.42-2.87	2.07	1.75-2.44
DRS	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.25	1.18-1.33	1.36	1.21-1.53
	3+	1.52	1.42-1.62	1.54	1.36-1.74
Maple	**Low (1) – mild (2)**	1.00 (ref)		1.00 (ref)	
	Moderate (3)	1.82	1.68-1.97	2.07	1.75-2.46
	High (4) – very high (5)	2.18	2.02-2.34	3.48	2.94-4.12
ADL hierarchy	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.90	1.78-2.02	2.13	1.89-2.40
	3-4	3.52	3.29-3.77	3.83	3.30-4.44
	5-6	6.99	6.37-7.68	7.02	5.59-8.81

ns = Non-significant at the 0.05 probability level
All other differences are significant at the 0.05 probability level

Table 4.10: Candidate variables for predicting ERL designation 1-2 as compared to ERL designation 3-5, HNHB 2003 – 2015 (N=70,292); TC 2012 – 2015 (N=8,996)

		HNHB		TC	
Variable	**Response set**	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
Transfer	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	2.54	2.38-2.71	2.14	1.86-2.46
Eating	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	2.83	2.57-3.10	2.58	2.12-3.14
Toilet Use	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	2.51	2.354-2.67	2.31	2.02-2.64
Locomotion in Home	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	2.81	2.61 – 3.02	2.46	2.12-2.85
Personal hygiene	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	2.06	1.95-2.19	2.05	1.83-2.30
Bathing	**Independent – Supervision**	1.00 (ref)		1.00 (ref)	
	Limited Assistance – Full Dependence	1.05	1.00-1.11 ns	0.71	0.64-0.79
Wheelchair	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.60	2.43-2.77	2.69	2.31-3.13
Client believes he/she capable of increased functional independence	**No**	1.00 (ref)		1.00 (ref)	
	Yes	0.71	0.67-0.75	0.74	0.65-0.85
Caregivers believes client capable of increased functional independence	**No**	1.00 (ref)		1.00 (ref)	
	Yes	0.78	0.72-0.83	0.91	0.75-1.10 ns
IADL capacity	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.04	0.86-1.27 ns	3.91	1.23-12.57
	3-4	1.31	1.09-1.59	3.73	1.17-11.92
	5-6	2.70	2.25-3.23	8.65	2.72-27.50
Meals Preparation	**Independent – Some help**	1.00 (ref)		1.00 (ref)	
	Full Help – By Others	2.06	1.93-2.19	2.45	2.15-2.78
Managing Medication	**Independent – Some help**	1.00 (ref)		1.00 (ref)	
	Full Help – By Others	1.87	1.78-1.97	2.49	2.25-2.75
Co-morbidities	**0-3**	1.00 (ref)		1.00 (ref)	
	≥ 4	1.37	1.30-1.44	1.42	1.29-1.57
Falls (last 90 days)	**0-1**	1.00 (ref)		1.00 (ref)	
	≥2	1.26	1.18-1.33	1.40	1.24-1.59
Unsteady Gait	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.24	1.17-1.31	1.48	1.31-1.66
Client limits going outdoors due to fear of falling	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.41	1.34-1.48	1.36	1.22-1.50
Pain	**Mild to moderate (0-2)**	1.00 (ref)		1.00 (ref)	
	Severe to horrible (3-4)	1.12	1.04-1.20	1.07	0.94-1.23 ns
Expression	**Understood – Often understood**	1.00 (ref)		1.00 (ref)	
	Something – rarely/never understood	2.01	1.82-2.23	2.64	2.13-3.28

ns = Non-significant at the 0.05 probability level
All other differences are significant at the 0.05 probability level

Table 4.11: Candidate variables for predicting ERL designation 1-2 as compared to ERL designation 3-5, HNHB 2003 – 2015 (N=70,292); TC 2012 – 2015 (N=8,996)

		HNHB		TC	
Variable	**Response set**	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
Comprehension	**Understands – Often Understands**	1.00 (ref)		1.00 (ref)	
	Sometimes – Rarely/Never Understands	2.06	1.88-2.27	2.62	2.13-3.21
Vision	**Adequate – Impaired**	1.00 (ref)		1.00 (ref)	
	Moderately – Severely Impaired	1.58	1.46-1.71	1.62	1.40-1.89
Hearing	**Hears adequately – minimal difficulty**	1.00 (ref)		1.00 (ref)	
	Hears in special occasions only – highly impaired	1.71	1.36-2.16	1.93	1.31-2.84
Oxygen Use	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.30	2.09-2.52	1.32	0.98-1.77 ns
Dialysis	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.70	2.33-3.12	1.45	0.97-2.15 ns
Medication use	**0-8**	1.00 (ref)		1.00 (ref)	
	≥9	1.32	1.25-1.38	1.21	1.10-1.34
Pressure ulcer	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.40	2.20-2.61	2.52	2.04-3.12
Bladder Incontinence	**Continent – Usually Continent**	1.00 (ref)		1.00 (ref)	
	Occasionally Incontinent – Incontinent	1.53	1.44-1.63	1.89	1.68-2.13
Bowel incontinence	**Continent – Usually Continent**	1.00 (ref)		1.00 (ref)	
	Occasionally Incontinent – Incontinent	2.46	2.29-2.65	2.94	2.51-3.45
Hospice care	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.70	2.33-3.12	1.45	0.97-2.15 ns

ns = Non-significant at the 0.05 probability level
All other differences are significant at the 0.05 probability level

Tables 4.9 – 4.11 illustrate that a large number of variables are significantly associated with increased odds of being assigned an ERL code of 1 or 2 at the bivariate level. HNHB clients with a CPS score of 3 or higher are more than twice as likely to have an ERL designation of 1 or 2 (CPS of 1-2 appeared to be non-significant). The odds ratio increases when looking at the TC CCAC data. TC CCAC clients with a CPS score of 1-2 are twice as likely to receive the ERL code of 1 or 2, with a score of 3-4 three times as likely and with a score of 5-6 4.5 times as likely.

The ADL hierarchy shows similar odds ratios for both CCACs. In both CCACs, clients with an ADL hierarchy score of 1-2 are almost twice as likely to receive an ERL designation of 1-2. The clients with an ADL hierarchy score of 3-4 are over 3.5 more likely and with a score of 5-6 almost 7 times more likely.

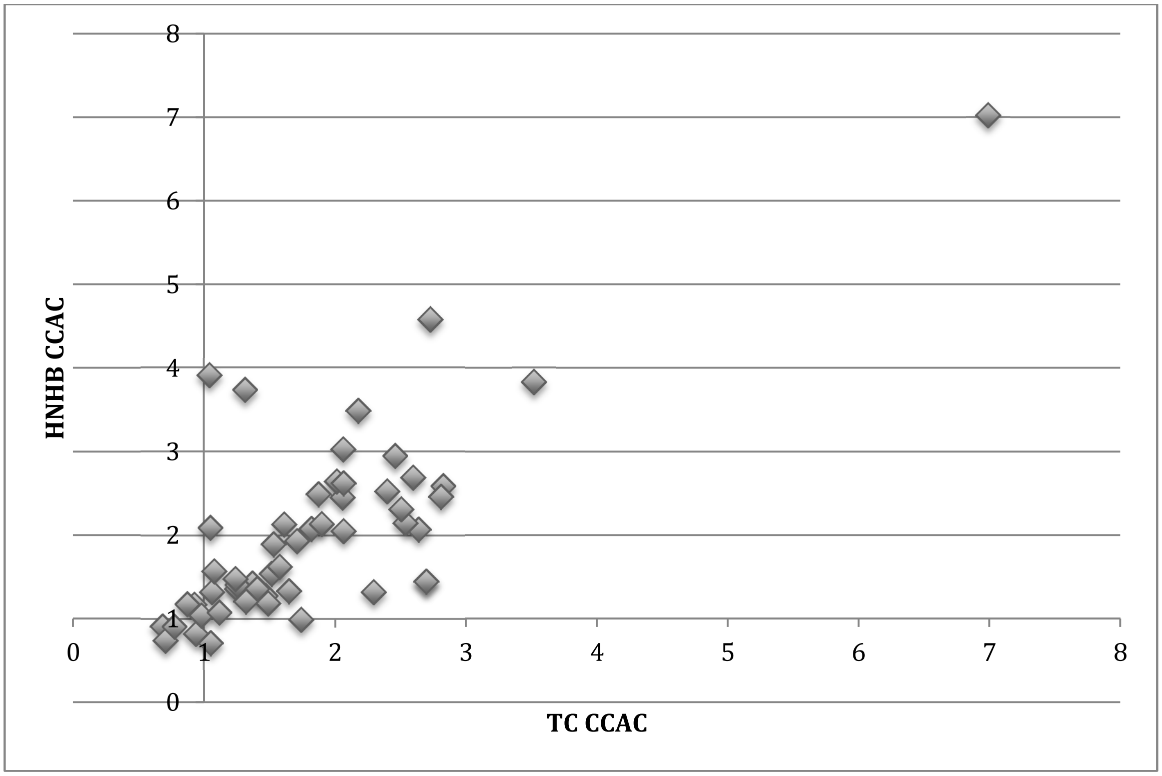
Other significant odds ratios where clients are over 2 times more likely to receive an ERL of 1 or 2 in both CCACs include: assistance with transferring, eating, toilet use, locomotion in home, personal hygiene and meals preparation, whether the client is in a wheelchair, difficulty with expression and comprehension and bowel incontinence.

Significant items that are protective include client believes he/she is capable of increased functional independence and the caregiver believes client is capable of increased functional independence.

Age, marital status, availability of primary helper, alone for long periods or always, pain, dialysis, oxygen use and hospice care appeared to be non-significant at the 0.05 probability level in the TC CCAC data. Age, marital status, CPS, assistance with bathing and IADL capacity were non-significant in the HNHB CCAC data.

When examining the consistency between the data in the two CCACs, it appears that the odds ratios of both are relatively constant. This is shown in figure 4.3. There are however several outliers. These include IADL capacity, CPS and the availability of a primary helper.

Figure 4.3: Odds ratio distribution for factors associated with ERL code designation 1 or 2, TC CCAC vs HNHB CCAC



Based on the findings from the bivariate analysis, a logistic regression model was developed. The variables with odds ratios ≤0.80 or ≥1.20 were included in the model. Table 4.12 presents the final multivariate models for both the HNHB and TC CCAC. The overall fit of the logistic regression models measured by the c-statistic is reasonable at 0.69 for both CCACs.

An ADL Hierarchy score of 5-6 is associated with having 4.65 times the odds in the HNHB CCAC and 3.11 times the odds in the TC CCAC of receiving an ERL 1 or 2 code. Having a pressure ulcer, receiving dialysis and being in a wheelchair also increases the odds of receiving an ERL designation of 1 or 2 in both CCACs.

Variables that are significant in the HNHB CCAC but not in the TC CCAC include having a primary helper, CHESS, needing oxygen and help with transfers. A CHESS of 3+ is associated with a 1.71 increase in the odds of being assigned an ERL1-2, and requiring oxygen doubles the odds. The availability of a primary helper seems to increase the odds of receiving an ERL1-2 designation in the HNHB CCAC and appears to be an anomalous association.

Caregiver distress, requiring assistance with bathing, meal preparation and managing medications, vision impairment and bowel incontinence are significant in the TC CCAC and not in the HNHB CCAC. When a caregiver expresses feelings of distress, anger or depression the client is close to 1.5 times more likely to receive an ERL code of 1 or 2. When a client requires limited assistance or is fully dependent on others for bathing does not increase the odds of receiving an ERL 1 or 2. In fact, the data shows that this seems to decrease the odds, which is again an unexpected association.

Table 4.12: Final multivariate logistic regression model for ERL 1 and 2 assignment as compared to ERL 3-5 assignment, HNHB 2003 – 2015 (N=70,292); TC 2012 – 2015 (N=8,996)

		HNHB C=0.69		TC C=0.69	
Variable	**Response set**	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
ADL Hierarchy	**0**	1.00 (ref)		1.00 (ref)	
	1-2	1.65	1.55-1.77	1.56	1.29-1.66
	3-4	2.78	2.58-3.00	1.98	1.38-1.78
	5-6	4.65	4.15-5.19	3.11	2.36-4.10
Wheelchair	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.24	1.14-1.34	1.38	1.16-1.66
Dialysis	**No**	1.00 (ref)		1.00 (ref)	
	Yes	2.68	2.30-3.12	1.53	1.02-2.32
Pressure ulcer	**No**	1.00 (ref)		1.00 (ref)	
	Yes	1.35	1.23 – 1.48	1.53	1.21-1.94
Oxygen	**No**	1.00 (ref)		ns	
	Yes	2.01	1.82-2.22		
Primary helper available	**No**	1.00 (ref)		ns	
	Yes	1.35	1.07 – 1.70		
CHESS	**0**	1.00 (ref)		ns	
	1-2	1.24	1.15-1.35		
	3+	1.71	1.57-1.87		
Transfer	**Independent – Supervision**	1.00 (ref)		ns	
	Limited Assistance – Full Dependence	1.32	1.22-1.42		
Caregiver expresses feelings of distress, anger or depression	**No**	ns		1.00 (ref)	
	Yes			1.46	1.29-1.66
Bathing	**Independent – Supervision**	ns		1.00 (ref)	
	Limited Assistance – Full Dependence			0.74	0.66-0.82
Meal Preparation	**Independent – Some help**	ns		1.00 (ref)	
	Full Help – By Others			1.36	1.18-1.58
Managing Medication	**Independent – Some help**	ns		1.00 (ref)	
	Full Help – By Others			1.43	1.26-1.61
Vision	**Adequate-Impaired**	ns		1.00 (ref)	
	Moderately – Severely Impaired			1.27	1.09-1.49
Bowel incontinence	**Continent – Usually Continent**	ns		1.00 (ref)	
	Occasionally Incontinent – Incontinent			1.41	1.17-1.69

ns = Non-significant at the 0.05 probability level

4.3.4 Survival Rates

Figures 4.4-4.9 illustrate the survival rates for clients by ERL designation as well as for the VPR algorithm. The clients with an ERL code 1 have a lower survival rate than clients with other ERL designations. This difference is more notable in the HNHB dataset.

When collapsing the ERL codes 1 and 2 into a single group, the difference between this combined group and the ERL 3 to 5 group (collapsed into a single group) is still substantial. The ERL designation appears to be predictive of survival rate. The Log-Rank test shows a statistically significant difference between ERL 1/2 and ERL 3-5. (X^2=673.17 (HNHB) resp. X^2=45.00 (TC); DF 1; $p<.0001$).

The VPR survival rates are included in Figures 4.8 and 4.9 which shows, consistent with chapter 3, that the VPR is predictive of survival rate in both CCACs.

Tables 4.13 and 4.14 show the Cox proportional hazards ratios with risk groups, age, gender, marital status, CHESS and Living Status. All hazards ratios illustrate that the clients with a higher ERL designation are more likely to die than clients with a lower ERL code.

For comparison the hazards ratios for the VPR and VPR Plus were calculated as well. Tables 4.13 and 4.14 show that the VPR and VPR Plus are predictive of mortality. However, the ERL codes seem to be more predictive than the VPR in the HNHB CCAC. In the TC dataset the VPR seems to be equally predictive.

Table 4.13: Cox proportional hazards ratios from multivariate survival models for mortality with risk level, age, gender, marital status, CHESS and living status in the HNHB CCAC, 2003 - 2015 (N=67,256)

	All ERLs	**ERL 1-2**	**VPR**	**VPR Plus**
ERLs (ref=5)			-	-
ERL 1 vs 5	2.52 (2.23 – 2.85)			
ERL 2 vs 5	2.25 (2.07 – 2.46)			
ERL 3 vs 5	1.35 (1.26 – 1.44)	-		
ERL 4 vs 5	0.99 (0.92 – 1.07) [ns]			
ERL Groups (ref=3-5)			-	-
ERL 1-2 vs 3-5	-	2.05 (1.92 – 2.19)		
Risk Level (ref=low)				
Medium			1.26 (1.16 – 1.37)	1.22 (1.10 – 1.35)
High	-	-	1.12 (1.05 – 1.20)	1.46 (1.38 – 1.55)
Age (ref= 18-64)				
65-74	1.34 (1.22 – 1.47)	1.35 (1.23 – 1.48)	1.33 (1.21 – 1.45)	1.33 (1.21 – 1.46)
75-84	1.24 (1.15 – 1.35)	1.24 (1.14 – 1.35)	1.19 (1.10 – 1.29)	1.21 (1.12 – 1.31)
85+	1.54 (1.42 – 1.67)	1.54 (1.42 – 1.66)	1.46 (1.34 – 1.58)	1.49 (1.38 – 1.61)
Gender (ref=female)				
Male	1.55 (1.48 – 1.63)	1.56 (1.48 – 1.62)	1.57 (1.49 – 1.65)	1.54 (1.47 – 1.62)
Marital status (ref=Not married)				
Married	**	**	**	**
CHESS (ref=0)				
CHESS 1	1.46 (1.33 – 1.60)	1.48 (1.35 – 1.63)	1.49 (1.36 – 1.63)	1.46 (1.34 – 1.61)
CHESS 2	2.05 (1.87 – 2.24)	2.10 (1.92 – 2.30)	2.12 (1.94 – 2.31)	2.04 (1.86 – 2.23)
CHESS 3	3.47 (3.17 – 3.79)	3.59 (3.28 – 3.93)	3.49 (3.18 – 3.84)	3.20 (2.91 – 3.51)
CHESS 4 – 5	5.90 (5.29 – 6.60)	6.19 (5.54 – 6.91)	6.04 (5.36 – 6.79)	5.31 (4.73 – 5.96)
Living Status (ref=not living alone)				
Living alone	0.83 (0.79 – 0.88)	0.84 (0.79 – 0.88)	0.87 (0.82 – 0.92)	0.87 (0.82-0.92)

[ns] = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

Table 4.14: Cox proportional hazards ratios from multivariate survival models for mortality with risk level, age, gender, marital status, CHESS and living status in the TC CCAC, 2003 - 2015 (N=4,147)

	All ERLs	ERL 1-2	VPR	VPR Plus
ERLs (ref=5)				
ERL 1 vs 5	3.62 (1.76 – 7.44)			
ERL 2 vs 5	2.88 (1.48 – 5.59)			
ERL 3 vs 5	2.18 (1.15 – 4,12)	-		
ERL 4 vs 5	1.27 (0.66 – 2.44) ns		-	-
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	-	1.94 (1.44 – 2.61)	-	-
Risk Level (ref=low)				
Medium			1.59 (1.01 – 2.50)	1.50 (0.90 – 2.49) ns
High	-	-	2.32 (1.62 – 3.31)	2.09 (1.52 – 2.88)
Age (ref= 18-64)				
65-74	0.81 (0.46 – 1.46) ns	0.82 (0.46 – 1.46) ns	0.75 (0.42 – 1.35) ns	0.78 (0.44 – 1.40) ns
75-84	0.74 (0.45 – 1.21)	0.73 (0.45 – 1.46) ns	0.65 (0.39 – 1.07) ns	0.70 (0.43 – 1.15) ns
85+	1.19 (0.74 – 1.90)	1.19 (0.75 – 1.90) ns	1.07 (0.66 – 1.71) ns	1.17 (0.73 – 1.87)
Gender (ref=female)				
Male	1.56 (1.18 – 2.07)	1.57 (1.18 – 2.07)	1.59 (1.19 – 2.09)	1.58 (1.19 – 2.09)
Marital status (ref=Not married)				
Married	**	**	**	**
CHESS (ref=0)				
CHESS 1	1.88 (1.05 – 3.36)	1.91 (1.07 – 3.40)	1.90 (1.06 – 3.39)	1.91 (1.07 – 3.41)
CHESS 2	3.25 (1.85 – 5.71)	3,42 (1.95 – 6.00)	3.29 (1.88 – 5.78)	3.34 (1.90 – 5.86)
CHESS 3	5.03 (2.82 – 9.00)	5.24 (2.93 – 9.35)	4.17 (2.29 – 7.59)	4.51 (2.49 – 8.16)
CHESS 4 – 5	10.36 (5.22 – 20.58)	11.42 (5.76 – 22.64)	7.79 (3.82 – 15.91)	8.62 (4.27 – 17.40)
Living Status (ref=not living alone)				
Living alone	0.49 (0.33 – 0.71)	0.47 (0.32 – 0.69)	0.51 (0.34 – 0.75)	0.50 (0.34 – 0.74)

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

Figure 4.4: Kaplan-Maier Survival Curve for days to death by ERLs separately in the HNHB CCAC, 2003 – 2012

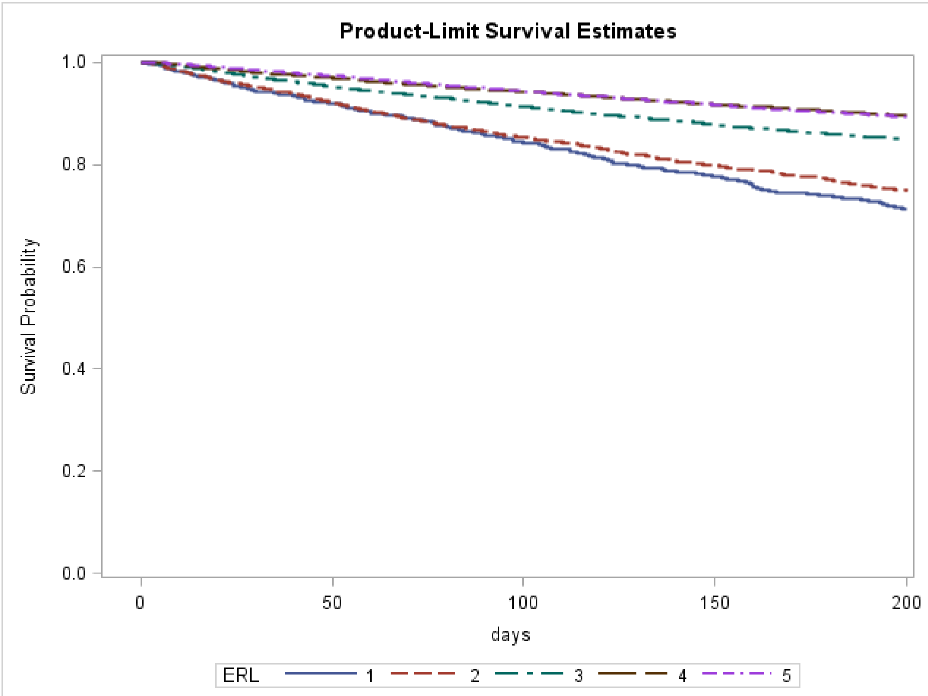


Figure 4.5: Kaplan-Maier Survival Curve for days to death by ERLs separately in the TC CCAC, 2012 – 2015

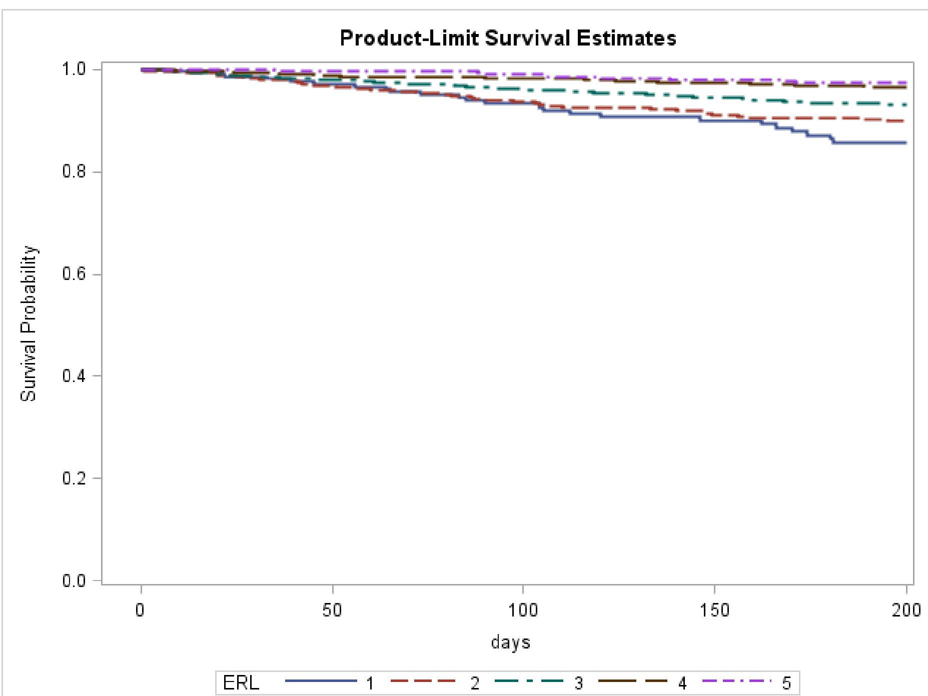


Figure 4.6: Kaplan-Maier Survival Curve for days to death by ERL designation ERL 1-2 and 3-5 in the HNHB CCAC, 2003 – 2015

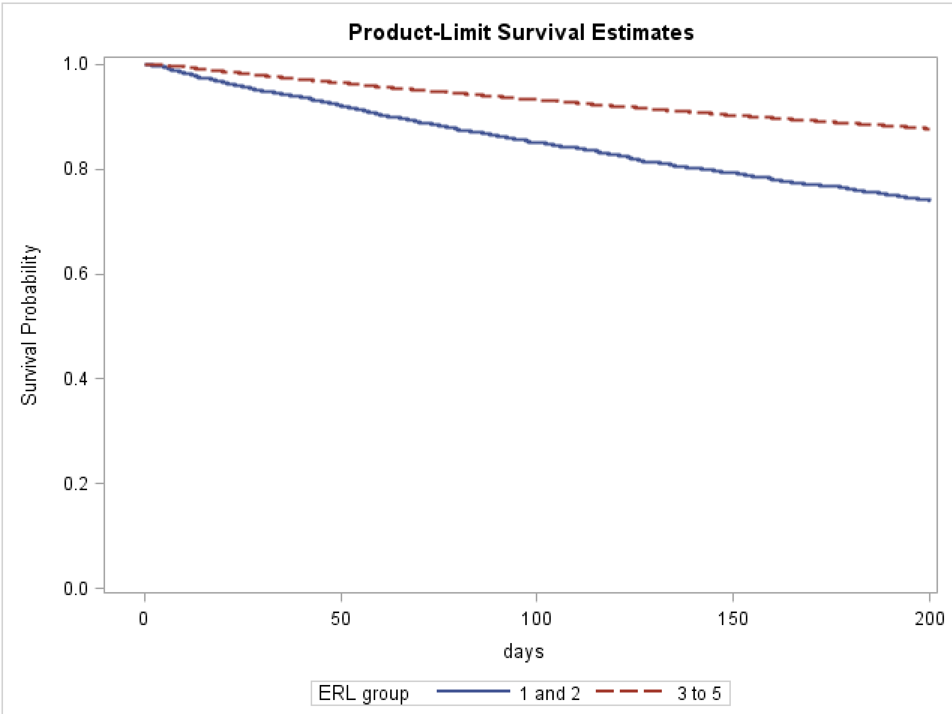


Figure 4.7: Kaplan-Maier Survival Curve for days to death by ERL designation ERL 1-2 and 3-5 in the TC CCAC, 2012 - 2015

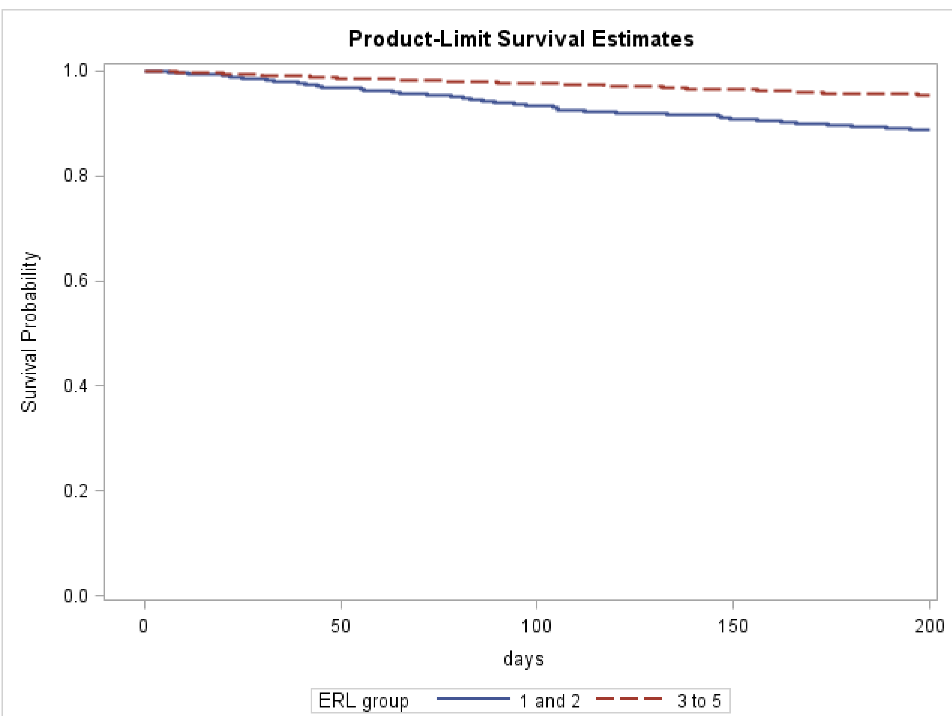


Figure 4.8: Kaplan-Maier Survival Curve for days to death by VPR in the HNHB CCAC, 2003 – 2015

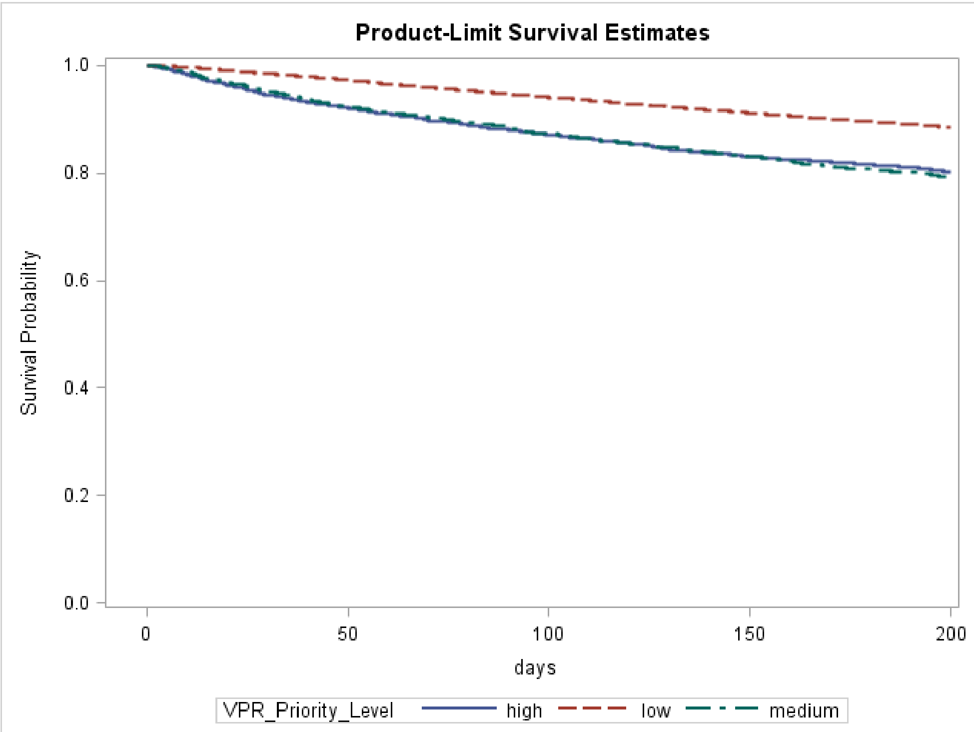
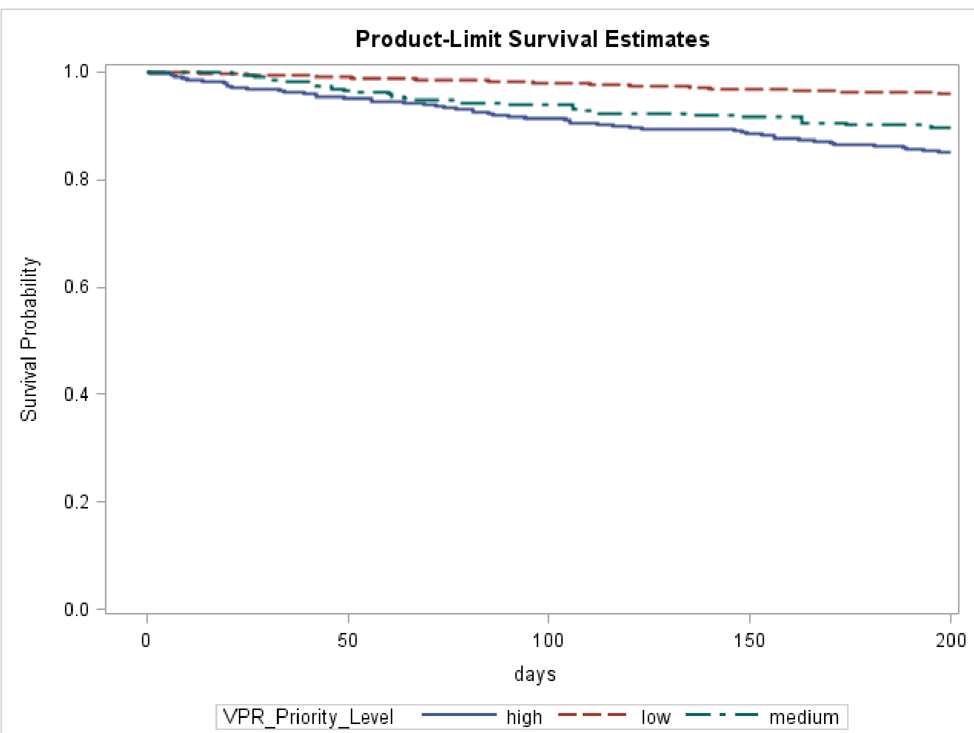


Figure 4.9: Kaplan-Maier Survival Curve for days to death by VPR in the TC CCAC, 2012 – 2015



4.3.5 LTC Admission Rate

Figures 4.10-4.15 show the long term care (LTC) admission rates for clients by ERL designation.

In both the HNHB and the TC CCAC dataset, the ERL 1 designation appears to be highly predictive of LTC admission. The difference between ERL 4 and 5 is in both CCACs negligible.

When combining the ERL 1 and 2 codes into a single group the designation remains highly predictive, although the differences are smaller within the TC CCAC dataset. The Log-Rank test shows again a statistically significant difference between the two groups (X^2= 2950.02 (HNHB) resp. X^2=59.27 (TC); DF 1; p<.0.001).

Table 4.15 represents the Cox proportional hazards ratios for the higher ERL versus the lower ERL when adjusting for age, gender, marital status, MAPLe and living status in the HNHB CCAC. The clients with an ERL 1 are much more likely to be admitted to LTC than the clients with an ERL of 5.

When applying the VPR and VPR Plus to the HNHB dataset table 4.15 as well as figures 4.14 and 4.15 (VPR only) show that these decision support algorithms are also predictive of LTC admission.

The number of LTC admissions (93 of 4,218 clients) in the TC CCAC dataset was too small to run Cox proportional hazards ratios and was therefore omitted.

Table 4.15: Cox proportional hazards ratios for LTC admission with risk level, age, gender, marital status, MAPLe and living status in the HNHB CCAC, 2003 – 2015 (N=67,258)

	All ERLs	ERL 1-2	VPR	VPR Plus
ERLs (ref=5)			-	-
ERL 1 vs 5	8.20 (7.50 – 8.98)			
ERL 2 vs 5	3.50 (3.20 – 3.83)			
ERL 3 vs 5	1.73 (1.61 – 1.86)			
ERL 4 vs 5	1.03 (0.95 – 1.12) ns	-		
ERL Groups (ref=3-5)			-	-
ERL 1-2 vs 3-5	-	3.84 (3.63 – 4.06)		
Risk Level (ref=low)				
Medium			2.10 (1.93 – 2.26)	1.87 (1.70 – 2.06)
High	-	-	2.96 (2.79 – 3.14)	2.63 (2.49 – 2.78)
Age (ref= 18-64)				
65-74	3.44 (2.88 – 4.12)	3.54 (2.96 – 4.23)	3.41 (2.85 – 4.09)	3.54 (2.96 – 4.24)
75-84	5.44 (4.62 – 6.41)	5.53 (4.70 – 6.51)	5.13 (4.36 – 6.04)	5.63 (4.78 – 6.63)
85+	7.33 (6.24 – 8.61)	7.47 (6.35 – 8.77)	6.65 (5.66 – 7.81)	7.50 (6.39 – 8.82)
Gender (ref=female)				
Male	0.88 (0.83 – 0.93)	0.89 (0.84 – 0.94)	0.88 (0.83 – 0.93)	0.87 (0.82 – 0.92)
Marital status (ref=not married)				
Married	0.72 (0.67 – 0.76)	0.73 (0.69 – 0.77)	0.68 (0.64 – 0.73)	0.71 (0.67 – 0.76)
MAPLe (ref=1and 2)				
MAPLe 3	4.42 (3.80 – 5.15)	4.69 (4.03 – 5.45)	3.87 (3.32 – 4.51)	3.90 (3.35 – 4.55)
MAPLe 4	9.07 (7.83 – 10.51)	9.52 (8.22 – 11.03)	6.82 (5.87 – 7.92)	7.72 (6.65 – 8.96)
MAPLe 5	15.68 (13.50 – 18.20)	16.88 (14.55 – 19.58)	10.48 (9.00 – 12.22)	12.51 (10.75 – 14.56)
Living Status (ref=not living alone)				
Living alone	0.93 (0.88 – 0.99)	**	**	1.07 (1.01 – 1.14)

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

Figure 4.10: Kaplan-Maier Survival Curve for days to LTC admission by ERLs separately in the HNHB CCAC, 2003 - 2015

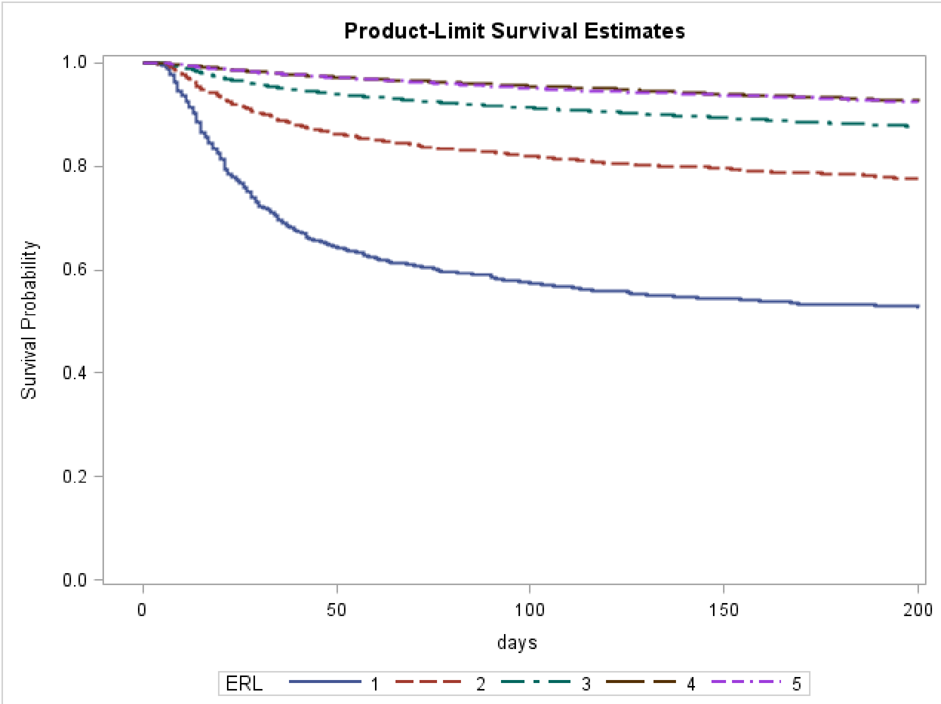


Figure 4.11: Figure 4.10: Kaplan-Maier Survival Curve for days to LTC admission by ERLs separately in the TC CCAC, 2012 - 2015

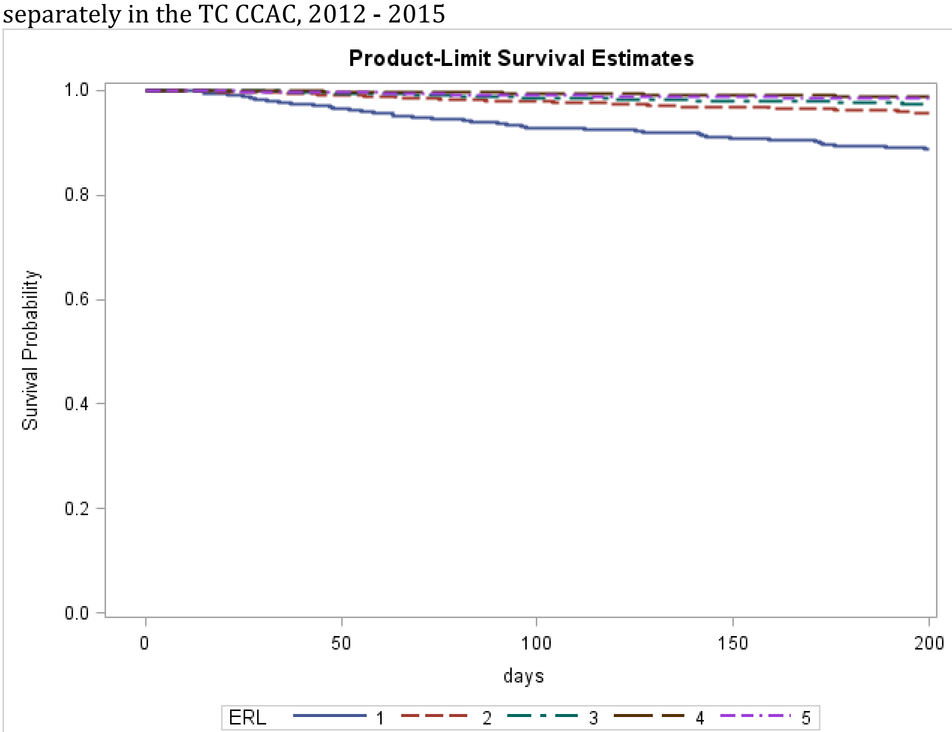


Figure 4.12: Figure 4.10: Kaplan-Maier Survival Curve for days to LTC admission by ERL 1-2 versus 3-4 and 5 in the HNHB CCAC, 2003 - 2015

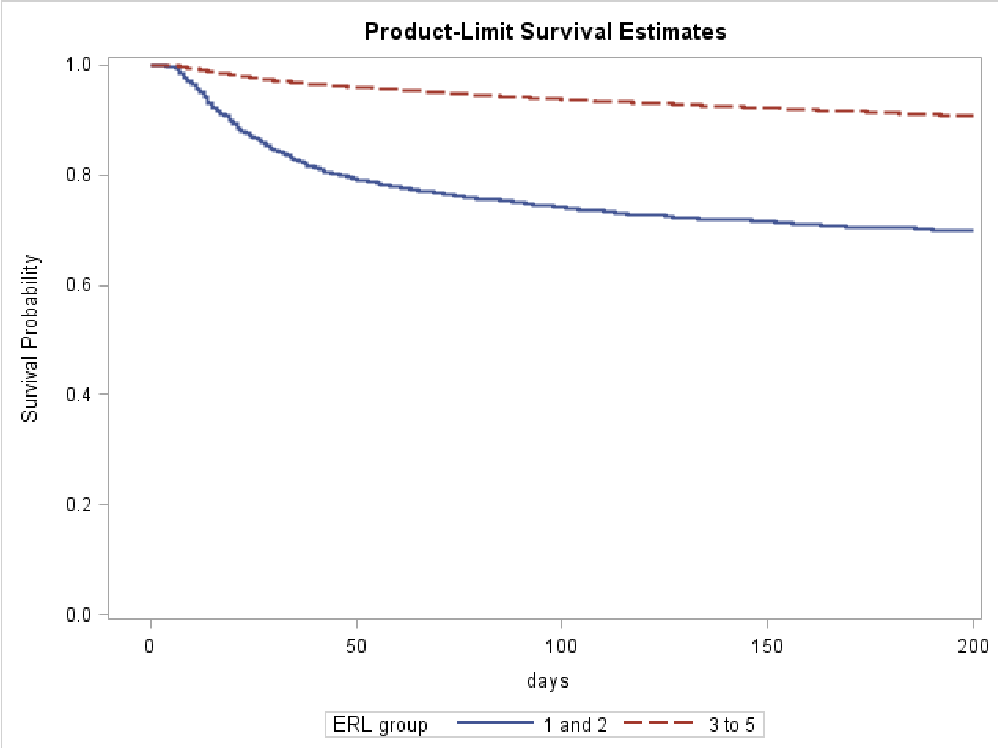


Figure 4.13: Kaplan-Maier Survival Curve for days to LTC admission by ERL 1-2 versus 3-4 and 5 in the TC CCAC, 2012 - 2015

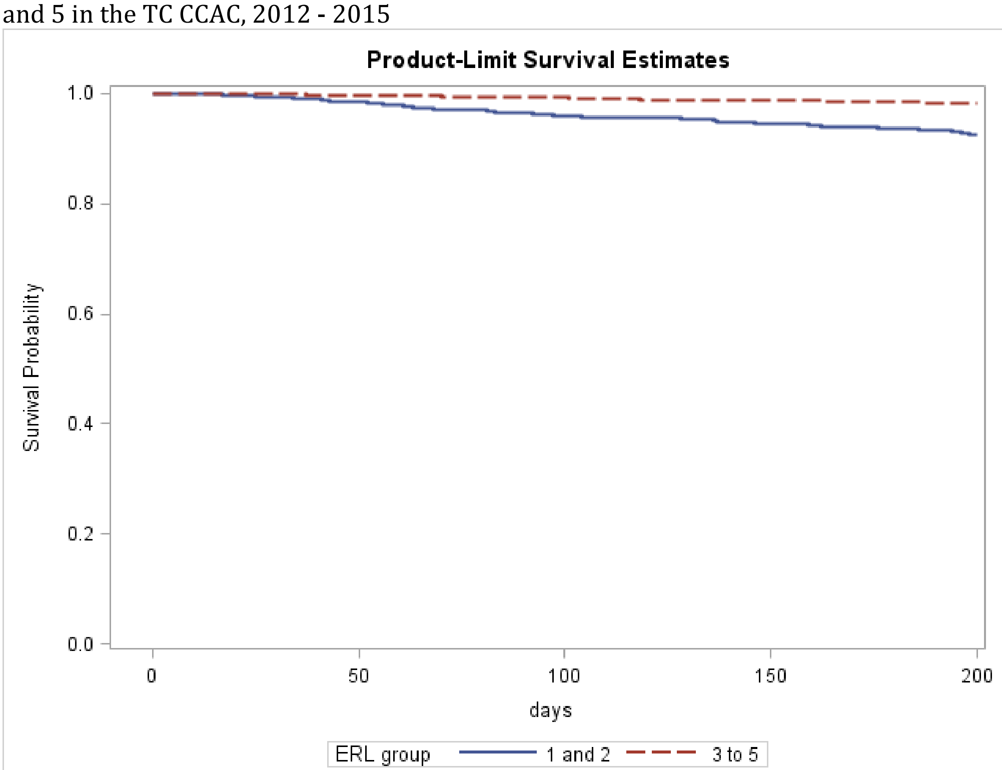


Figure 4.14: Kaplan-Maier Survival Curve for days to LTC admission by VPR in the HNHB CCAC, 2003 - 2015

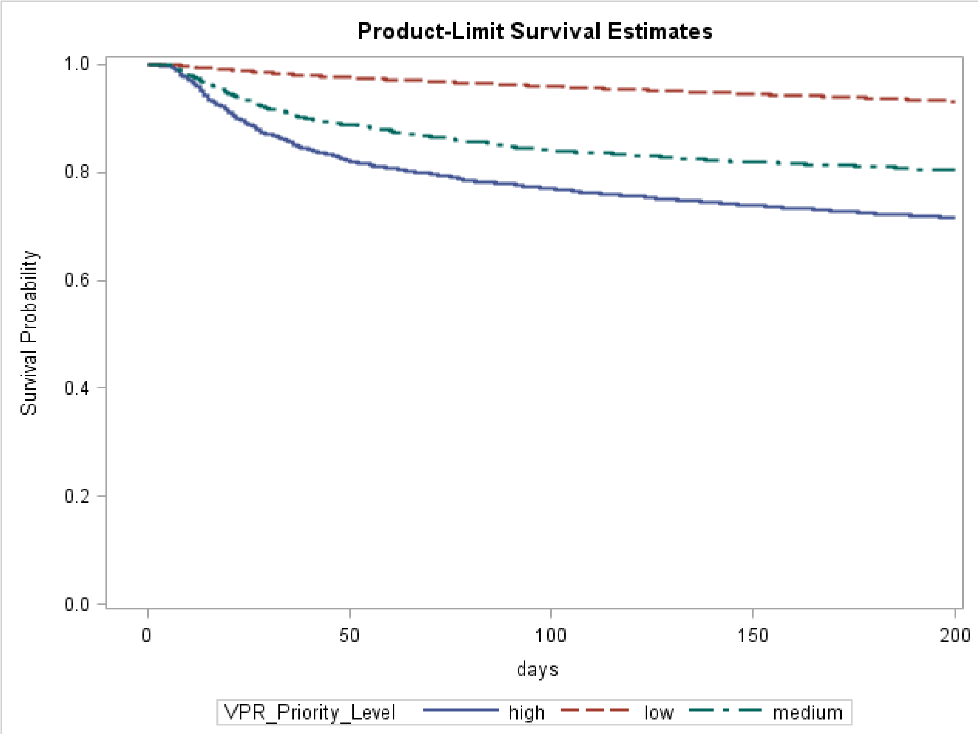
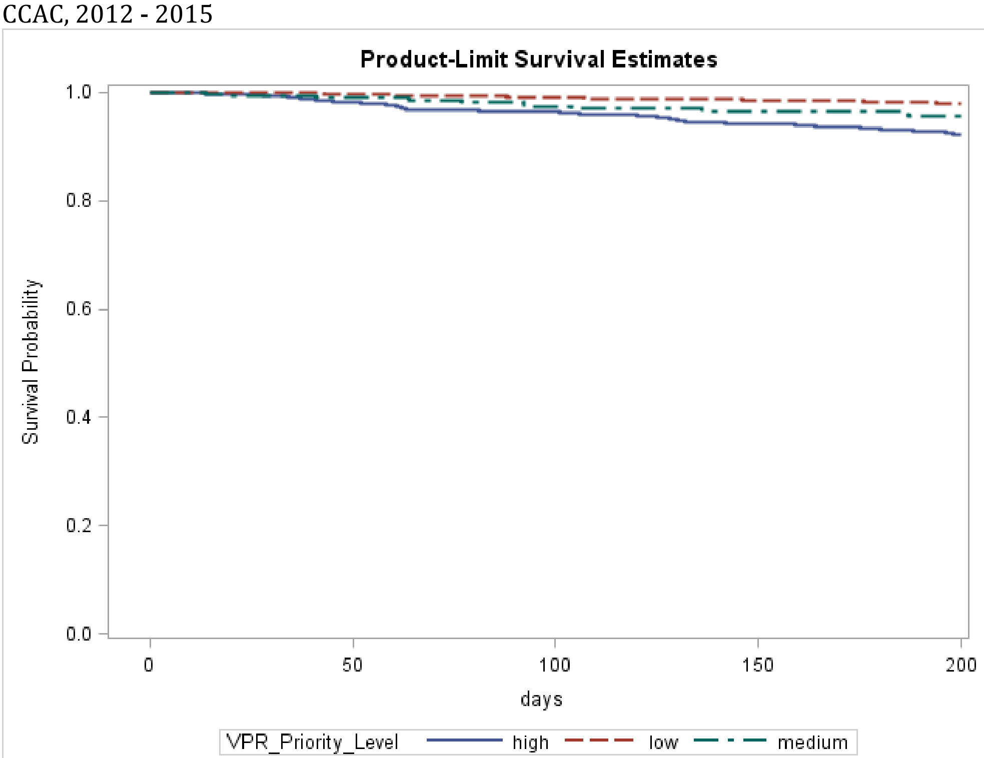


Figure 4.15: Kaplan-Maier Survival Curve for days to LTC admission by VPR in the TC CCAC, 2012 - 2015



4.3.6 Hospitalization Rate

Figures 4.16-4.21 illustrate the hospitalization rates for clients by ERL designation. The difference between the groups is clearest when combining the ERL 1 and 2 and comparing this group with the group ERL 3-5. For the HNHB CCAC the differences in hospitalization rates appear to be small between ERL 1 and 2 and ERL 3 to 5. The differences between rates are clearer when comparing rates in the TC CCAC. The differences between the group ERL 1/2 and ERL 3-5 are statistically significant in both CCACs as illustrated by the Log-Rank test (X^2=18.53 (HNHB) resp. X^2=26.76 (TC); DF 1; p<.0.001).

Table 4.16 and 4.17 show the Cox proportional hazards ratios for risk groups when adjusting for age, gender, marital status, CHESS and living status for both CCACs. When comparing ERL 1 with ERL 5 in the HNHB CCAC the results are non-significant. The hazards ratio is however significant for the ERL 1/2 group, compared to ERL 3 – 5. (1.17). In the TC CCAC these groups are 1.97 respectively 1.62 times more likely of being hospitalized as compared to clients with an ERL of 5.

The VPR and VPR Plus are not significant in both CCACs.

Table 4.16: Cox proportional hazards ratios for hospitalization with risk level, age, gender, marital status, CHESS and living status in the HNHB CCAC, 2003 – 2015 (N=67,256)

	All ERLs	**ERL 1-2**	**VPR**	**VPR Plus**
ERLs (ref=5)			-	-
ERL 1 vs 5	1.10 (0.95 – 1.28) ns			
ERL 2 vs 5	0.95 (0.86 – 1.05) ns			
ERL 3 vs 5	0.82 (0.77 - 0.86)			
ERL 4 vs 5	0.73 (0.69 – 0.78)	-		
ERL Groups (ref=3-5)			-	-
ERL 1-2 vs 3-5	-	1.17 (1.08 – 1.27)		
Risk Level (ref=low)				
Medium			0.99 (0.91 – 1.07) ns	1.04 (0.94 – 1.14) ns
High	-	-	1.12 (1.05 – 1.20)	1.10 (1.05 – 1.16)
Age (ref= 18-64)				
65-74	1.62 (1.48 – 1.77)	1.62 (1.47 – 1.77)	1.61 (1.47 – 1.76)	1.61 (1.47 – 1.77)
75-84	1.93 (1.78 – 2.09)	1.93 (1.79 – 2.10)	1.91 (1.77 – 2.07)	1.93 (1.79 – 2.09)
85+	1.87 (1.73 – 2.02)	1.87 (1.73 – 2.03)	1.85 (1.71 – 2.00)	1.87 (1.73 – 2.02)
Gender (ref=female)				
Male	1.28 (1.22 – 1.34)	1.28 (1.22 – 1.34)	1.28 (1.22 – 1.34)	1.27 (1.22 – 1.33)
Marital status (ref=Not married)				
Married	**	**	**	**
CHESS (ref=0)				
CHESS 1	1.17 (1.10 – 1.25)	1.16 (1.09 – 1.24)	1.16 (1.08 – 1.24)	1.16 (1.08 – 1.24)
CHESS 2	1.25 (1.17 – 1.34)	1.24 (1.15 – 1.32)	1.23 (1.15 – 1.32)	1.23 (1.14 – 1.31)
CHESS 3	1.64 (1.52 – 1.77)	1.61 (1.50 – 1.74)	1.57 (1.45 – 1.70)	1.56 (1.45 - 1.69)
CHESS 4 – 5	2.13 (1.90 – 2.39)	2.12 (1.89 – 2.38)	2.01 (1.78 – 2.28)	2.02 (1.79 – 2.28)
Living Status (ref=not living alone)				
Living alone	**	**	**	**

ns = Non-significant at the 0.05 probability level
** Non-significant at the 0.05 probability level and removed from the model

Table 4.17: Cox proportional hazards ratios for hospitalization with risk level, age, gender, marital status, CHESS and living status in the TC CCAC, 2012 – 2015 (N=4,147)

	All ERLs	ERL 1-2	VPR	VPR Plus
ERLs (ref=5)				
ERL 1 vs 5	1.97 (1.11 – 3.49)			
ERL 2 vs 5	2.41 (1.52 – 3.81)			
ERL 3 vs 5	1.76 (1.14 – 2.72)			
ERL 4 vs 5	1.26 (0.82 – 1.95) ns	-	-	-
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	-	1.62 (1.27 – 2.06)	-	-
Risk Level (ref=low)				
Medium			1.16 (0.79 – 1.70) ns	1.15 (0.74 – 1.78) ns
High	-	-	1.16 (0.79 – 1.70) ns	1.42 (1.09 – 1.84) ns
Age (ref= 18-64)				
65-74	0.96 (0.64 – 1.43) ns	0.94 (0.63 – 1.41) ns	0.93 (0.62 – 1.39) ns	0.93 (0.62 – 1.40) ns
75-84	0.81 (0.57 – 1.14) ns	0.79 (0.56 – 1.12) ns	0.78 (0.55 – 1.10) ns	0.79 (0.56 – 1.12) ns
85+	0.85 (0.60 – 1.19) ns	0.83 (0.59 – 1.17) ns	0.82 (0.58 – 1.15) ns	0.84 (0.60 – 1.18) ns
Gender (ref=female)				
Male	1.27 (1.01 – 1.61)	1.29 (1.02 – 1.62)	1.32 (1.05 – 1.66)	1.30 (1.03 – 1.64)
Marital status (ref=Not married)				
Married	0.71 (0.55 – 0.92)	0.71 (0.55 – 0.92)	0.70 (0.54 – 0.91)	0.71 (0.55 – 0.91)
CHESS (ref=0)				
CHESS 1	0.97 (0.71 – 1.33) ns	0.98 (0.71 – 1.34) ns	0.97 (0.71 – 1.33) ns	0.97 (0.71 – 1.34) ns
CHESS 2	1.15 (0.83 – 1.59) ns	1.18 (0.85 – 1.63) ns	1.18 (0.85 – 1.63) ns	1.17 (0.85 – 1.63) ns
CHESS 3	1.78 (1.25 – 2.53)	1.81 (1.27 – 2.47)	1.78 (1.23 – 2.57)	1.73 (1.21 – 2.49)
CHESS 4 – 5	2.46 (1.41 – 4.30)	2.63 (1.51 – 4.58)	2.51 (1.40 – 4.51)	2.38 (1.34 – 4.21)
Living Status (ref=not living alone)				
Living alone	0.59 (0.45 – 0.78)	0.58 (0.44 – 0.76)	0.57 (0.43 – 0.76)	0.59 (0.44 – 0.78)

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

Figure 4.16: Kaplan-Maier Survival Curve for days to hospitalization by ERLs separately in the HNHB CCAC, 2003 - 2015

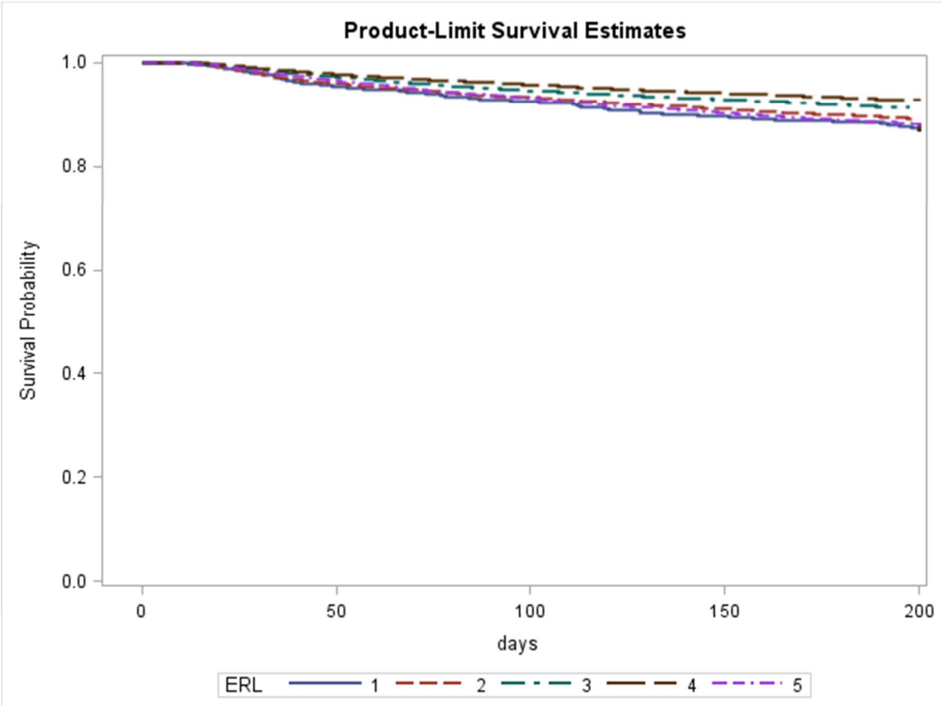


Figure 4.17: Kaplan-Maier Survival Curve for days to hospitalization by ERLs separately in the TC CCAC, 2012 - 2015

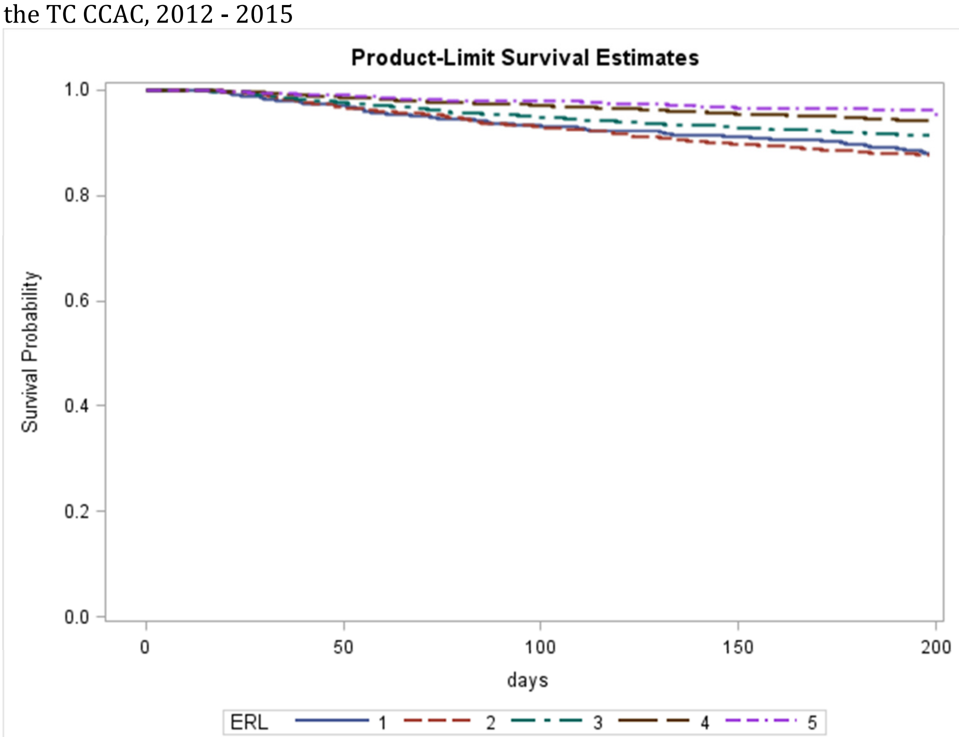


Figure 4.18: Kaplan-Maier Survival Curve for days to hospitalization by ERL 1-2 and 3-5 in the HNHB CCAC, 2003 - 2015

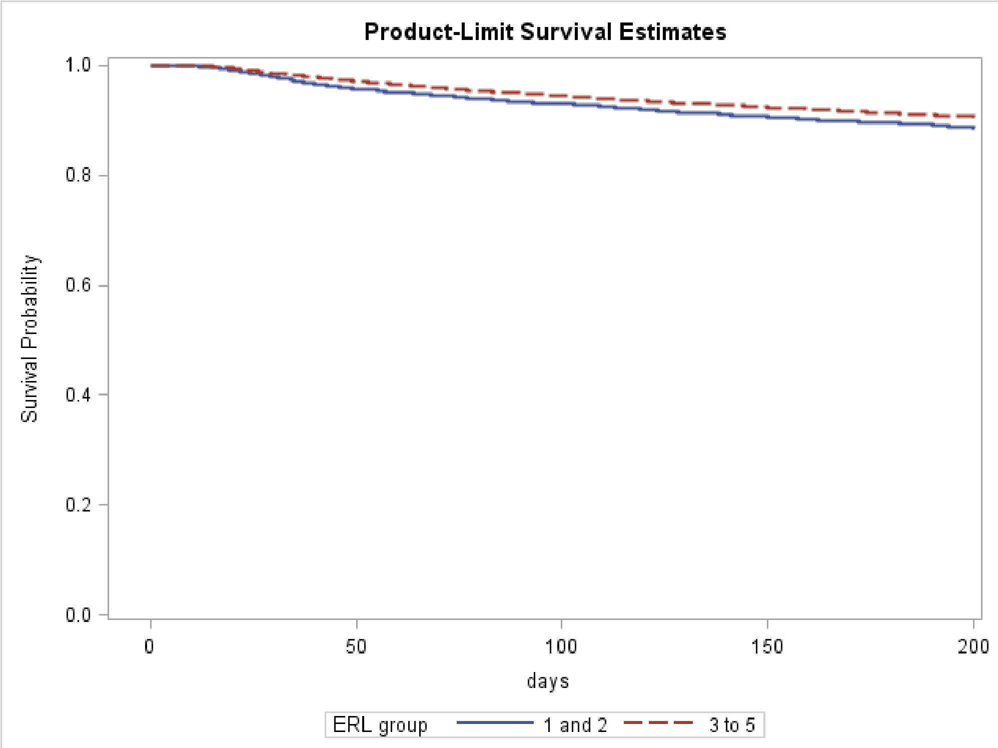


Figure 4.19: Kaplan-Maier Survival Curve for days to hospitalization by ERL 1-2 and 3-5 in the TC CCAC, 2012 - 2015

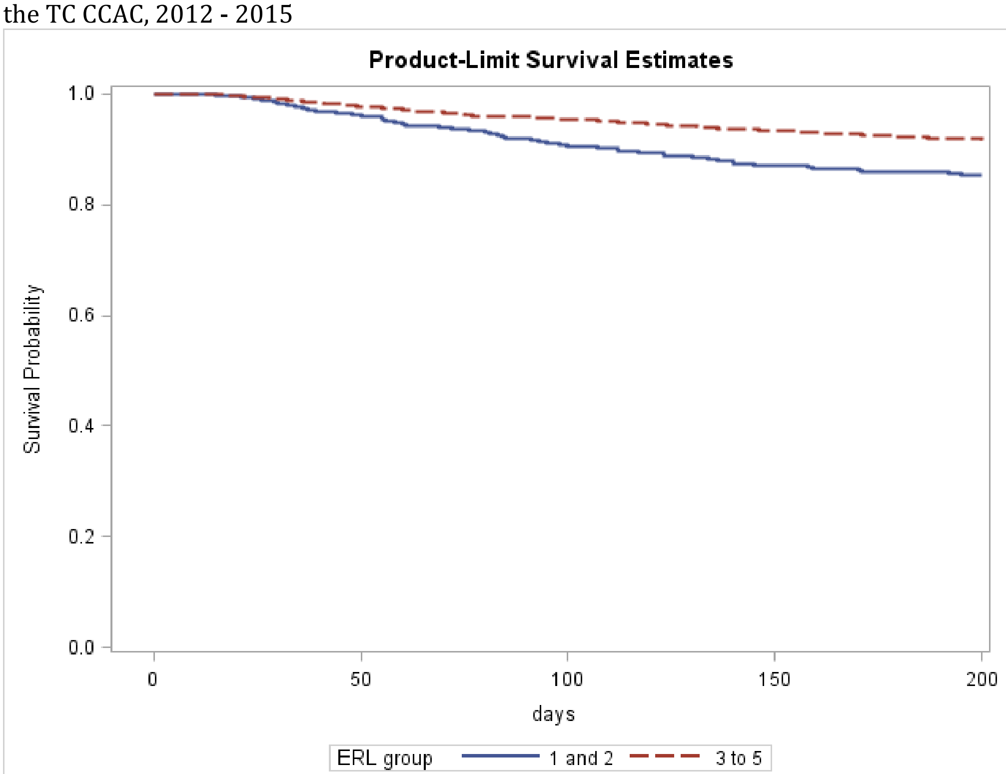


Figure 4.20: Kaplan-Maier Survival Curve for days to hospitalization by VPR in the HBHB CCAC, 2003 - 2015

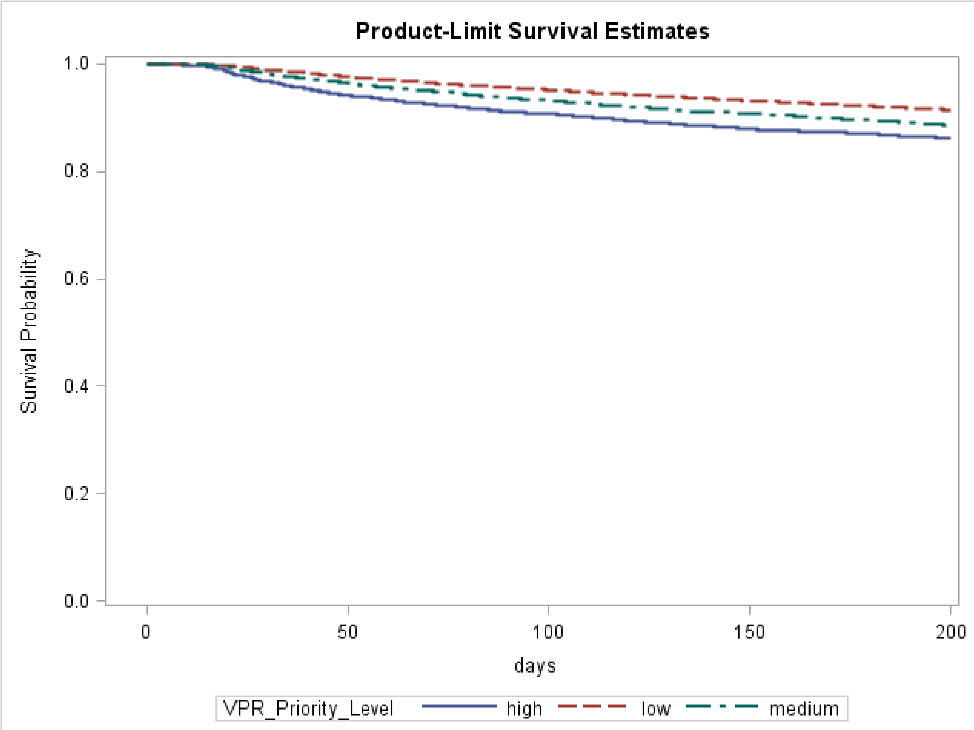
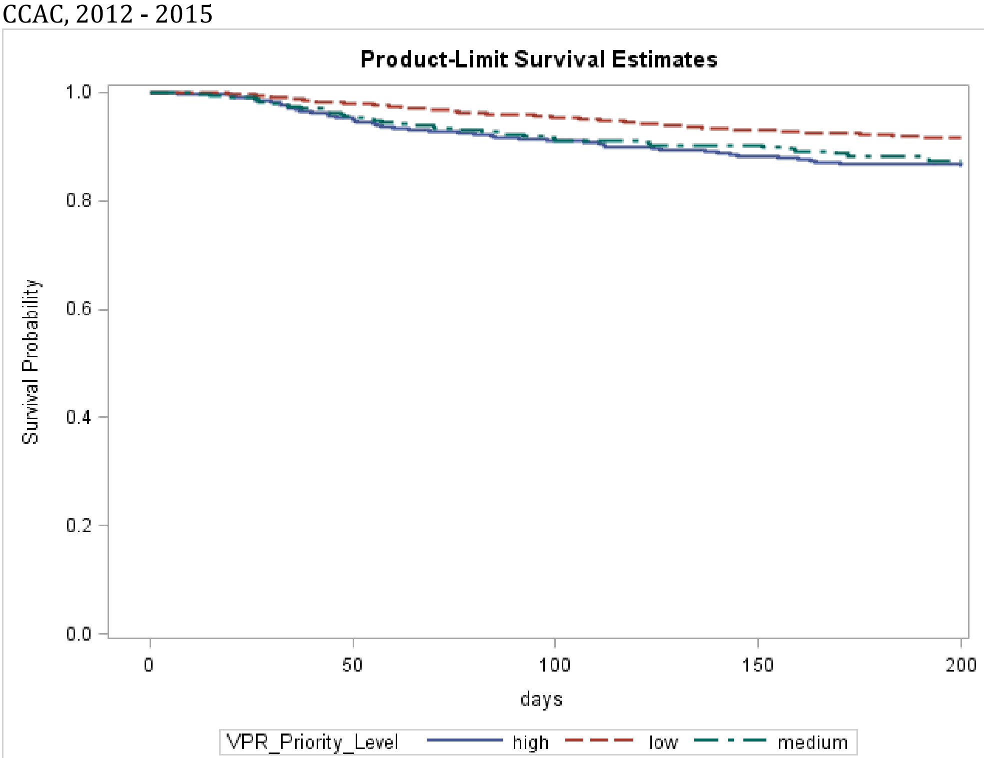


Figure 4.21: Kaplan-Maier Survival Curve for days to hospitalization by VPR in the TC CCAC, 2012 - 2015



4.3.7 VPR vs ERL Models

In the previous chapter, chapter 3, four different decision support algorithms were examined. The VPR appeared to be highly predictive of survival, LTC admission as well as hospitalization. Logistic modeling was used to assess which RAI-HC items were predictive of ERL designation. This resulted in two different models for the HNHB CCAC and TC CCAC. In Table 4.18, all RAI-HC items that are in one of the models are included to assess which items are used in all models.

The ADL Hierarchy Scale was used in all three models. Items that were used in the VPR but were not found to be predictive of ERL designation in the HNHB and TC CCAC include: CPS, locomotion, toilet use, social isolation items ('living alone', 'is always alone', 'shows withdrawal from activities' and 'has reduced social interaction') as well as the caregiver items ('a caregiver is unable to continue care activities' and 'primary caregiver is not satisfied with support received from family or friends').

Being dependent on a wheelchair and requiring dialysis were predictive of ERL 1 or 2 designations in both the HNHB as the TC CCAC. Oxygen use was only predictive in the HNHB CCAC.

Pressure ulcers, bathing and bowel incontinence were predictive of ERL 1 or 2 designations in the TC CCAC with pressure ulcers also being predictive in the HNHB CCAC. These are the only items that are not included in the VPR or VPR Plus.

Table 4.18: RAI-HC items included in the three risk algorithms

Variable	HNHB ERL	TC ERL	VPR
CPS	No	No	Yes
CHESS	Yes	No	Yes
Vision	No	Yes	Yes
ADL Hierarchy	Yes	Yes	Yes
Transfer	Yes	No	Yes
Locomotion	No	No	Yes
Toilet use	No	No	Yes
Meal Preparation	No	Yes	Yes
Managing Medication	No	Yes	Yes
Lives alone	No	No	Yes
Is always alone	No	No	Yes
Primary helper available	Yes	No	Yes
Shows withdrawal from activities	No	No	Yes
Has reduced social interaction	No	No	Yes
A caregiver is unable to continue caring activities	No	No	Yes
Primary caregiver is not satisfied with support received from family or friends	No	No	Yes
Caregiver expresses feelings of distress, anger or depression	No	Yes	Yes
Wheelchair	Yes	Yes	In VPR Plus
Dialysis	Yes	Yes	In VPR Plus
Oxygen	Yes	No	In VPR Plus
Pressure ulcer	Yes	Yes	No
Bathing	No	Yes	No
Bowel incontinence	No	Yes	No

Table 4.19 and 4.20 list the distribution of clients with an ERL designation of 1 or 2 and a designation of 3 to 5 by VPR and VPR Plus level. The tables show that there is a large proportion of clients with an ERL 1 or 2 that would receive a low priority VPR (55.8/56.2%) or VPR Plus (41.0/47.8%) designation, contrary to the expectation. However, there is larger proportion of ERL 1 or 2 clients that received a high priority designation based on the VPR Plus algorithm in the HNHB CCAC. The percentage of clients with an ERL 1 or 2 designation receiving a high priority status increases considerably when comparing the VPR Plus with the VPR in the TC CCAC.

Table 4.19: Distribution of VPR designations by ERL 1 or 2 and ERL3-5 in the HNHB (2003 – 2015; N=70,292) and TC CCACs (2012 – 2015; N=8,996)

	HNHB		**TC**	
	ERL 1 or 2 n= 6,574	**ERL 3-5 n=63,718**	**ERL 1 or 2 N=1,986**	**ERL 3-5 N=7,010**
VPR 0	55.8 (3,666)	77.8 (49,572)	56.2 (1,116)	81.8 (5,732)
VPR 1	12.1 (793)	7.4 (4,5742)	14.5 (288)	6.9 (482)
VPR 2	32.3 (2,115)	14.9 (9,404)	29.3 (582)	11.4 (796)

Table 4.20: Distribution of VPR Plus designation by ERL 1 or 2 and ERL3-5 in the HNHB and TC CCACs (2003 – 2015; N=70,292) and TC CCACs (2012 – 2015; N=8,996)

	HNHB		**TC**	
	ERL 1 or 2 n= 6,574	**ERL 3-5 n=63,718**	**ERL 1 or 2 N=1,988**	**ERL 3-5 N=8,145**
VPR Plus 0	41.0 (2,694)	69.4 (44,227)	47.8 (949)	75.3 (5,278)
VPR Plus 1	7.0 (460)	5.3 (3,354)	10.2 (203)	5.4 (378)
VPR Plus 2	52.0 (3,420)	25.3 (16,718)	42.0 (834)	19.3 (1,354)

Table 4.21 illustrates the odds ratios for ERL 1 or 2 designation by priority clients based on each of the four algorithms. The VPR and VPR plus are highly predictive of ERL designation. Clients assigned a high priority level based on the VPR are over 3 times more likely to be assigned an ERL code of 1 or 2 in both the HNHB as the TC CCAC.

Table 4.21: Odds ratios for ERL designation 1 or 2 versus ERL 3 to 5 by priority clients as selected by four decision support algorithms for HNHB (2003 – 2015, N=70,292) and TC CCAC (2012 – 2015, N=8,996)

	HNHB		TC CCAC	
Priority Clients	**ERL=1 or 2**	**95% CI**	**ERL=1 or 2**	**95% CI**
University of Waterloo Algorithm	1.27	1.20 – 1.34	1.55	1.37 – 1.76
New Zealand Algorithm	1.73	1.65 – 1.82	2.12	1.89 – 2.37
VPR Medium	2.26	2.08 – 2.46	3.07	2.62 – 3.60
VPR High	3.04	2.87 – 3.22	3.76	3.32 – 4,25
VPR Plus Medium	2.25	2.03 – 2.50	2.99	2.49 – 3.59
VPR Plus 2 High	3.48	3.30 – 3.67	3.43	3.07 – 3.83

Table 4.22 shows the concordance statistic for different logistic regression models. For each CCAC each logistic model the statistic was calculated for two options. One option is where clients who were discharged were considered not to have died (died=0). The other option is where clients who were discharged were considered missing values. The table shows that models that include the VPR or VPR Plus are equally or more predictive of death than the models that only include the ERL. When including both the ERL as the VPR/VPR Plus the c-statistic does not improve substantially.

Table 4.23 – 4.29 list all the odds ratios for these various models.

Table 4.22: Concordance statistics (c-stat) for different logistic regression models predicting death where discharged clients are considered not to have died and where discharged clients are considered missing, by HNHB and TC CCAC

	HNHB		TC CCAC	
	Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
	N=67,258	N = 37,475	N=4,218	N=2,924
Age – Gender – ERL	0.60	0.62	0.65	0.66
Age – Gender – VPR	0.61	0.63	0.70	0.71
Age – Gender – VPR Plus	0.62	0.64	0.69	0.70
Age – Gender – VPR- ERL	0.62	0.65	0.71	0.72
Age – Gender – VPR Plus – ERL	0.63	0.66	0.70	0.72
	N=67,256	N = 37,474	N=4,147	N=2,853
Age – Gender – CHESS – ERL	0.66	0.69	0.72	0.74
Age – Gender – CHESS – VPR	0.66	0.69	0.73	0.75
Age – Gender – CHESS – VPR Plus	0.66	0.69	0.73	0.74
Age – Gender – CHESS – VPR – ERL	0.67	0.69	0.74	0.76
Age – Gender – CHESS – VPR Plus – ERL	0.67	0.70	0.74	0.75

Table 4.23: Logistic regression model for mortality adjusted for age and gender in the HNHB (N=67,258/36,475) and TC CCAC (N=4,218/2,924) for ERL, VPR and VPR Plus

		HNHB		TC	
		Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL	ERL Groups (ref=3-5) ERL 1-2 vs 3-5	2.03 (1.89 – 2.18)	2.68 (2.47 – 2.90)	2.27 (1.68 – 3.08)	2.65 (1.94 – 3.61)
	Age (ref= 18-64) 65-74 75-84 85+	1.44 (1.31 – 1.59) 1.34 (1.23 – 1.45) 1.63 (1.50 – 1.77)	1.55 (1.40 – 1.72) 1.43 (1.31 – 1.57) 1.81 (1.66 – 1.98)	1.07 (0.59 – 1.93) ns 0.95 (0.57 – 1.58) ns 1.76 (1.09 – 2,84)	1.01 (0.55 – 1.84) 0.81 (0.49 – 1.36) 1.41 (0.86 – 2.29)
	Gender (ref=female) Male	1.68 (1.59 – 1.77)	1.70 (1.61 – 1.80)	2.27 (1.68 – 3.08)	1.77 (1.32 – 2.37)
VPR	VPR Risk Level (ref=low) Medium High	1.87 (1.72 – 2.03) 1.60 (1.50 -1.70)	2.07 (1.90 – 2.26) 2.19 (2.04 – 2.34)	2.60 (1.66 – 4.06) 3.87 (2.78 – 5.38)	2.65 (1.68 – 4.19) 4.45 (3.17 – 6.24)
	Age (ref= 18-64) 65-74 75-84 85+	1.40 (1.27 – 1.54) 1.24 (1.14 – 1.35) 1.47 (1.35 – 1.60)	1.47 (1.33 – 1.63) 1.28 (1.17 – 1.40) 1.55 (1.42 – 1.70)	0.91 (0.50 – 1.66) ns 0.76 (0.46 – 1.27) ns 1.30 (0.80 – 2.12) ns	0.84 (0.46 – 1.55) ns 0.63 (0.38 – 1.06) ns 1.06 (0.64 – 1.74) ns
	Gender (ref=female) Male	1.64 (1.56 – 1.73)	1.65 (1.56 – 1.74)	1.75 (1.31 – 2.34)	1.76 (1.31 – 2.36)
VPR Plus	VPR Plus Risk Level (ref=low) Medium High	1.83 (1.65 – 2.03) 194 (1.84 – 2.05)	1.96 (1.76 – 2.19) 2.26 (2.14 – 2.40)	2.45 (1.48 – 4.07) 3.14 (2.32 – 4.27)	2.53 (1.51 – 4.24) 3.53 (2.58 – 4.82)
	Age (ref= 18-64) 65-74 75-84 85+	1.41 (1.28 – 1.55) 1.29 (1.18 – 1.40) 1.54 (1.42 – 1.68)	1.50 (1.36 – 1.66) 1.39 (1.27 – 1.52) 1.74 (1.59 – 1.90)	1.00 (0.55 – 1.81) ns 0.91 (0.55 – 1.51) ns 1.62 (1.00 – 2.63)	0.91 (0.49 – 1.66) ns 0.76 (0.45 – 1.28) ns 1.32 (0.80 – 2.16) ns
	Gender (ref=female) Male	1.62 (1.53 – 1.70)	1.62 (1.53 – 1.71)	1.74 (1.30 – 2.32)	1.76 (1.31 – 2.36)

ns = Non-significant at the 0.05 probability level

Table 4.24: Logistic regression model for mortality adjusted for age, CHESS and gender in the HNHB (N=67,256/36,474) and TC CCAC (N=4,147/ 2,853) for ERL and VPR

		HNHB		TC	
		Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL	ERL Groups (ref=3-5)				
	ERL 1-2 vs 3-5	1.75 (1.63 – 1.89)	2.42 (2.23 – 2.63)	1.89 (1.39 – 2.59)	2.20 (1.59 – 3.04)
	Age (ref= 18-64)				
	65-74	1.31 (1.19 – 1.44)	1.39 (1.25 – 1.54)	0.84 (0.46 – 1.54) ns	0.78 (0.42 – 1.45) ns
	75-84	1.18 (1.08 – 1.28)	1.25 (1.14 – 1.37)	0.80 (0.48 – 1.34) ns	0.71 (0.42 – 1.20) ns
	85+	1.40 (1.29 – 1.53)	1.56 (1.42 – 1.71)	1.43 (0.88 – 2.31)	1.13 (0.69 – 1.86) ns
	CHESS (ref=0)				
	1	1.42 (1.30 – 1.57)	1.58 (1.43 – 1.74)	1.82 (1.01 – 3.27)	1.91 (1.06 – 3.44)
	2	1.96 (1.78 – 2.15)	2.37 (2.15 – 2.60)	3.33 (1.88 – 5.90)	3.61 (2.03 – 6.41)
	3	3.31 (3.01 – 3.64)	4.36 (3.95 – 4.82)	5.00 (2.76 – 9.04)	6.01 (3.30 – 10.95)
	4-5	4.85 (4.30 – 5.47)	8.67 (7.56 – 9.95)	11.05 (5.34 – 22.90)	13.69 (6.41 – 29.27)
	Gender (ref=female)				
	Male	1.67 (1.58 – 1.76)	1.69 (1.60 – 1.79)	1.69 (1.26 – 2.26)	1.69 (1.25 – 2.28)
VPR	VPR Risk Level (ref=low)				
	Medium	1.30 (1.19 – 1.42)	1.42 (1.29 – 1.56)	1.80 (1.13 – 2.90)	1.76 (1.08 – 2.86)
	High	0.97 (0.90 – 1.04) ns	1.25 (1.15 – 1.35)	2.62 (1.81 – 3.81)	2.94 (2.00 – 4.31)
	Age (ref= 18-64)				
	65-74	1.30 (1.18 – 1.43)	1.34 (1.21 – 1.49)	0.77 (0.42 – 1.41) ns	0.69 (0.37 – 1.29) ns
	75-84	1.16 (1.07 – 1.27)	1.17 (1.07 – 1.29)	0.70 (0.42 – 1.18) ns	0.58 (0.34 – 0.99)
	85+	1.39 (1.27 – 1.51)	1.44 (1.32 – 1.58)	1.20 (0.73 – 1.96)	0.96 (0.58 – 1.59) ns
	CHESS (ref=0)				
	1	1.44 (1.31 – 1.58)	1.58 (1.44 – 1.75)	1.81 (1.00 – 3.25)	1.92 (1.07 – 3.47)
	2	2.00 (1.83 – 2.20)	2.36 (2.15 – 2.60)	3.19 (1.80 – 5.66)	3.51 (1.97 – 6.24)
	3	3.38 (3.06 – 3.73)	4.06 (3.66 – 4.49)	3.71 (2.01 – 6.86)	4.46 (2.40 – 8.30)
	4-5	5.20 (4.57 – 5.92)	7.83 (6.78 – 9.05)	7.00 (3.28 – 14.97)	8.89 (4.06 – 19.49)
	Gender (ref=female)				
	Male	1.66 (1.58 – 1.75)	1.69 (1.60 – 1.78)	1.70 (1.27 – 2.27)	1.69 (1.26 – 2.29)

ns = Non-significant at the 0.05 probability level

Table 4.25: Logistic regression model for mortality adjusted for age, CHESS and gender in the HNHB (N=67,256/36,474) and TC CCAC (N=4,147/ 2,853) for VPR Plus

		HNHB		TC	
		Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
VPR Plus	VPR Plus Risk Level (ref=low)				
	Medium	1.31 (1.18 – 1.46)	1.33 (1.19 – 1.49)	1.65 (0.97 – 2.81) ns	1.61 (0.93 – 2.78) ns
	High	1.41 (1.33 – 1.49)	1.58 (1.48 – 1.68)	2.28 (1.63 – 3.18)	2.54 (1.81 – 3.57)
	Age (ref= 18-64)				
	65-74	1.30 (1.18 – 1.43)	1.35 (1.22 – 1.50)	0.81 (0.44 – 1.48) ns	0.72 (0.39 – 1.35) ns
	75-84	1.16 (1.06 – 1.26)	1.21 (1.10 – 1.32)	0.78 (0.47 – 1.29) ns	0.65 (0.38 – 1.09) ns
	85+	1.38 (1.26 – 1.50)	1.50 (1.37 – 1.64)	1.36 (0.83 – 2.21) ns	1.08 (0.66 – 1.78) ns
	CHESS (ref=0)				
	1	1.41 (1.28 – 1.55)	1.56 (1.42 – 1.72)	1.83 (1.02 – 3.29)	1.94 (1.08 – 3.51)
	2	1.90 (1.73 – 2.09)	2.28 (2.07 – 2.51)	3.25 (1.83 – 5.75)	3.58 (2.01 – 6.36)
	3	2.96 (2.68 – 3.27)	3.79 (3.42 – 4.20)	4.09 (2.23 – 7.51)	4.97 (2.69 – 9.16)
	4-5	4.23 (3.73 – 4.79)	7.11 (6.18 – 8.19)	8.01 (3.80 – 16.89)	10.22 (4.72 – 22.12)
	Gender (ref=female)				
	Male	1.64 (1.55 – 1.72)	1.65 (1.56 – 1.75)	1.69 (1.26 – 2.26)	1.69 (1.25 – 2.28)

ns = Non-significant at the 0.05 probability level

Table 4.26: Logistic regression model for mortality adjusted for ERL group, VPR, age and gender in the HNHB (N=67,258/36,475) and TC CCAC (N=4,218/2,924)

	HNHB		TC	
	Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	1.85 (1.72 – 2.00)	2.49 (2.29 – 2.69)	1.71 (1.24 – 2.35)	1.93 (1.39 – 2.68)
VPR Risk Level (ref=low)				
Medium	1.78 (1.63 – 1.93)	1.99 (1.82 – 2.18)	2.29 (1.46 – 3.61)	2.32 (1.46 – 3.69)
High	1.47 (1.38 – 1.57)	2.07 (1.93 – 2.22)	3.39 (2.41 – 4.77)	3.75 (2.64 – 5.34)
Age (ref= 18-64)				
65-74	1.41 (1.28 – 1.56)	1.52 (1.37 – 1.69)	0.93 (0.51 – 1.70) ns	0.88 (0.48 – 1.62) ns
75-84	1.26 (1.16 – 1.38)	1.35 (1.23 – 1.48)	0.79 (0.47 – 1.31) ns	0.66 (0.39 – 1.11) ns
85+	1.48 (1.36 – 1.61)	1.64 (1.50 – 1.79)	1.33 (0.81 – 2.17) ns	1.07 (0.65 – 1.76) ns
Gender (ref=female)				
Male	1.65 (1.57 – 1.74)	1.63 (1.55 – 1.73)	1.70 (1.27 – 2.27)	1.71 (1.27 – 2.30)

ns = Non-significant at the 0.05 probability level

Table 4.27: Logistic regression model for mortality adjusted for ERL group, VPR, CHESS, age and gender in the HNHB (N=67,256/36,474) and TC CCAC (N= 4,147/2,853)

	HNHB		TC	
	Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	1.77 (1.64 – 1.90)	2.38 (2.19 – 2.59)	1.65 (1.20 – 2.28)	1.89 (1.35 – 2.64)
VPR Risk Level (ref=low)				
Medium	1.25 (1.14 – 1.36)	1.38 (1.25 – 1.52)	1.65 (1.23 – 2.22)	1.59 (0.97 – 2.60) ^{ns}
High	0.91 (0.84 – 0.98)	1.20 (1.11 – 1.30)	2.36 (1.61 – 3.45)	2.55 (1.72 – 3.78)
CHESS (ref=0)				
1	1.43 (1.30 – 1.57)	1.58 (1.43 – 1.74)	1.83 (1.02 – 3.29)	1.95 (1.08 – 3.53)
2	1.96 (1.79 – 2.15)	2.34 (2.13 – 2.57)	3.18 (1.79 – 5.63)	3.54 (1.99 – 6.30)
3	3.33 (3.01 – 3.67)	4.00 (3.60 – 4.43)	3.63 (1.96 – 6.70)	4.39 (2.36 – 8.18)
4-5	5.00 (4.38 – 5.68)	7.51 (6.49 – 8.69)	6.83 (3.19 – 14.60)	8.45 (3.84 – 18.62)
Age (ref= 18-64)				
65-74	1.31 (1.19 – 1.45)	1.39 (1.25 – 1.54)	0.79 (0.43 – 1.45) ^{ns}	0.73 (0.39 – 1.36) ^{ns}
75-84	1.18 (1.08 – 1.29)	1.23 (1.13 – 1.35)	0.72 (0.43 – 1.20) ^{ns}	0.61 (0.36 – 1.03) ^{ns}
85+	1.40 (1.29 – 1.53)	1.52 (1.39 – 1.67)	1.22 (0.74 – 1.99) ^{ns}	0.97 (0.58 – 1.60) ^{ns}
Gender (ref=female)				
Male	1.67 (1.58 – 1.76)	1.38 (1.25 – 1.52)	1.66 (1.23 – 2.22)	1.65 (1.22 – 2.23)

^{ns} = Non-significant at the 0.05 probability level

Table 4.28: Logistic regression model for mortality adjusted for ERL group, VPR Plus, age and gender in the HNHB (N=67,258/36,475) and TC CCAC (N=4,218/2,924)

	HNHB		TC	
	Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	1.73 (1.61 – 1.86)	2.49 (2.29 – 2.69)	1.77 (1.29 – 2.43)	1.98 (1.43 – 2.75)
VPR Plus Risk Level (ref=low)				
Medium	1.76 (1.59 – 1.95)	1.99 (1.82 – 2.18)	2.17 (1.30 – 3.63)	2.20 (1.30 – 3.72)
High	1.81 (1.71 – 1.91)	2.07 (1.93 – 2.22)	2.78 (2.03 – 3.81)	3.01 (2.18 – 4.16)
Age (ref= 18-64)				
65-74	1.42 (1.28 – 1.56)	1.52 (1.37 – 1.69)	1.01 (0.56 – 1.84) ns	0.94 (0.51 – 1.73) ns
75-84	1.30 (1.19 – 1.41)	1.35 (1.23 – 1.48)	0.92 (0.55 – 1.53) ns	0.78 (0.46 – 1.31) ns
85+	1.54 (1.42 – 1.68)	1.64 (1.55 – 1.73)	1.61 (1.00 – 2.61)	1.30(0.79 – 2.13) ns
Gender (ref=female)				
Male	1.62 (1.54- 1.71)	1.63 (1.55 – 1.73)	1.69 (1.27 – 2.27)	1.72 (1.27 – 2.31)

ns = Non-significant at the 0.05 probability level

Table 4.29: Logistic regression model for mortality adjusted for ERL group, VPR Plus, CHESS, age and gender in the HNHB (N=67,256/36,474) and TC CCAC (N=4,147/2,853)

	HNHB		TC CCAC	
	Discharged treated as not died	**Discharged treated as missing**	**Discharged treated as not died**	**Discharged treated as missing**
ERL Groups (ref=3-5)				
ERL 1-2 vs 3-5	1.66 (1.54 – 1.78)	2.28 (2.09 – 2.47)	1.68 (1.22 – 2.30)	1.90 (1.36 – 2.65)
VPR Plus Risk Level (ref=low)				
Medium	1.27 (1.15 – 1.42)	1.29 (1.15 – 1.45)	1.52 (0.89 – 2.60) ns	1.45 (0.83 – 2.52) ns
High	1.32 (1.25– 1.41)	1.47 (1.38 – 1.57)	2.08 (1.48 – 2.92)	2.25 (1.59 – 3.19)
CHESS (ref= 0)				
1	1.40 (1.27 – 1.54)	1.56 (1.42 – 1.72)	1.85 (1.03 – 3.33)	1.97 (1.09 – 3.56)
2	1.88 (1.71 – 2.06)	2.27 (2.06 – 2.50)	3.23 (1.82 – 5.73)	3.61 (2.03 – 6.43)
3	2.93 (2,66 – 3.23)	3.78 (3.41 – 4.19)	3.95 (2.15 – 7.25)	4.84 (2.62 – 8.94)
4-5	4.07 (3.59 – 4.62)	6.94 (6.02 – 8.00)	7.66 (3.63 – 16.19)	9.55 (4.39 – 20.80)
Age (ref= 18-64)				
65-74	1.30 (1.18 – 1.44)	1.39 (1.25 – 1.54)	0.82 (0.45 – 1.51) ns	0.76 (0.41 – 1.41) ns
75-84	1.17 (1.07 – 1.27)	1.26 (1.15 – 1.38	0.78 (0.47 – 1.31) ns	0.67 (0.39 – 1.13) ns
85+	1.38 (1.27 – 1.50)	1.57 (1.43 – 1.72)	1.36 (0.83 – 2.21) ns	1.07 (0.65 – 1.77) ns
Gender (ref=female)				
Male	1.64 (1.56 – 1.73)	1.65 (1.56 – 1.74)	1.65 (1.23 – 1.21)	1.65 (1.22 – 2.23)

ns = Non-significant at the 0.05 probability level

4.4. Discussion

The purpose of this chapter was to describe the demographics and clinical characteristics of Home Care (HC) clients with Emergency Response Level (ERL) designation in the HNHB and TC CCACs, and to develop a predictive model for ERL designation. This chapter began by showing that almost half of the clients in the HNHB CCAC and over 85% of the clients in TC CCAC had only one ERL code while these clients had multiple HC assessment, with more than 40% being assessed six or more times.

This chapter further examined which HC items are taken into account when a care coordinator assigns an ERL code. The initial analysis showed that clients with an ERL code of 1 were clearly a more impaired group than clients designated with a higher code. The clients with an ERL 1 designation had a higher CPS, CHESS, ADL and DRS score as well as a higher MAPLe. A large proportion of ERL 1 clients more often used a wheelchair, had higher frequency of falls and had more moderate to severe vision impairments and had difficulties making oneself understood and understanding others.

Logistic regression modeling was used to assess which HC items were predictive of ERL designation. This resulted in a large number of significantly associated variables that were subsequently included in a multivariate logistic model. There were some differences in predictive variables in the TC CCAC and HNHB CCAC, but many common variables were identified as well, including the ADL hierarchy score, wheelchair use, dialysis requirements and pressure ulcers.

In the previous chapter, four unique decision support algorithms were tested. It was concluded that the VPR and VPR Plus were the algorithms most predictive of mortality, LTC admission and hospitalization, and may be considered valid algorithms for assigning priority levels to HC clients. The ERL designation was also found to be predictive of survival and LTC admission, but less predictive of hospitalization. The consistency of the VPR and ERL designation in predicting survival rates, LTC admission and hospitalization is not surprising as there was considerable overlap between variables included in the multivariate model predicting ERL designation and the VPR. There were only three items that were associated with ERL designation in one or both CCACs but that were not included in the VPR. These items were pressure ulcers, bathing and bowel incontinence.

The ADL Hierarchy score was an item that was found to be significant in both CCACs as well as in the VPR. Surprisingly, the CPS and CHESS score, items included in the VPR, were not predictive of the ERL designation for either of the CCACs. This was also the case for the isolation and caregiver items of the VPR, such as living alone and whether a caregiver is able to continue care activities. In contrast to expectation, the availability of primary caregiver was significant in the HNHB model, but appeared to predict an ERL 1 or 2 designation. The item 'caregiver expresses feelings of distress, anger or depression' was only significant in the TC model.

To not include the CPS, CHESS, social isolation and caregiver items is in contradiction with the theoretical framework used in this dissertation. The framework assumes that a person's competency and ability to adapt to changing environmental conditions depends on biological, psychological and social resources (Lawton & Nehamow, 1973; Lawton, 1983). This is also the core feature of the frailty definition in this dissertation which asserts that increased vulnerability is due to impairments in multiple, inter-rated systems that lead to decline in reserve capacity and resiliency. This reserve capacity is multi-dimensional and includes physical health status, cognition, mental health and social resources such as family relationships. Those who are considered 'frail' are those whose reserve capacity has fallen below a threshold needed to cope with any challenges in either of the four dimensions.

The domains of reserve in this model (physical frailty, cognition, mental health and social resources) show complex and dynamic interactions. When the physical reserve falls short due to health related limitations, the older person's quality of life may be mitigated or compounded by other domains of reserve such as social networks and family support, which are considered important elements of reserve (Grundy, 2006). The higher the reserve in all domains, the more the older adult can compensate for any shortcomings in another domain.

As the CHESS scale is considered a measure of physical frailty (Armstrong et al., 2010; Hirdes et al., 2003), the literature supports the inclusion of this scale in a model predictive of disaster vulnerability. This literature emphasizes that physical frailty increases vulnerability during emergencies (Banks, 2013; Fernandez et al., 2002; Lach et al., 2005; Rothman & Brown, 2007).

Similarly, the same rational applies to the CPS, social isolation and caregiver items. It is well documented that cognitive impairment and social isolation increase vulnerability during emergencies (Campbell, 2007a; Eisenman et al., 2007; Inouye et al., 2007; Pekovic et al., 2007; Robertson et al., 2013; Rothman & Brown, 2007; Tuohy & Stephens, 2011). Including the CHESS, CPS and items addressing social isolation and caregiver distress is consistent with the multidimensional approach in this dissertation as well as the conclusions drawn in the literature regarding disaster vulnerability.

The analysis has shown that the ERL designation and VPR are not mutually exclusive. In fact, there are several similarities. However, care coordinators in both CCACs appear to underestimate the importance of cognitive and social impairments in contributing to disaster vulnerability. The multi-dimensional perspective of the VPR is therefore a better candidate algorithm for prioritizing persons in relation to disaster vulnerability. This chapter illustrates that the VPR is strongly associated with the subjective ERL designation and can therefore be considered a strong and objective alternative to inform response priority designation. Further, when modeling the VPR and VPR Plus for death, adjusted for age, gender and CHESS it shows a higher c-statistic than when modeling the ERL. Adding the ERL in the VPR or VPR Plus model does not substantially increase the c-statistic.

As the ERL code designations appeared to be assigned only once, the potential for these designations to become obsolete rapidly is great. This could result in ERL codes that are unreliable for making decisions during emergency response. Objective clinical input should be a key component when assigning an emergency response priority of one individual over another. Designating an emergency risk level should also be consistent across care settings and CCACs to ensure fairness. A decision support algorithm that is predictive of emergency vulnerability, which can be applied as a standard to HC assessments across CCACs and ensures an automatic update of the priority designation is a goal that lays in the centre of this dissertation. In chapter 5 the applicability of the VPR to a real-life emergency will be explored. The algorithm will be applied to clients that were affected by the 2013 ice storm in order to test its ability to predict priority clients.

5. Examination of Person-Level Determinants of Adverse Events After the Hydro Outage of December 2013 in Southern Ontario

The failure of a power grid can adversely affect the ability of people with functional needs to remain in the community. Frail older adults are more vulnerable to hypothermia and hyperthermia during extreme temperatures, and as a result may be harmed during a power outage when living in a climate controlled home (Jenkins et al., 2014). During heat waves, older adults -especially those with pre-existing medical conditions- are vulnerable to loss of power and air conditioning and at heightened risk for exacerbation of chronic diseases (Jenkins et al., 2014; Vandentorren et al., 2006).

Hurricane Sandy had a massive effect on people who were dependent on home nursing and personal care attendance as well as for those dependent on electric medical technology such as nebulizers and home oxygen therapy (Jan & Lurie, 2012; Jenkins et al., 2014). People requiring refrigeration of critical medications and the powering of medical equipment were also adversely affected by the power outage.

People using medical devices may be expected to seek care in emergency departments during power outages. The 48-hour August 2003 blackout (Greenwald, Rutherford, Green, & Giglio, 2004; Prezant et al., 2005) resulted in an increase in health care utilization in New York City (Greenwald, Rutherford, Green, & Giglio, 2004; Prezant et al., 2005). Chronically ill community-based patients with respiratory device failure as a result of the outage had an increase of emergency department (ED) visits as well as hospital admissions (Prezant et al., 2005). ED visits increased by 6% in total, but the visits as a result of respiratory device failure increased by 74%. Of the 65 ED visits that were related to respiratory device failure, 57% of the patients were admitted with the remaining patients receiving prolonged ED treatment (Prezant et al., 2005). Ambulance calls increased by 62% on the first day and 53% on the second day. Prezant et al. (2005) concluded that the health system could be easily overwhelmed if the power failure had lasted longer than 48 hours and the temperature was substantially higher resulting in heat-related hospital visits and ambulance calls. The researchers recommend that disaster planning should take medically needed electrical power requirements in health care facilities and the community under consideration, including the availability of backup power as well as developing a registry of patients dependent on electrically powered lifesaving devices (Greenwald et al., 2004; Prezant et al., 2005).

DeSalvo et al. (2014) followed up on this last recommendation and used Medicare claims data to identify individuals living in New Orleans and who had an oxygen concentrator or ventilator by assessing if they submitted a claim for either of these devices. The researchers found that the Medicare data was 93% accurate in identifying patients dependent on these devices (DeSalvo et al., 2014). They suggest by using these data before a power outage emergency management professionals could identify 'clusters' of patients, optimal shelter locations and potential backup requirements. It would enable the quick identification of individuals who require assistance and support (e.g., with evacuation or supply of batteries) as well as inform utility companies which residence should get priority for re-establishing power (DeSalvo et al., 2014, p. 1162). The researchers stated that using existing data is a better way of identification as self-registries have proven to be incomplete. However, they also acknowledge that not all patients are covered by Medicare and further research should be undertaken to validate information from other potential insurers, the Medicaid program or other non-governmental resources.

Patients on other powered mechanical devices such as dialysis, cardiac support and intravenous medication pumps remained relatively unharmed during the 2003 blackout due to the relatively short outage and backup power systems in the institutions where they are receiving the treatment could overcome this period (Prezant et al., 2005). Following Hurricane Sandy, 2012 Medicare data were used to examine how well the health system ensured the uninterrupted care of dialysis patients (Kelman et al., 2014). Patients with end-stage renal disease (ESRD) are vulnerable because these patients have kidneys that no longer work and therefore require regular dialysis. Kelman et al. (2014) concluded that (Medicare) patients with end-stage renal disease visited the emergency department more frequently, had higher hospitalization rate and showed an increased 30-day mortality rate after Hurricane Sandy.

5.1 Rational and Objectives

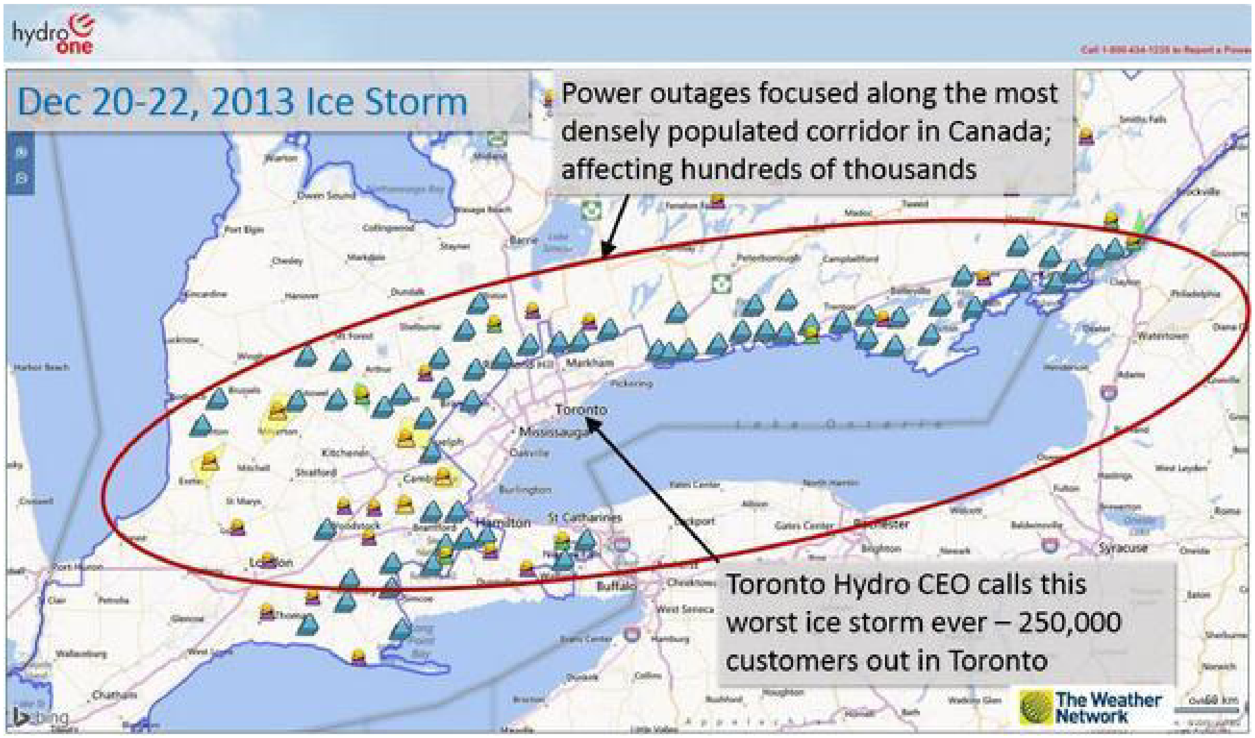
On the evening of December 21st 2013 through December 22nd southern Ontario was struck by a massive ice storm. Twenty to thirty millimetres of freezing rain fell in two days, resulting in trees and branches falling on hydro wires, and causing a widespread power outage. On Sunday December 22nd, 313,000 Toronto Hydro customers were without power (at peak) and over half (57%) of their customers lost power at one point during the event (416,000 customers) (Davies Consulting, June 19, 2014). More than one million residents of Toronto were affected. The Toronto's Emergency Operations Centre (EOC) was activated to manage the emergency (City Manager and Deputy City Manager Toronto, June 17, 2014).

In response to the hydro outages, the City of Toronto opened 13 reception centres across Toronto staffed by city staff and volunteers from the Canadian Red Cross (City Manager and Deputy City Manager Toronto, June 17, 2014). 5,201 registered individuals stayed at the shelters, although most did not stay overnight. The shelters provided services such as meals, showers, power (cell phone charge) and information on the outage. Over 1,000 cots were delivered to the centres to accommodate people staying overnight.

Further, Toronto Police and Toronto Community Housing staff went door to door to ensure the wellness of the residents of the affected neighbourhoods (City Manager and Deputy City Manager Toronto, June 17, 2014). In addition, Emergency Medical Services (EMS) and Toronto Fire Services (TFS) assisted people who requested help with leaving their home. The City of Toronto concluded that the Emergency Support Function "Emergency Human Services" and the Vulnerable Persons Protocol (VPP) worked properly during the response, although a number of actions were not implemented in accordance with the protocols (City Manager and Deputy City Manager Toronto, June 17, 2014). Therefore, the establishment of partnerships with Toronto Central LHIN to "improve the implementation of the Vulnerable Population Protocol (VPP) and support services to vulnerable residents during an emergency situation (p.27)" is an important recommendation made (City Manager and Deputy City Manager Toronto, June 17, 2014).

Toronto was not the only city that was affected by the ice storm. 120,000 customers of Hydro One in cities such as Guelph, Newmarket and Orangeville lost power as well (CBC News, 2013; Office of the Premier, 2013). There were approximately 830,000 customers left without electricity province-wide (Office of the Fire Marshal and Emergency Management, 2015). The power outage affected health services, governmental organizations and residents across several municipalities. Among the recommendations made by the Office of the Fire Marshal and Emergency Management (OFMEM) included the use of Geographic Information Systems (GIS) that enable sharing the common operating picture amongst involved agencies as well as assigning a lead ministry responsible for vulnerable populations in the event of an emergency (Office of the Fire Marshal and Emergency Management, 2015). The report concludes that the current emergency management programs lack a focus on the needs of vulnerable populations. The lack of a clear definition for vulnerable populations was brought forward as an obstacle as well as the myriad of agencies involved in assisting these populations (Office of the Fire Marshal and Emergency Management, 2015).

Figure 5.1: Power Outages Southern Ontario, December 20th – 22nd 2013



Sources: Hydro One; Copyright Permission Granted Thursday July 21st, 2016 from Joe Dales, Farms.com

This chapter of the dissertation examines whether there was a change in exposed CCAC clients' health, mortality, service utilization, ED visits and hospital admissions during and after the December 2013 ice storm and if so, what person-level determinants may explain that change.

This chapter will answer the following questions:

1. Were clients exposed to the hydro outage more at risk of health deterioration as compared to those not exposed?
2. What determinants can be defined for deterioration in health?
3. Did the hydro outage lead to higher service utilization and if so, what are the determinants of this service utilization?
4. Was there an increase in emergency department (ED) visits and hospital admission after the outage by exposed clients versus non-exposed?

5. What were the patient characteristics of clients that visited the ED or were admitted to hospital admissions during and/or after the outage?
6. Was there an increase in mortality, LTC admission and hospitalization of exposed clients versus non-exposed clients six months after the outage?

5.2 Methods

5.2.1 Data Sources

RAI-HC

Data used for this analysis come from the RAI-HC database in Ontario. The data are sent annually by the Ontario Association of Community Care Access Centres (OACCAC) to the University of Waterloo through a licensing agreement between interRAI and OACCAC that permits the sharing of de-identified assessment data.

The Ontario Association of Community Care Access Centres (OACCAC) Client Health Related Information System (CHRIS)

The Client Health and Related Information System (CHRIS) is a web-based patient management system for Ontario's CCACs (Ontario Association of Community Care Access Centres, 2013). CHRIS includes information on home care services coordinated through CCACs and all community based discharges and admissions. It includes patient information; service utilization, referrals as well as the care plan details (Ontario Association of Community Care Access Centres, 2013). For this dissertation CHRIS was used to identify clients who received nursing and/or personal support worker (PSW) visits. CHRIS also includes billing information for home care services (Ontario Association of Community Care Access Centres, 2013).

Hydro Outages Toronto Hydro

Toronto Hydro has provided the University of Waterloo with listings of all outages 24 hours or longer from December 21^{st} 2013 until the last outage was resolved on January 7^{th} 2014. The dataset received used street boundaries to define areas affected. As the RAI datasets are organized by Forward Sortation Area (FSA), the street boundaries have been converted to FSA using ArcGIS software. This resulted in a dataset that is only an approximation of the affected area.

Hydro Outages other areas

The hydro outages in areas other than those included in the Toronto Hydro dataset have been estimated based on Figure 5.1. This includes clients living in affected areas in Mississauga, south of the Central East (CE) CCAC service area and south of the South East (SE) CCAC area.

5.2.2 Sample

The exposure cohort was identified as CCAC HC clients residing in FSA areas that were affected by a power outage during the period December 21^{st} 2013 – January 7^{th} 2014 and had a RAI-HC assessment before and after the outage in the period July 1^{st} 2013 and June 30^{th} 2014. This will include clients living in areas affected by Toronto Hydro outage, Mississauga, south of the Central East CCAC and south of the South East CCAC. As the gathered data for the Toronto Hydro service are on FSA level, a more detailed analysis of exposed clients versus non-exposed clients was possible. The exposure cohort in that area consists of clients residing in FSAs affected by an outage 24 hours or longer.

In line with Kelman's et al. (2014) research on the effect of the power outage on dialysis patients, two comparison groups were defined to examine whether health impacts, service utilization, ED visits and hospital admissions were related to the power outage versus other factors. Comparison group 1 comprised of clients with HC assessments in the same period and receiving services during the same week but living in areas unaffected by the ice storm. This group includes clients living in the CCAC areas Erie St. Clair (ESC), North West (NW), Champlain, North Simcoe Muskoka (NSM) and North East (NE), city of Ottawa (postal codes K1, K2, K4) and the unaffected areas served by Toronto Hydro.

Comparison group 2 includes clients receiving HC services residing in the same area affected by the storm (affected Toronto Hydro service area, Mississauga, south of the Central East CCAC and south of the South East CCAC) during the period December 21st 2012 – January 7th 2013, and had a RAI-HC assessment before and after the outage in the period July 1st 2012 and June 30th 2013 which is one year prior to ice storm.

5.2.3 Outcomes

Descriptive characteristics were obtained from the RAI-HC for all three cohorts.

To examine morbidity IADL capacity, CHESS, DRS and self-rated health were selected as dependent variables. To determine the level of decline the score of these variables before the outage was evaluated against the most recent collected HC score after the outage.

Service utilization data (nursing and personal support work (PSW)) come from the CHRIS dataset. Service utilization of the exposed cohort during the outage and within one month after the outage (December 21st 2013 – February 7th 2014) was compared with the two comparison groups.

Hospital admissions and emergency department (ED) visits within 90 days since last assessment after the outage (December 21st 2013 – June 30th 2014) of exposed clients were compared to the two comparison groups.

Information on death, LTC admission and hospitalization came from the CHRIS dataset. Six month rates have been established for the exposed clients and compared to the two comparison groups.

5.2.4. Statistical Analysis

All statistical analyses were carried out using SAS version 9.4 statistical software system.

Frequencies and percentages (%) are reported for categorical variables, with chi-square tests and corresponding p-values used to determine significance of group differences. Confidence levels have been calculated at the 95% level (alpha=0.05).

Differences in morbidity rates were determined for all three cohorts. Bivariate logistic regression analyses were run with exposure status in order to determine their risk for the decline in the dependent variable. Multivariate logistic regression was then used to assess the relationship between health deterioration and exposure to the power outage (yes/no), simultaneously controlling for possible confounders.

For daily average of nursing and personal support worker (PSW) visits multilevel analysis by exposure status was performed per CCAC to control for differences in CCAC response during the ice storm in CCAC areas affected by outages.

Chi-square tests will be applied to compare ED visits and hospitalizations for clients in the study group with those in the 2 comparison groups.

For the survival rates, 6 month Kaplan-Meier survival plots were calculated using the LIFETEST procedure in SAS. The same test is used for rates of LTC admissions and hospitalization of clients. The rates were compared to the 6 months rates for clients with those in the 2 comparison groups. Cox proportional hazards ratios were calculated using the PHREG procedure.

5.3 Results

5.3.1 Socio-Demographic and Clinical Characteristics by Exposure Status

Tables 5.1 and 5.2 present the descriptive characteristics of the exposed cohort at the time of or within 6 months after the outage in comparison to the two non-exposed cohorts. A total of 10,748 HC clients were identified as affected by the hydro outage and having an assessment before and after the outage, of which 7,407 lived in the area serviced by Toronto Hydro. Within the Toronto Hydro area the average time of exposure was almost five days (SD=60.09 hours) with a minimum exposure of 24 hours and a maximum exposure of 11 days. For clients living in an area not served by Toronto Hydro the duration of the outage was unknown. The two comparison groups consisted of 12,072 clients that lived in non-affected areas during the year of the outage, and 10,886 clients that lived in the affected areas one year prior to the outage.

As noted in the table, there were no substantial differences between the three cohorts regarding demographic characteristics. The lowest proportion of high priority clients as identified by the VPR and VPR Plus is found amongst the non-exposed cohort one year prior to the ice storm, while the highest proportion is found amongst the non-exposed client living in the Toronto hydro service area at the time of the outage.

In relation to the clinical characteristics, the non-exposed cohort in the year of the ice storm seems to be a slightly more impaired group. This cohort has a larger proportion of clients that scored 3+ on the CHESS and the DRS scale, as well as a higher proportion of persons with a MAPLe score of 4 or 5. A higher proportion of the clients in this cohort also have two or more falls in the last 90 days.

The exposed cohort seems to be more impaired in cognitive performance (CPS) and performing Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) as compared to both unexposed cohorts.

Table 5.1: Descriptive demographic characteristics by exposed and non-exposed Ontario home care clients in all selected areas and amongst Toronto Hydro clients in the year of the outage (July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841) and one year prior (July 1st 2012 – June 30th 2013; N=21,634 resp. N=15,210)

% (n) by exposure status						
	All Selected Areas % (n)			**Toronto Hydro Clients % (n)**		
Age †	**Exposed cohort n=10,748**	**Non-exposed same period n=12,072**	**Non-exposed one year prior n=10,886**	**Exposed n=7,407**	**Non-exposed n=7,434**	**Non-exposed one year prior n=7,803**
18-64 yrs.	10.5 (1,124)	13.0 (1,574)	11.3 (1,232) ns	9.1 (677)	11.4 (845)	10.8 (840)
65-74 yrs.	11.4 (1,222)	13.4 (1,621)	11.1 (1,210) ns	10.5 (775)	12.4 (925)	10.2 (798)
75-84 yrs.	32.2 (3,463)	31.8 (3,839)	32.7 (3,562) ns	32.8 (2,429)	32.2 (2,391)	33.6 (2,624)
85+ yrs.	45.9 (4,935)	41.7 (5,036)	44.8 (4,879) ns	47.6 (3,523)	46.6 (3,523)	45.4 (3,539)
Gender						
Female	65.7 (7,057)	63.3 (7,639)	66.2 (7,209)	65.4 (4,846) ns	64.5 (4,798) ns	66.3 (5,173) ns
Marital Status						
Married	39.0 (4,193)	43.0 (4,658)	39.4 (4,292) ns	40.0 (2,965)	38.3 (2,850)	39.5 (3,079) ns
Living Arrangement						
Living alone ‡	30.3 (3,220)	28.9 (3,456)	31.2 (3,369)	30.2 (2,206)	27.0 (1,981)	31.6 (2,446) ns
No primary caregiver	2.4 (257)	2.8 (338)	2.6 (285) ns	2.3 (172)	3.1 (230)	3.0 (234)
VPR						
Low **Medium** **High**	54.1 (5,818) 12.0 (1,294) 33.8 (3,636)	58.0 (6.997) 9.6 (1,162) 32.4 (3,913)	60.3 (6,562) 11.2 (1,214) 28.6 (3,110)	53.7 (3,979) 11.6 (861) 34.7 (2,567)	53.4 (3,967) 10.2 (761) 36.4 (2,706)	60.6 (4,727) 10.4 (812) 29.0 (2,2264)
VPR Plus						
Low **Medium** **High**	47.3 (5,087) 8.0 (857) 44.7 (4,804)	48.4 (5,847) 5.8 (704) 45.7 (5,521)	52.6 (5,728) 7.4 (810) 39.9 (4,348)	47.5 (3,520) 7.8 (579) 44.7 (3,308)	45.5 (3,382) 6.28 (467) 48.2 (3,585)	53.7 (4,190) 7.0 (545) 39.3 (3,068)

† Frequency missing = 6 (same period); 7 (one year prior)
‡ Frequency missing =246 (same period); 210 (one year prior)
ns = Non-significant at the 0.05 probability level

Table 5.2: Descriptive clinical characteristics by exposed and non-exposed Ontario home care clients in all selected areas and amongst Toronto Hydro clients in the year of the outage (July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841) and one year prior (July 1st 2012 – June 30th 2013; N=21,634 resp. N=15,210)

		All Selected Areas			Toronto Hydro Clients		
	Response Set	**Exposed cohort n=10,748**	**Non Exposed – same period n=12,072**	**Non Exposed –one year prior n=10,886**	**Exposed n=7,407**	**Non Exposed – same period n=7,434**	**Non Exposed – one year prior n=7,803**
CPS	**0**	11.8 (1,272)	12.9 (1,559)	15.8 (1,719)	12.1 (899)	8.9 (663)	16.8 (1,308)
	1-2	60.0 (6,447)	59.5 (7,183)	60.2 (6,552)	58.0 (4,298)	61.8 (4,592)	58.8 (4,587)
	3-4	45.7 (1,817)	17.9 (2,163)	14.9 (1,624)	17.5 (1,293)	18.7 (1,389)	14.7 (1,149)
	5-6	11.3 (1,212)	9.7 (1,167)	9.1 (991)	12.4 (917)	10.6 (790)	9.7 (759)
CHESS	**0**	24.0 (2,579)	21.9 (2,645)	26.8 (2,918)	25.8 (1,909)	22.7 (1,684)	29.1 (2,267)
	1-2	58.4 (6,272)	57.6 (6,953)	57.4 (6,248)	59.0 (4,373)	58.2 (4,328)	57.8 (4,506)
	3+	17.7 (1,997)	20.5 (2,474)	15.8 (1,720)	15.2 (1,125)	19.1 (1,422)	13.2 (1,030)
DRS	**0**	48.6 (5,226)	46.9 (5,660)	49.6 (5,402)	48.1 (3,564) ns	47.9 (3,563) ns	49.1 (3,832) ns
	1-2	27.3 (2,933)	26.9 (3,248)	26.5 (2,886)	28.0 (2,073)	26.8 (1,990)	26.4 (2,062)
	3+	24.1 (2,589)	26.2 (3,164)	23.9 (2,598)	23.9 (1,770)	25.3 (1,881)	24.5 (1,909)
MAPLe	**Low (1) – mild (2)**	4.3 (466)	6.1 (739)	7.4 (802)	4.0 (299)	3.5 (261)	7.4 (576)
	Moderate (3)	36.8 (3,950)	31.7 (3,827)	36.9 (4,021)	37.5 (2,779)	34.1 (2,533)	38.7 (3,020)
	High (4) – very high (5)	58.9 (6,332)	62.2 (7,506)	55.7 (6,063)	58.4 (4,329)	62.4 (4,64)	53.9 (4,207)
ADL Hierarchy	**0**	29.7 (3,187)	33.1 (3,992)	36.0 (3,913)	29.9 (2,212)	25.4 (1,891)	36.1 (2,829)
	1 -2	37.5 (4,025)	39.2 (4,737)	35.6 (3,875)	34.9 (2,581)	43.8 (3,254)	34.2 (2,668)
	3-4	23.0 (2,475)	19.9 (2,405)	20.6 (2,238)	23.7 (1,755)	22.1 (1,642)	20.8 (1,622)
	5-6	9.9 (1,061)	7.8 (938)	7.9 (860)	11.6 (859)	8.7 (647)	8.9 (693)
IADL Capacity	**0**	0.2 (22)	0.5 (65)	0.5 (57)	0.1 (6)	0.3 (24)	0.4 (27)
	1 -2	2.9 (314)	5.2 (632)	4.3 (465)	2.2 (159)	3.2 (234)	3.8 (293)
	3-4	13.1 (1,404)	14.6 (1,756)	14.5 (1,583)	12.0 (889)	12.9 (959(	13.6 (1,063)
	5-6	83.8 (9,008)	79.7 (9,619)	80.7 (8,781)	85.8 (6,353)	83.6 (6,217)	82.3 (6,420)
Falls (last 90 days)	**0-1**	83.5 (8,971)	80.3 (9,695)	83.8 (9,117) ns	85.3 (6,317)	80.4 (5,979)	85.7 (6,686) ns
	≥2	16.6 (1,777)	19.7 (2,377)	16.3 (1,769)	14.7 (1,090)	19.6 (1,455)	14.3 (1,117)

ns = Non-significant at the 0.05 probability level

5.3.2 Morbidity by Exposure Status

Tables 5.3 and 5.4 show the odds ratios for worsening in Depression Rating Scale (DRS), CHESS, IADL and self-rated health for exposed clients as compared to non-exposed clients. Table 5.3 compares the exposed clients with the non-exposed clients in the year of the outage. The table shows that exposed clients are less likely to show decline in DRS, CHESS and IADL than non-exposed.

All odds ratios are non-significant when comparing the exposed clients with the same population one-year prior. This indicates that the health status on the four variables of the clients have not significantly changed.

Table 5.3: Bivariate analysis for predicting decline in DRS, Chess, IADL and self rated health for exposed Ontario home care clients versus non-exposed clients in the outage year (July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841)

	All Selected Areas		**Toronto Hydro Clients**	
Dependent Variable	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
DRS decline	**1.00 (ref)**		**1.00 (ref)**	
	0.87	0.82 – 0.93	**0.91**	0.84 – 0.99
CHESS decline	**1.00 (ref)**		**1.00 (ref)**	
	0.90	0.85 – 0.96	**0.87**	0.80 – 0.94
IADL decline	**1.00 (ref)**		**1.00 (ref)**	
	0.74	0.69 – 0.80	**0.76**	0.69 – 0.83
Self rated health	**1.00 (ref)**		**1.00 (ref)**	
decline	**1.01**	0.88 – 1.16 ns	**0.91**	0.77 – 1.09 ns

ns = Non-significant at the 0.05 probability level

Table 5.4: Bivariate analysis for predicting decline in DRS, Chess, IADL and self rated health for exposed Ontario home care clients versus non-exposed clients one year prior (July 1st 2012 – June 30th 2013; N=21,634 resp. N=15,210)

	All Selected Areas		**Toronto Hydro Clients**	
Dependent Variable	**Point Estimate**	**95% CI**	**Point Estimate**	**95% CI**
DRS decline	**1.00 (ref)**	0.91 – 1.04 ns	**1.00 (ref)**	
	0.97		**0.96**	0.88 – 1.04 ns
CHESS decline	**1.00 (ref)**	0.89-1.01 ns	**1.00 (ref)**	0.87 – 1.01 ns
	0.95		**0.94**	
IADL decline	**1.00 (ref)**		**1.00 (ref)**	0.84 – 1.04 ns
	0.95	0.88 – 1.03 ns	**0.94**	
Self rated health	**1.00 (ref)**	0.79 – 1.04 ns	**1.00 (ref)**	
decline	**0.91**		**1.18**	1.00 – 1.41 ns

ns = Non-significant at the 0.05 probability level

Table 5.5: Logistic regression model for DRS decline adjusted for age and gender in hydro outage year, Ontario home care clients, July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841

	All Selected Areas		**Toronto Hydro Clients**	
	Point Estimate	95% CI	Point Estimate	95% CI
Exposure status (ref=no)	0.87	0.82 – 0.93	0.91	0.84 – 0.99
Age (ref= 18-64)				
65-74	1.16	1.02 – 1.32	1.16 ns	0.97 – 1.38
75-84	1.13	1.01 – 1.26	1.12 ns	0.97 – 1.30
85+	0.98	0.88 – 1.09 ns	0.98 ns	0.84 – 1.13
Gender (ref=female)				
Male	0.90	0.84 – 0.97	0.89	0.81 – 0.97

ns = Non-significant at the 0.05 probability level

Table 5.6: Logistic regression model for CHESS decline adjusted for age and gender in hydro outage year, Ontario home care clients, July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841

	All Selected Areas		**Toronto Hydro Clients**	
	Point Estimate	95% CI	Point Estimate	95% CI
Exposure status (ref=no)	0.88	0.83 – 0.94	0.85	0.79 – 0.92
Age (ref= 18-64)				
65-74	1.35	1.18 – 1.54	1.46	1.22 – 1.75
75-84	1.43	1.28 – 1.60	1.53	1.31 – 1.79
85+	1.71	1.53 – 1.91	1.85	1.60 – 2.15
Gender (ref=female)				
Male	1.05	0.99 – 1.12 ns	1.03	0.95 – 1.12 ns

ns = Non-significant at the 0.05 probability level

Table 5.7: Logistic regression model for IADL decline adjusted for age and gender in hydro outage year, Ontario home care clients, July 1st 2013 – June 30th 2014; N=22,820 resp. N=14,841

	All Selected Areas		**Toronto Hydro Clients**	
	Point Estimate	95% CI	Point Estimate	95% CI
Exposure status (ref=no)	0.73	0.68 – 0.79	0.75	0.68 – 0.82
Age (ref= 18-64)				
65-74	1.45	1.23 – 1.70	1.76	1.39 – 2.22
75-84	1.57	1.37 – 1.80	1.85	1.51 – 2.27
85+	1.53	1.34 – 1.75	1.82	1.49 – 2.22
Gender (ref=female)				
Male	0.98 ns	0.91 – 1.06	0.99 ns	0.90 – 1.10

ns = Non-significant at the 0.05 probability level

5.3.3 Service Utilization, Hospitalization and Emergency Department Visits

Table 5.8 shows utilization of nursing and personal support worker (PSW) services by exposure status. When comparing nursing visits for exposed clients and non-exposed clients in the year of the hydro outage, there is a larger proportion of non-exposed clients that have utilized nursing services during and within 30 days after the outage. The difference between exposed clients with non-exposed clients one year prior to the outage was non-significant.

As for PSW visits the analysis shows that most clients received PSW services, regardless of exposure status. However, a higher proportion of non-exposed clients received a higher frequency of these services during and within 30 days after the outage.

Table 5.8: Nursing and PSW visits during and 30 days after the outage (December 21st 2013 – February 7th 2014) for exposed Ontario home care clients versus non-exposed clients in all selected areas and amongst Toronto Hydro clients in the year of the outage (N=19,138 resp. N= 12,616) and one year prior (N=18,470 resp. N=13,018)

	All Selected Areas % (n)			Toronto Hydro Clients % (n)		
Nursing Visits	**Exposed cohort n=9,235**	**Non-exposed same period n=9,903**	**Non-exposed one year prior n=9,235**	**Exposed n=6,377**	**Non-exposed same period n=6,239**	**Non-exposed one year prior n= 6,641**
0	76.9 (7,103)	70.8 (7,012)	78.2 (7,225) ns	79.2 (5,052)	74.5 (4,648)	80.4 (5,342) ns
1 – 9	13.3 (1,229)	17.9 (1,777)	12.1 (1,117) ns	11.5 (730)	15.0 (937)	10.1 (670) ns
10 – 24	7.1 (653)	8.2 (813)	6.8 (632) ns	6.5 (415)	7.6 (473)	6.5 (415) ns
25 – 49	2.1 (189)	2.4 (236)	2.1 (194) ns	2.0 (130)	2.2 (139)	2.0 (130) ns
50 – 99	0.6 (54)	0.6 (56)	0.7 (61) ns	0.7 (43)	0.6 (39)	0.8 (53) ns
100 – 149	0.1 (7)	0.1 (7)	0.1 (5) ns	0.1 (6)	0.1 (3)	0.1 (4) ns
150	0.01 (1)	0.02 (2)	0.01 (1) ns	0.02 (1)	0.0 (0)	0.0 (0) ns
PSW Visits	**Exposed cohort n=9,217 †**	**Non-exposed same period n=9,891‡**	**Non-exposed one year prior n=9,222§**	**Exposed n=6,363¶**	**Non-exposed same period n=6,235#**	**Non-exposed one year prior n=6,632††**
0	4.1 (377)	6.7 (661)	5.1 (474)	3.2 (203)	4.8 (296)	4.3 (284)
1 – 24	48.7 (4,491)	44.2 (4,370)	53.1 (4,895)	49.3 (3,136)	47.2 (2,941)	55.6 (3,689)
25 – 49	23.6 (2,179)	22.8 (2,252)	21.8 (2,010)	22.0 (1,397)	25.1 (1,566)	22.7 (1,348)
50 – 99	19.4 (1,792)	19.6 (1,943)	16.6 (1,535)	21.3 (1,353)	18.8 (1,169)	20.3 (1,093)
100 - 199	4.0 (365)	6.2 (611)	3.2 (292)	4.2 (267)	4.0 (252)	3.1 (207)
200 – 299	0.1 (9)	0.4 (35)	0.1 (8)	0.1 (5)	0.1(7)	0.1 (5)
> 300	0.04 (4)	0.2 (19)	0.1 (8)	0.03 (2)	0.1 (4)	0.1 (6)

ns = Non-significant at the 0.05 probability level
† Frequency missing = 17
‡ Frequency missing = 12
§ Frequency missing = 13
¶ Frequency missing = 14
#Frequency missing = 5
†† Frequency missing = 9

Tables 5.9 and 5.10 show the nursing and PSW service utilization from December 21st – February 7th 2016 by CCACs. In the Central East and Central CCACs a higher proportion of the clients not affected by the power outage received nursing services during and 30 days after the outage. This was different for the Champlain CCAC where a higher proportion of exposed clients received more nursing services. A higher proportion of exposed TC clients received 1 – 24 nursing visits while a higher proportion of non-exposed clients serviced by this CCAC received more than 25 visits.

The same trend is seen in the TC CCAC and Central when considering PSW visits, while a higher proportion of affected clients in the Central East CCAC received more PSW services overall. In the Champlain CCAC the difference is non-significant.

Table 5.9: Nursing visits for exposed Ontario home care clients versus non-exposed clients during and 30 days after the outage (December 21st 2013 – February 7th 2014), by CCAC (N=19,138)

	Nursing Visits % (n)						
CCAC	**0**	**1-9**	**10-24**	**25-49**	**50-99**	**100-149**	**>150**
Central East							
Exposed (n=3,511)	82.5 (2,895)	10.3 (363)	5.4 (191)	0.4 (15)	0.1 (2)	-	-
Non Exposed (n=1,357)	74.7 (1,014)	16.9 (229)	6.9 (94)	0.0	0.0		
Central							
Exposed (n=2,354)	77.6 (1,826)	12.6 (297)	7.1 (168)	0.7 (17)	0.04 (1)	0.04 (1)	0.04 (1)
Non Exposed (n=2,424)	74.6 (1,809)	14.4 (350)	7.8 (190)	0.5 (13)	0.04 (1)	0.0	0.0
Champlain							
Exposed (n=68)	70.6 (48)	17.7 (12)	7.4 (5)	0.0	-	-	-
Non Exposed (n=1,183)	75.9 (898)	14.5 (171)	7.3 (86)	0.5 (6)			
Central West							
Exposed (n=179)	77.7 (139)	14.0 (25)	7.3 (13)	1.1 (2)	-	-	-
ESC							
Non Exposed (n=1,097)	62.1 (681)	24.7 (271)	10.1 (111)	0.3 (3)	-	-	-
Mississauga Halton							
Exposed (n=164)	79.3 (130)	10.4 (17)	0.6 (1)	0.6 (1)	-	-	-
North East							
Non Exposed (n=1,494)	72.5 (1,083)	18.3 (273)	7.0 (105)	2.0 (30)	0.2 (3)	-	-
NSM							
Non Exposed (n=787)	61.1 (481)	26.3 (207)	10.4 (82)	1.8 (14)	0.4 (3)	-	-
NW							
Non Exposed (n=646)	67.0 (433)	18.9 (122)	8.8 (57)	3.3 (21)	1.1 (7)	0.6 (4)	0.3 (2)
SE							
Non Exposed (n=1200)	63.0 (756)	23.2 (278)	10.5 (126)	2.8 (33)	0.5 (6)	0.1 (1)	-
TC							
Exposed (n=1,758)	74.4 (1,308)	13.5 (237)	7.6 (134)	3.5 (61)	0.9 (15)	0.2 (3)	-
Non Exposed (n=914)	67.1 (613)	16.7 (153)	9.6 (88)	4.1 (37)	2.3 (21)	0.2 (2)	

Table 5.10: PSW visits for exposed Ontario home care clients versus non-exposed clients during and 30 days after the outage (December 21st 2013 – February 7th 2014), by CCAC (N=19,138)

	PSW Visits % (n)						
CCAC	**0**	**1-24**	**25-49**	**50-99**	**100-199**	**200-299**	**>300**
Central East †							
Exposed (n=3,507)	2.9 (100)	51.8 (1,816)	26.9 (943)	16.8 (589)	1.6 (57)	0.1 (2)	0
Non Exposed (n=1,357)	5.8 (78)	51.2 (695)	26.5 (359)	14.2 (193)	2.3 (31)	0	0.1 (1)
Central ‡							
Exposed (n=2,344)	3.2 (76)	56.4 (1,321)	20.1 (472)	17.5 (409)	2.7 (64)	0.1 (2)	0
Non Exposed (n=2,422)	4.9 (118)	49.6 (1,200)	22.9 (554)	19.3 (467)	3.1 (75)	0.3 (6)	0.1 (2)
Champlain § **ns**							
Exposed (n=68)	7.7 (5)	57.4 (39)	11.8 (8)	13.3 (9)	10.3 (7)	0	0
Non Exposed (n=1,182)	6.6 (78)	39.9 (472)	20.6 (243)	20.7 (245)	10.7 (127)	0.9 (10)	0.6 (7)
Central West							
Exposed (n=179)	6.7 (12)	55.9 (100)	14.5 (26)	21.2 (38)	1.1 (2)	0.6 (1)	-
Non Exposed (n=0)	-	-	-	-	-	-	
Erie St. Clair §							
Non Exposed (n=1,096)	6.7 (73)	46.2 (506)	24.3 (266)	18.4 (202)	4.3 (47)	0.1 (1)	0.1 (1)
Mississauga Halton							
Exposed (n=164)	6.1 (10)	45.1 (74)	22.0 (36)	20.7 (34)	6.1 (10)	-	-
North East ¶							
Non Exposed (n=1,489)	6.5 (97)	52.7 (785)	19.7 (294)	14.8 (221)	5.6 (83)	0.4 (6)	0.2 (3)
North Simcoe Muskoka §							
Non Exposed (n=786)	16.3 (128)	21.6 (170)	22.9 (180)	24.6 (193)	13.4 (105)	0.9 (7)	0.4 (3)
North West &							
Non Exposed (n=644)	7.8 (50)	42.55 (274)	24.8 (160)	19.6 (126)	4.5 (29)	0.6 (4)	0.2 (1)
South East							
Non Exposed (n=1298) #	8.6 (103)	42.7 (511)	26.1 (313)	17.4 (208)	4.8 (58)	0.3 (3)	0.2 (3)
Toronto Central &							
Exposed (n=1,758)	4.0 (71)	35.8 (629)	21.7 (381)	28.8 (505)	9.5 (167)	0.1 (1)	0.1 (2)
Non Exposed (n=914)	4.3 (39)	29.3 (268)	21.4 (196)	32.4 (296)	12.5 (114)	0	0.1 (1)

† Frequency missing = 4
‡ Frequency missing = 12
§ Frequency missing = 1
¶ Frequency missing = 5
# Frequency missing = 2
ns = Non-significant at the 0.05 probability level

Table 5.11 lists the proportions of hospital admissions and emergency department (ED) visits without an overnight stay in the past 90 days since last assessment in the three cohorts. A higher proportion of non-exposed clients had one or more hospital stays as well as ED visits in the outage year. In Toronto Hydro the same results are shown.

When comparing hospitalization and ED visits for the full group of exposed and non-exposed one year prior the difference was non-significant. The results are also non-significant for ED visits in the Toronto Hydro area. However, when comparing hospitalizations of exposed Toronto Hydro clients with clients one year prior, there was a higher percentage of exposed clients that were admitted to the hospitals as compared to the clients one year before the outage.

Table 5.11: Hospitalization and Emergency Department (ED) visits for exposed Ontario home care clients versus non-exposed clients in all selected areas and among Toronto Hydro clients in the year of the outage (July 1st 2013 – June 30th 2014; N=19,138 resp. N=14,841) and one year prior (July 1 2012 – June 30 2013; N=18,470 resp. N=13,018)

	All Selected Areas % (n)			Toronto Hydro Clients % (n)		
Hospitalization	**Exposed cohort n=9,235**	**Non-exposed same period n=9,903**	**Non-exposed one year prior n=9,235 ns**	**Exposed n=6,377**	**Non-exposed same period n=6,239 ns**	**Non-exposed one year prior n= 6,641**
0	80.4 (7,423)	76.8 (7,609)	81.7 (7,544)	81.0 (5,167)	79.3 (4,950)	83.0 (5,513)
>1	16.4 (1,513)	18.7 (1,850)	15.5 (1,430)	15.9 (1,014)	17.0 (1,063)	14.4 (957)
2+	3.2 (299)	4.5 (444)	2.8 (261)	3.1 (196)	3.6 (226)	2.6 (171)
ED Visits	**Exposed cohort n=9,235**	**Non-exposed same period n=9,903**	**Non-exposed one year prior n=9,235 ns**	**Exposed n=6,377**	**Non-exposed same period n=6,239**	**Non-exposed one year prior n= 6,641 ns**
0	82.9 (7,656)	80.7 (7,993)	83.7 (7,726)	86.0 (5,483)	80.8 (5,039)	86.3 (5,513)
1	12.1 (1,119)	13.2 (1,311)	12.1 (1,119)	10.9 (692)	12.9 (805)	10.6 (703)
2+	5.0 (460)	6.1 (599)	4.2(390)	3.1 (202)	6.3 (395)	3.1 (425)

ns = Non-significant at the 0.05 probability level

Table 5.12 shows the odds ratios for ED visits and hospitalization during and after the outage for clients on oxygen or requiring dialysis (hydro dependent treatments) assessed within 3 months after the start of the power outage. The analysis shows that exposed clients on oxygen in the full study population (all selected areas) are 2.68 (CI: 1.93 – 3.72) times more likely to be hospitalized and 1.94 (CI: 1.36 – 2.76) more likely to visit an ED than exposed clients not on oxygen. This compared to 1.94 (CI: 1.46 – 2.56) and 1.27 (CI: 0.92 – 1.73 NS) in the unexposed areas. For dialysis the odds ratios are non-significant.

Exposed Toronto Hydro clients on oxygen are 3.15 (CI: 1.94 – 5.12) more likely to be hospitalized as compared to 2.31 (CI: 1.64 – 3.26) for non-exposed clients on oxygen. All other odds ratios are non-significant.

Table 5.12: Odds ratios for ED visits and hospitalizations within 90 days of the outage of exposed Ontario home care clients versus non-exposed dependent on oxygen or dialysis – all selected areas

	Exposed	**Non-exposed**
ED visit	OR (CI)	OR (CI)
Oxygen No (ref) Yes	1.94 (1.36 – 2.76)	1.27 (0.92 – 1.74) ns
Dialysis No (ref) Yes	1.36 (0.69 – 2.68) ns	1.55 (0.88 – 2.72)
Hospitalization	OR (CI)	OR (CI)
Oxygen No Yes	2.68 (1.93 – 3.72)	1.94 (1.46 -2.56)
Dialysis No Yes	1.19 (0.62 – 2.30) ns	2.06 (1.23 – 3.45)

ns = Non-significant at the 0.05 probability level

Table 5.13: Odds ratios for ED visits and hospitalizations within 90 days of the outage of exposed Ontario home care clients versus non-exposed dependent on oxygen or dialysis – Toronto Hydro clients

	Exposed	**Non-exposed**
ED visit	OR (CI)	OR (CI)
Oxygen No Yes	1.44 (0.78 – 2.65) ns	1.33 (0.90 – 1.95) ns
Dialysis No Yes	0.80 (0.28 – 2.28) ns	1.44 (0.67 – 3.11) ns
Hospitalization	OR (CI)	OR (CI)
Oxygen No Yes	3.15 (1.94 – 5.12)	2.31 (1.64 – 3.26)
Dialysis No Yes	1.39 (0.64 – 2.99) ns	1.29 (0.59 – 2.78) ns

ns = Non-significant at the 0.05 probability level

5.3.4 Survival Rates

Figures 5.2 to 5.5 present the survival rates of all affected HC clients and HC clients affected by the Toronto hydro outage compared to the two comparison groups.

The log rank test shows a statistically non-significant difference between exposed and non-exposed in the outage year when comparing the population in all selected areas (X^2= 0.08; DF 1; p=0.78). The lines are practically identical. The difference remains non-significant when comparing Toronto hydro clients (X^2= 1.96; DF 1; p=0.16).

When comparing the cohorts with the cohort one year prior, the log rank test is significant for the population in all selected areas (X^2= 10.49; DF 1; p=0.0012) and for Toronto hydro clients (X^2= 10.61; DF 1; p=0.0011). The exposed clients seem to have a slightly higher mortality rate than the non-exposed.

Table 5.14 shows the Cox proportional hazards ratios for exposure status adjusting for age, gender, marital status, CHESS and living status. For the population in the hydro outage year, the hazards ratios are non-significant, for both the population in all selected areas as the Toronto hydro population. The hazards ratios when comparing exposed to non-exposed one year prior show that the clients in the affected areas are almost 1.17 (all selected areas) and 1.23 (Toronto Hydro area) times more likely to die than the unaffected clients.

90 days after the outage 7.0% (n=398) of the exposed HC clients died as compared to 6.1 (n=377) of the non-exposed clients in all selected areas. This difference is however non-significant (p=0.055). The difference remains insignificant when comparing the exposed Toronto hydro clients with the non-exposed (p=0.87). 6.1% (n=247) of the exposed Toronto hydro clients died within 90 days of the outage as compared to 6.0% (n=231) of the non-exposed.

Figure 5.2: Kaplan-Maier Survival Curve for days to death by exposed versus non-exposed in the outage year – all selected areas within 6 months after outage

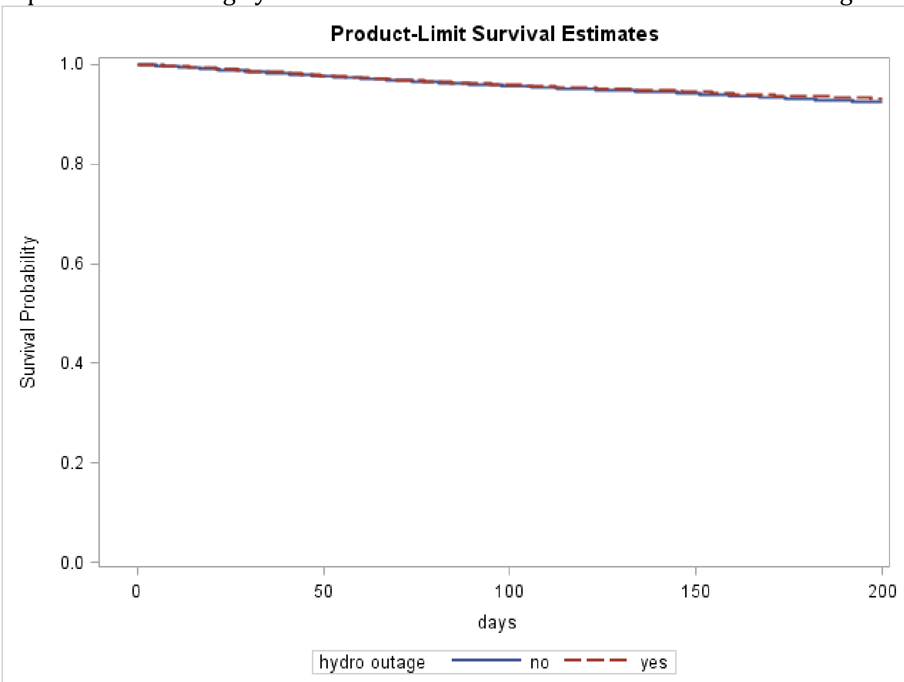


Figure 5.3: Kaplan-Maier Survival Curve for days to death by exposed versus non-exposed in the outage year – Toronto Hydro clients within 6 months after outage

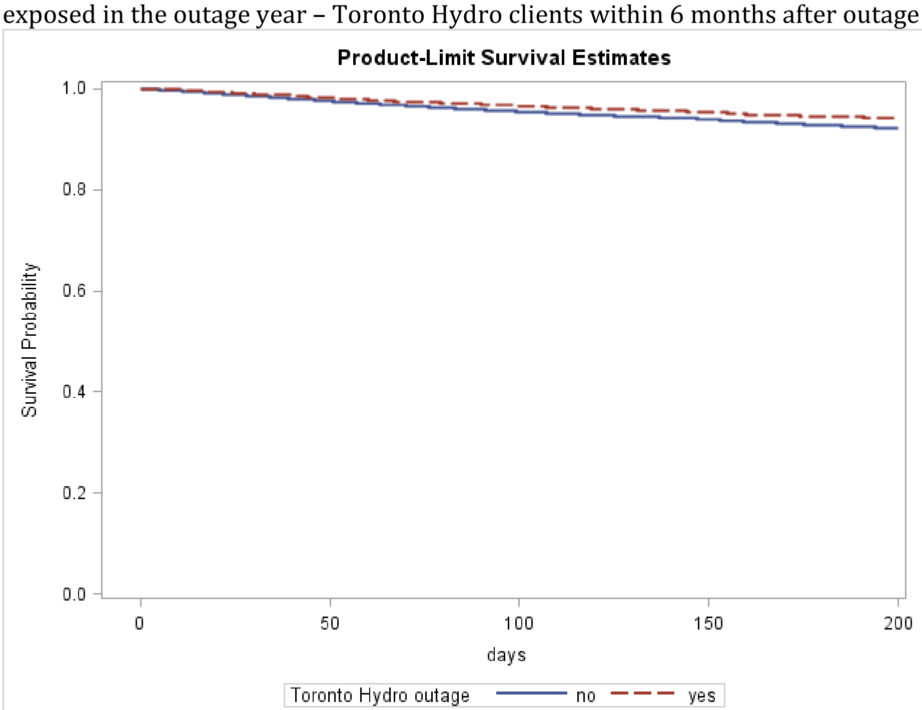


Figure 5.4: Kaplan-Maier Survival Curve for days to death by exposed versus non-exposed one year prior– all selected areas within 6 months after outage

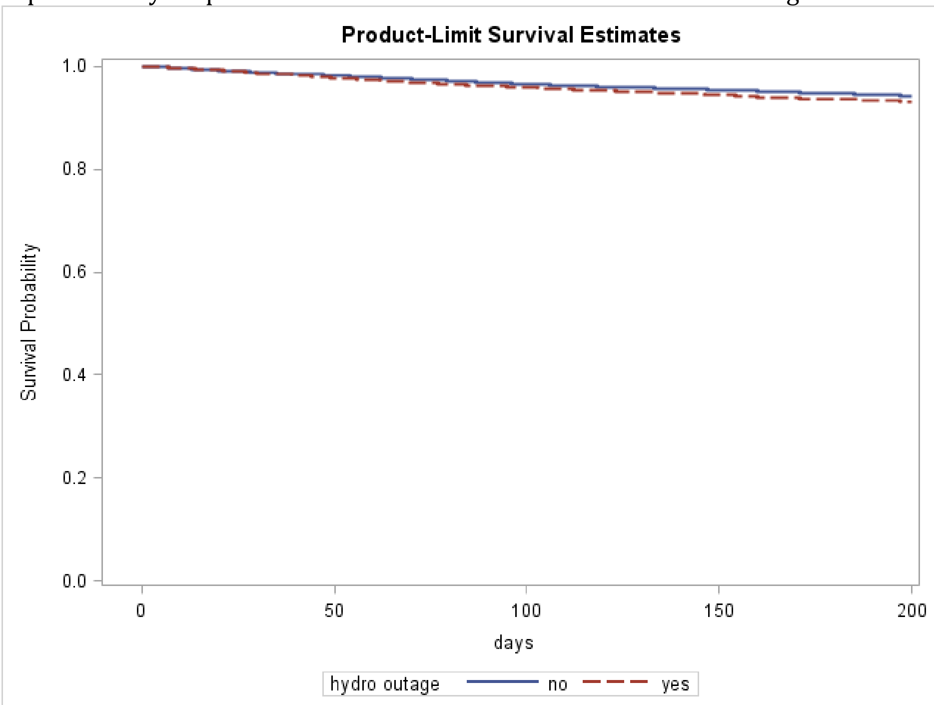


Figure 5.5: Kaplan-Maier Survival Curve for days to death by exposed versus non-exposed one year prior – Toronto Hydro clients within 6 months after outage

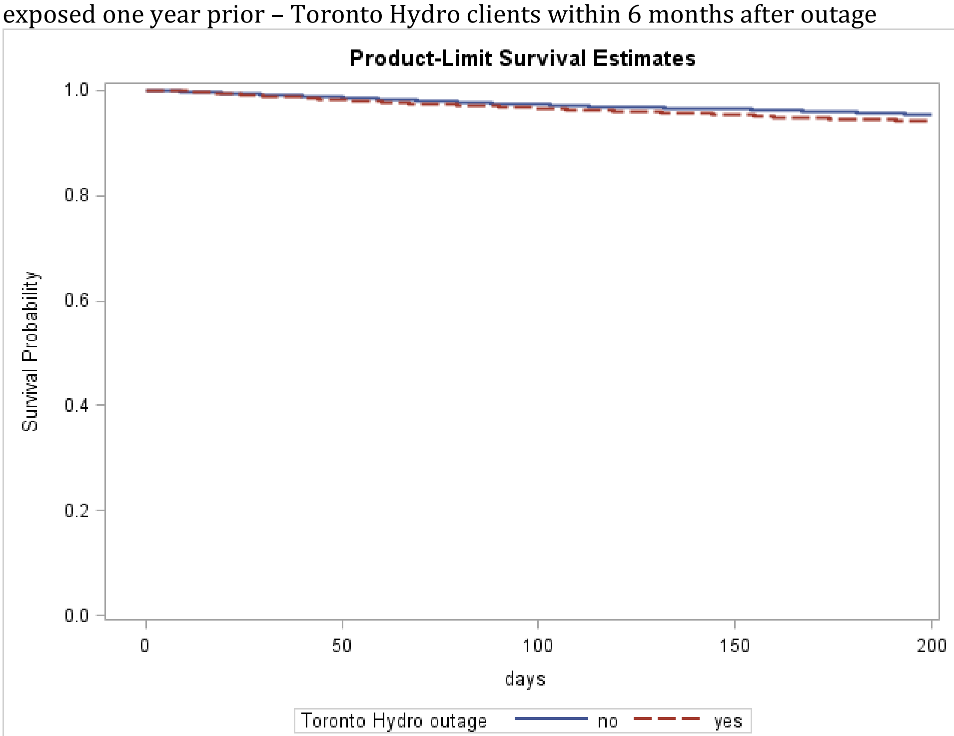


Table 5.14: Cox proportional hazards ratios for mortality with exposure status, age, gender, marital status, CHESS and living status for Ontario home care clients in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013– June 30th 2014; N=20,878 resp. N=13,525) and one year prior (December 31st 2012 – June 30th 2013; N=19,592 resp. N=13,855)

	All Selected Areas		**Toronto Hydro Clients**	
	Exposed versus non-exposed same period	**Exposed versus Non-exposed one year prior**	**Exposed versus non-exposed same period**	**Exposed versus Non-exposed one year prior**
Exposure status (ref=no)				
Exposed	1.02 (0.91 – 1.14) ns	1.17 (1.04 – 1.32)	0.93 (0.80 – 1.07) ns	1.23 (1.05 – 1.44)
Age (ref= 18-64)				
65-74	1.20 (0.92 – 1.56) ns	1.01 (0,75 – 1.36) ns	1.19 (0.78 – 1.82) ns	1.03 (0.62 – 1.71) ns
75-84	1.26 (1.01 – 1.58)	1.17 (0.92 – 1.49) ns	1.74 (1.22 – 2.47)	1.83 (1.23 – 2.73)
85+	1.87 (1.51-2.32)	1.65 (1.31 – 2.08)	2.76 (1.97 – 3.86)	3.03 (2.06 – 4.46)
Gender (ref=female)				
Male	1.35 (1.20 – 1.51)	1.50 (1.32 – 1.70)	1.40 (1.19 – 1.65)	1.45 (1.23 – 1.70)
Marital status (ref=Not married)				
Married	**	**	0.80 (0.67 – 0.95)	**
CHESS (ref=0)				
CHESS 1	1.26 (1.04 – 1.52)	1.30 (1.06 – 1.58)	1.04 (0.83 – 1.31) ns	1.12 (0.89 – 1.41) ns
CHESS 2	1.54 (1.27 – 1.85)	1.68 (1.38 – 2.05)	1.30 (1.04 – 1.63)	1.37 (1.08 – 1.72)
CHESS 3	2.84 (2.35 – 3.43)	3.14 (2.56 – 3.84)	2.23 (1.76 – 2.82)	2.07 (1.60 – 2.68)
CHESS 4 – 5	6.62 (5.37 – 8.16)	7.88 (6.32 – 9.84)	4.77 (3.61 – 6.30)	5.29 (3.93 – 7.11)
Living Status (ref=not living alone)				
Living alone	0.75 (0.66 – 0.86)	0.80 (0.69 – 0.92)	0.70 (0.67 – 0.95)	0.81 (0.68 – 0.98)

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

5.3.5 LTC Admission Rate

Figures 5.6 to 5.9 present the long term care (LTC) admission rates of all affected HC clients and HC clients affected by the Toronto hydro outage compared to the two comparison groups.

The log rank test shows a statistically significant difference between exposed and non-exposed in the outage year when comparing clients in all selected areas (X^2= 75.37; DF 1; p<0.0001) as well as the Toronto Hydro population (X^2= 18.24; DF 1; p=0.0001). The non-exposed clients seemed to be more likely to be admitted to LTC than the exposed clients.

When comparing the exposed cohorts with the cohorts one year prior, the log rank test is non-significant for the population in all selected areas (X^2= 2.30; DF 1; p=0.13) and for Toronto Hydro clients (X^2= 2.49; DF 1; p=0.11), which is confirmed by the identical lines in the survival curves.

The Cox proportional hazards ratios in table 5.15 show that exposed clients are 0.70 times less likely to be admitted to LTC than clients that lived in non-exposed areas during the ice storm when adjusting for age, gender, marital status, MAPLe and living status. However, when considering only Toronto Hydro clients, the exposed clients are 1.30 more likely to be admitted to LTC.

The hazards ratios for exposed versus non-exposed one year prior are non-significant.

Figure 5.6: Kaplan-Maier Survival Curve for days to LTC admission by exposed versus non-exposed in the outage year – all selected areas within 6 months after outage

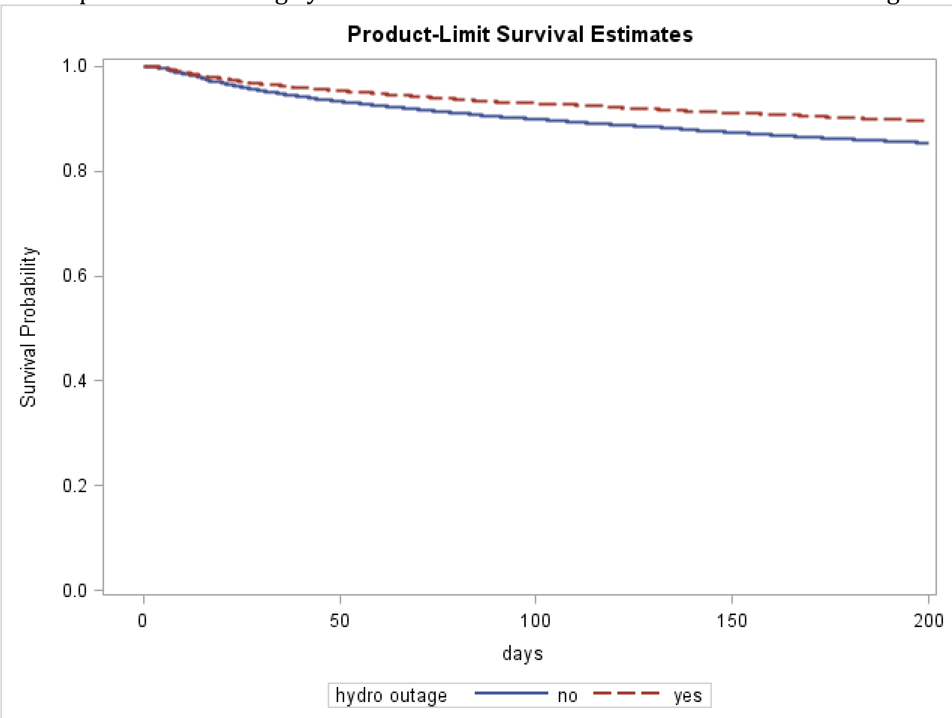


Figure 5.7: Kaplan-Maier Survival Curve for days to LTC admission by exposed versus non-exposed in the outage year – Toronto Hydro clients within 6 months after outage

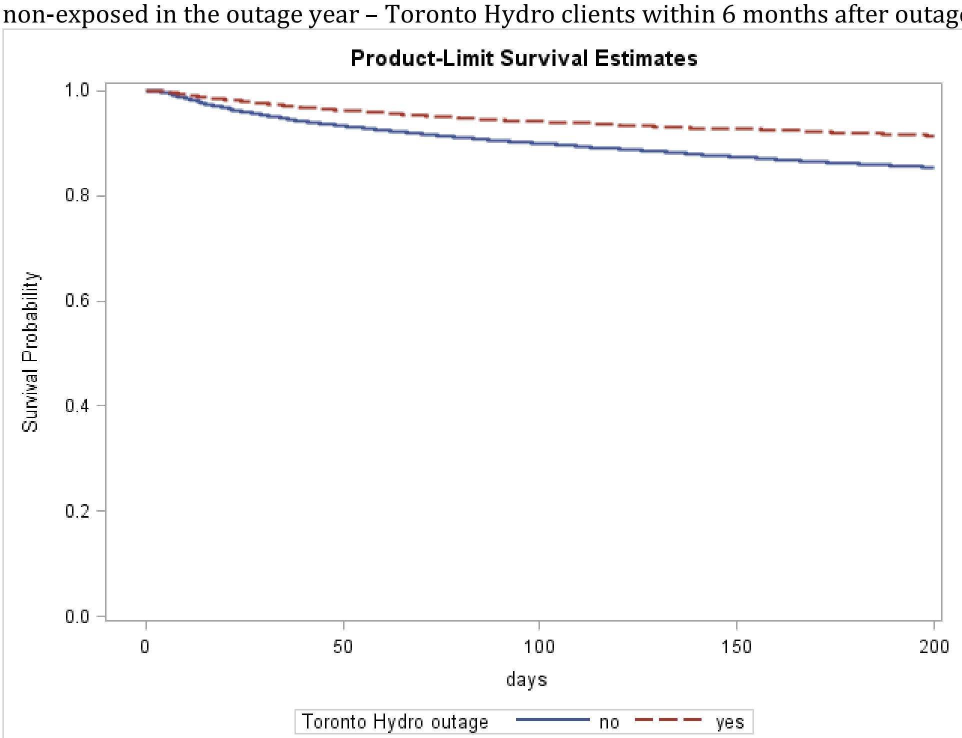


Figure 5.8: Kaplan-Maier Survival Curve for days to LTC admission by exposed versus non-exposed one year prior – all selected areas within 6 months after outage

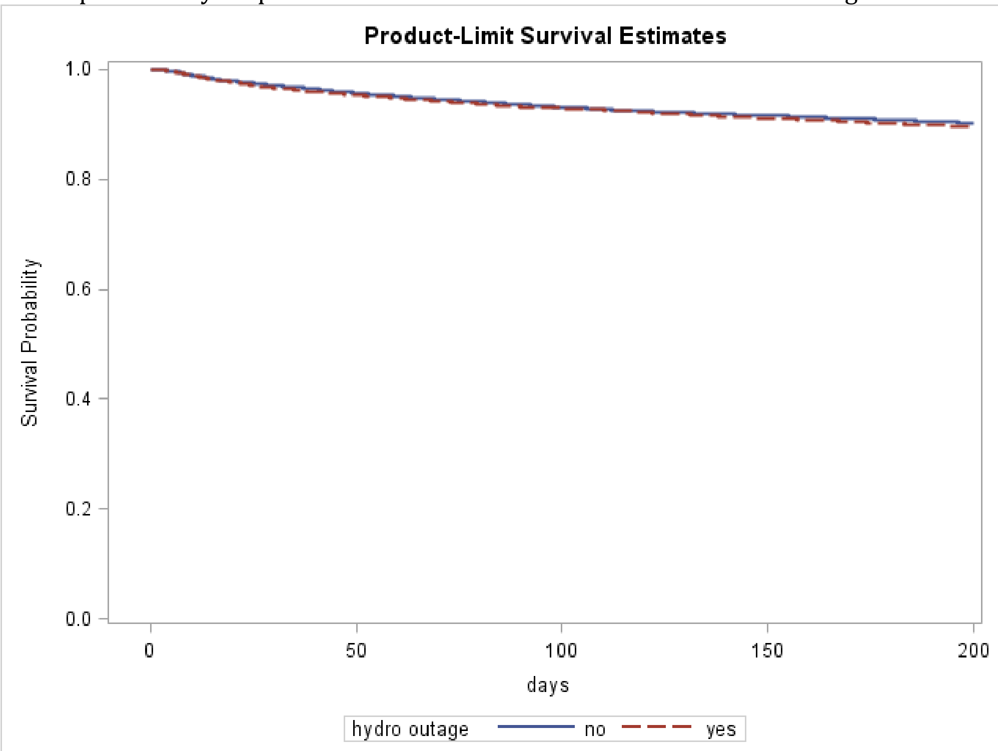


Figure 5.9: Kaplan-Maier Survival Curve for days to LTC admission by exposed versus non-exposed one year prior – Toronto Hydro clients within 6 months after outage

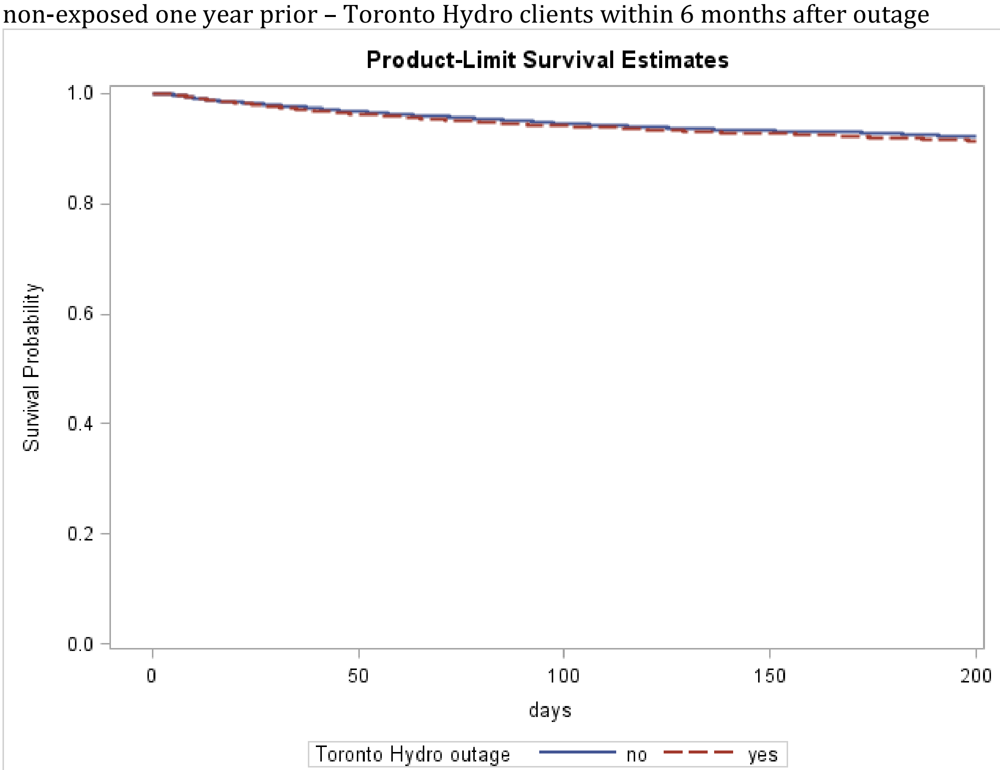


Table 5.15: Cox proportional hazards ratios for LTC admission with exposure status, age, gender, marital status, MAPLe and living status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 - June 30th 2014; N=20,878 resp. N=13,525) and one year prior (December 31st 2012 – June 30th 2013; N=19,592 resp. N=13,855)

	All Selected Areas		**Toronto Hydro Clients**	
	Exposed versus non-exposed same period	**Exposed versus Non-exposed one year prior**	**Exposed versus non-exposed same period**	**Exposed versus Non-exposed one year prior**
Exposure status (ref=no)				
Exposed	0.70 (0.65-0.76)	1.00 (0.91 – 1.10) ns	1.30 (1.15 – 1.47)	1.01 (0.89 – 1.14) ns
Age (ref= 18-64)				
65-74	1.91 (1.52 – 2.39)	1.87 (1.42 – 2.47)	1.70 (1.18 – 2.43)	2.27 (1.50 – 3.44)
75-84	2.69 (2.21 – 3.27)	2.55 (2.01 – 3.23)	2.80 (2.06 – 3.80)	3.33 (2.32 – 4.78)
85+	3.11 (2.57 – 3.76)	3.04 (2.41 – 3.83)	3.28 (2.43 – 4.42)	6368 (2.57 – 5.25)
Gender (ref=female)				
Male	**	1.13 (1.02 – 1.26)	1.13 (1.00 – 1.27)	1.16 (1.04 – 1.30)
Marital status (ref=Not married)				
Married	0.88 (0.81 – 0.96)	**	**	**
MAPLe (ref=1and 2)				
MAPLe 3	4.9 (2.82 – 8.51)	4.36 (2.39 – 7.95)	5.20 (1.94 – 14.00)	3.52 (1.74 – 7.15)
MAPLe 4	10.32 (5.97 – 17.84)	10.52 (5.80 – 19.08)	12.01 (4.49 – 32.13)	8.79 (4.36 – 17.70)
MAPLe 5	19.92 (11.52 – 34.44)	22.53 (12.41 – 40.90)	23.52 (8.78 - 63.00)	18.12 (8.98 – 36.57)
Living Status (ref=not living alone)				
Living alone	**	1.23 (1.10 – 1.38)	1.30 (1.15 – 1.47)	1.48 (1.30 – 1.69)

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

5.3.6 Hospitalization Rate

Figures 5.10 to 5.13 present the hospitalization rates of all exposed home care clients and home care clients affected by the Toronto Hydro outage compared to the two comparison groups.

The log rank test shows a statistically significant difference between exposed and non-exposed in the outage year when comparing the population in all selected areas (X^2= 21.31; DF 1; p<0.0001) as well as the Toronto hydro population (X^2= 42.80; DF 1; p=0.0001). The non-exposed clients seemed to be more likely to be admitted to hospital than the exposed clients.

The Cox proportional hazards ratios in Table 5.16 show that exposed clients are 0.82 times less likely to be admitted in the hospital than non-exposed clients when comparing the population in all selected areas in the hydro outage year. However, Toronto Hydro clients that were affected were 1.16 more likely to be admitted.

When comparing the exposed cohorts with the cohorts one year prior, the log rank test is non-significant for both populations (X^2= 0.45; DF 1; p=0.50 resp. X^2= 0.80; DF 1; p=0.37). The hazards ratios are non-significant as well.

Figure 5.10: Kaplan-Maier Survival Curve for days to hospitalization by exposed versus non-exposed in the outage year – all selected areas within 6 months after outage

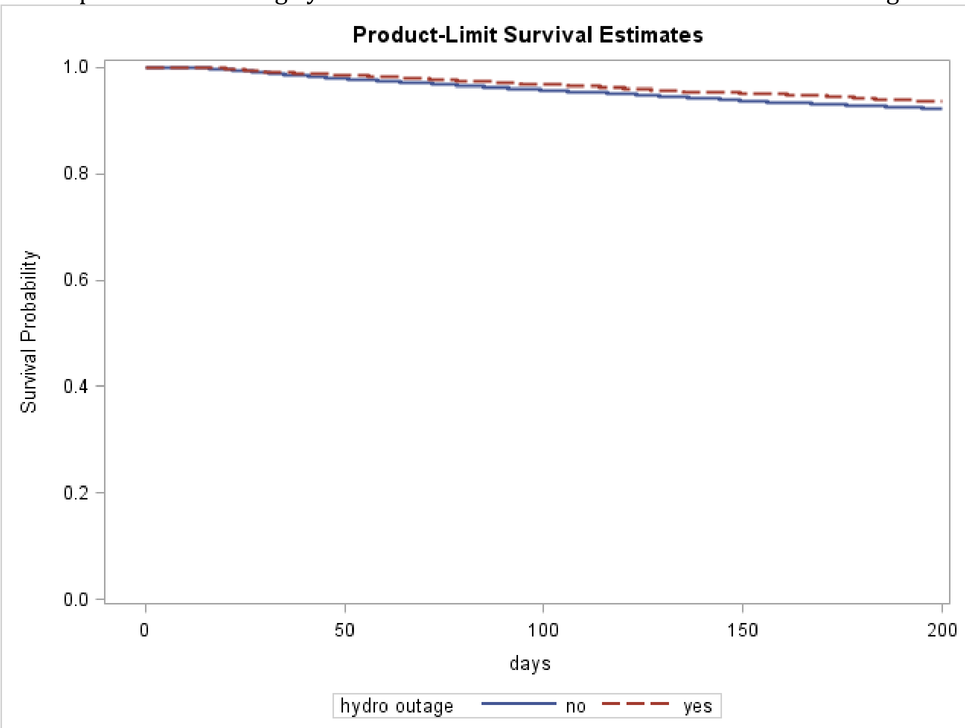


Figure 5.11: Kaplan-Maier Survival Curve for days to hospitalization by exposed versus non-exposed in the outage year – Toronto Hydro clients within 6 months after outage

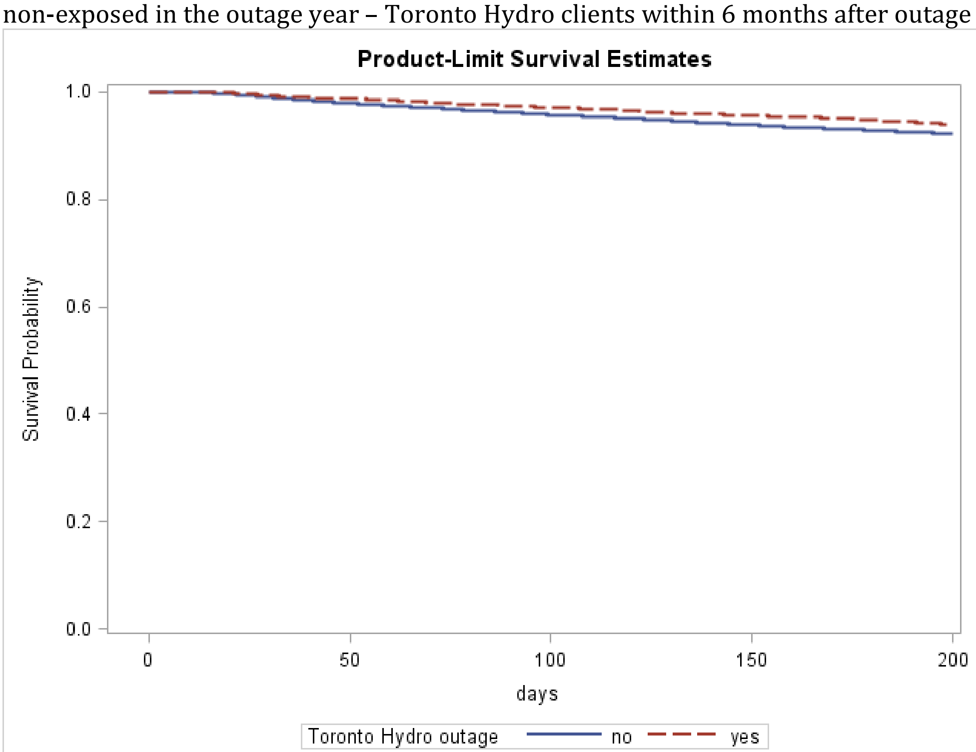


Figure 5.12: Kaplan-Maier Survival Curve for days to hospitalization by exposed versus non-exposed one year prior – all selected areas within 6 months after outage

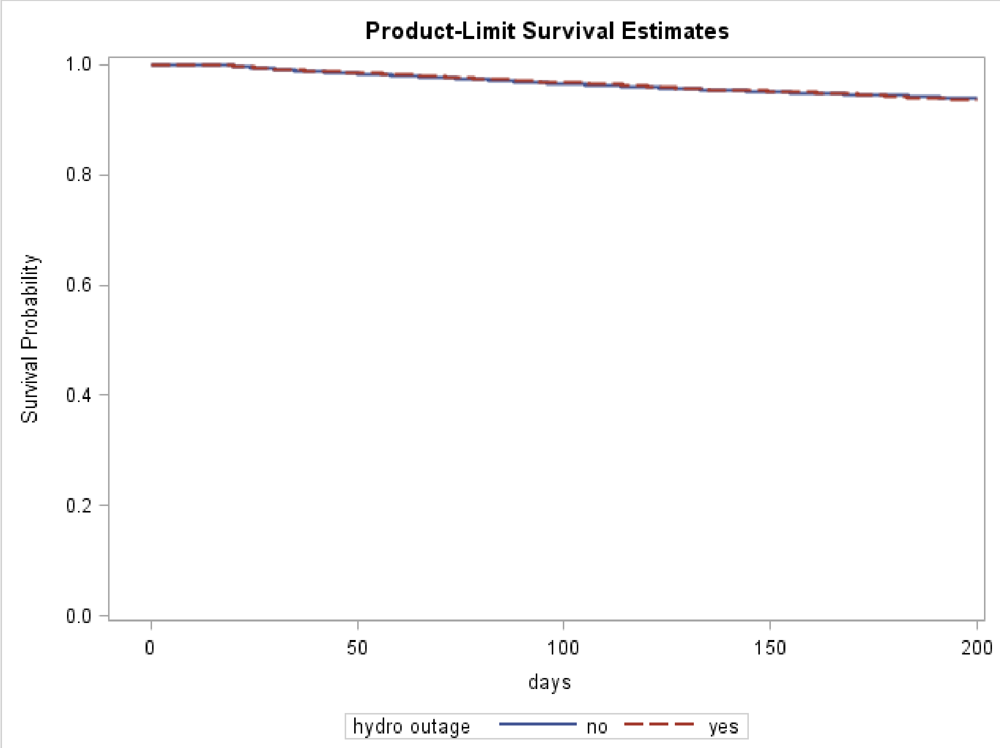


Figure 5.13: Kaplan-Maier Survival Curve for days to hospitalization by exposed versus non-exposed one year prior – Toronto Hydro clients within 6 months after outage

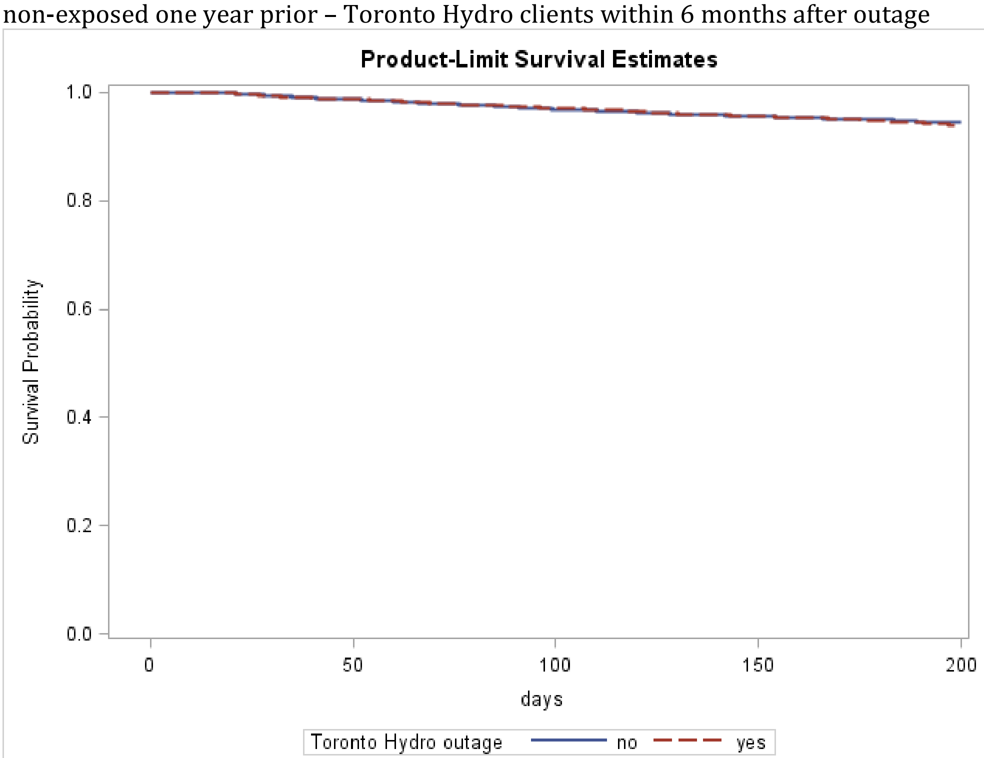


Table 5.16: Cox proportional hazards ratios for hospitalization with exposure status, age, gender, marital status, CHESS and living status in all selected areas and amongst Toronto Hydro clients in the year of the outage ((December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525) and one year prior (December 31st 2012 – June 30th 2013; N=19,592 resp. N=13,855)

	All Selected Areas		**Toronto Hydro Clients**	
	Exposed versus non-exposed same period	**Exposed versus Non-exposed one year prior**	**Exposed versus non-exposed same period**	**Exposed versus Non-exposed one year prior**
Exposure status (ref=no)				
Exposed	0.82 (0.75 – 0.89)	1.01 (0.90 – 1.14) ns	1.16 (1.03 – 1.32)	1.03 (0.89 – 1.19) ns
Age (ref= 18-64)				
65-74	1.60 (1.31 – 1.95)	1.82 (1.35 – 2.45)	1.78 (1.35 – 2.35)	1.74 (1.19 – 2.56)
75-84	1.60 (1.35 – 1.91)	1.76 (1.35 – 2.29)	1.70 (1.32 – 2.18)	1.51 (1.08 – 2.11)
85+	1.79 (1.51 – 2.12)	1.84 (1.42 – 2.39)	2.05 (1.61 – 2.62)	1.87 (1.35 – 2.59)
Gender (ref=female)				
Male	1.29 (1.18 – 1.42)	1.26 (1.10 – 1.43)	1.30 (1.16 – 1.46)	1.29 (1.10 – 1.50)
Marital status (ref=Not married)				
Married	**	**	**	**
CHESS (ref=0)				
CHESS 1	1.13 (0.98 – 1.29) ns	1.35 (1.11 – 1.63)	1.08 (0.91 – 1.28) ns	1.31 (1.05 – 1.64)
CHESS 2	1.58 (1.38 – 1.80)	1.98 (1.64 – 2.39)	1.54 (1.32 – 1.81)	1.93 (1.55 – 2.40)
CHESS 3	1.85 (1.59 – 2.14)	2.70 (2.21 – 3.32)	1.74 (1.45 – 2.10)	2.46 (1.91 – 3.16)
CHESS 4 – 5	2.54 (2.08 – 3.11)	3.20 (2.40 – 4.26)	2.50 (1.91 – 3.28)	2.94 (2.01 – 4.30)
Living Status (ref=not living alone)				
Living alone	1.23 (1.12 – 1.35)	1.20 (1.05 – 1.37)	1.16 (1.03 – 1.32)	**

ns = Non-significant at the 0.05 probability level

** Non-significant at the 0.05 probability level and removed from the model

5.3.7 Testing the VPR in the Ice Storm Dataset

To test whether the VPR and VPR Plus are useful decision support algorithms in the context of a disaster a set of Cox proportional hazards models were applied. The first set of models test the risk of death (Tables 5.17 – 5.19). When including exposure status and VPR/VPR Plus in one model (Table 5.17), the analysis shows that people with a higher VPR or VPR Plus risk level, are more likely to die. The exposure status was non-significant in the models.

Table 5.18 represents the stratified model. The analysis shows here that when stratifying by exposure status, the exposed clients with a high VPR/VPR Plus are more likely to die than high-risk clients in the unaffected areas.

When modeling risk of LTC admission, the analysis shows similar results for the stratified model (Table 5.20). Exposed clients with a high priority status are more likely to be admitted to LTC than non-exposed (the results for medium risk VPR/VPR Plus are non-significant). The risk levels are non-significant when modeling hospitalization stratified by exposure status (Table 5.22).

It should be noted that the models were also tested including an interaction term exposure * VPR/VPR Plus, but all results were non-significant.

Table 5.17: Cox proportional hazards ratios for death with age, gender, VPR/VPR Plus level and exposure status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013– June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas	Toronto Hydro Clients
VPR	VPR Risk Level (ref=low)		
	Medium	2.11 (1.78 – 2.50)	2.34 (1.87 – 2.92)
	High	2.23 (1.97 – 2.52)	2.48 (2.10 – 2.92)
	Exposed (ref=no)	0.93 (0.83 – 1.04) ns	0.87 (0.75 – 1.01) ns
	Age (ref= 18-64)		
	65-74	1.31 (1.01 – 1.70)	1.22 (0.80 – 1.86) ns
	75-84	1.41 (1.12 – 1.76)	1.80 (1.27 – 2.54)
	85+	2.04 (1.65 – 2.53)	2.88 (2.06 – 4.02)
	Gender (ref=female)		
	Male	1.34 (1.19 – 1.51)	1.30 (1.12 – 1.51)
VPR Plus	VPR Plus Risk Level (ref=low)		
	Medium	2.09 (1.68 – 2.61)	2.30 (1.73 – 3.07)
	High	2.71 (2.38 – 3.09)	3.09 (2.59 – 3.69)
	Exposed (ref=no)	0.95 (0.85 – 1.06) ns	0.89 (0.77 – 1.03) ns
	Age (ref= 18-64)		
	65-74	1.38 (1.06 – 1.80)	1.29 (0.85 – 1.98) ns
	75-84	1.59 (1.27 – 1.99)	2.06 (1.45 – 2.91)
	85+	2.39 (1.93 – 2.96)	3.40 (2.44 – 4.74)
	Gender (ref=female)		
	Male	1.32 (1.18 – 1.48)	1.28 (1.10 – 1.49)

ns = Non-significant at the 0.05 probability level

Table 5.18: Cox proportional hazards ratios for death with age, gender, VPR/VPR Plus level stratified by exposure status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas		Toronto Hydro Clients	
		Exposed	**Not Exposed**	**Exposed**	**Not Exposed**
VPR	VPR Risk Level (ref=low)				
	Medium	2.10 (1.73 – 2.79)	2.03 (1.59 – 2.58)	2.62 (1.92 – 2.57)	2.07 (1.51 – 2.86)
	High	2.39 (1.99 – 2.86)	2.10 (1.77 – 2.48)	2.60 (2.04 – 3.31)	2.38 (1.90 – 2.98)
	Age (ref= 18-64)				
	65-74	0.87 (0.58 – 1.34) ns	1.71 (1.21 – 2.42)	1.10 (0.51 – 2.38) ns	1.28 (0.77 – 2.12) ns
	75-84	1.26 (0.91 – 1.74) ns	1.54 (1.13 – 2.10)	2.44 (1.34 – 4.44)	1.50 (0.98 – 2.31) ns
	85+	1.77 (1.30 – 2.40)	2.31 (1.72 – 3.10)	3.91 (2.19 – 7.00)	2.37 (1.58 – 3.57)
	Gender (ref=female)				
	Male	1.34 (1.13 – 1.58)	1.35 (1.15 – 1.58)	1.38 (1.12 – 1.71)	1.22 (0.99 – 1.51) ns
VPR Plus	VPR Plus Risk Level (ref=low)				
	Medium	2.16 (1.60 – 2.92)	2.01 (1.45 – 2.80)	2.45 (1.66 – 3.62)	2.14 (1.40 – 3.29)
	High	2.78 (2.30 – 3.37)	2.65 (2.22 – 3.17)	3.23 (2.50 – 4.17)	2.97 (2.33 – 3.80)
	Age (ref= 18-64)				
	65-74	0.93 (0.61 – 1.41) ns	1.80 (1.28 – 2.55)	1.17 (0.54 – 2.54) ns	1.35 (0.81 – 2.24) ns
	75-84	1.42 (1.03 – 1.97)	1.72 (1.26 – 2.35)	2.80 (1.54 – 5.10)	1.71 (1.11 – 2.63)
	85+	2.06 (1.52 – 2.80)	2.69 (2.01 – 3.61)	4.66 (2.60 – 8.34)	2.78 (1.85 – 4.19)
	Gender (ref=female)				
	Male	1.32 (1.12 – 1.56)	1.32 (1.13 – 1.55)	1.37 (1.11 – 1.69)	1.20 (0.97 – 1.48) ns

ns = Non-significant at the 0.05 probability level

Table 5.19: Cox proportional hazards ratios for LTC admission with age, gender, VPR/VPR Plus level and exposure status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas	**Toronto Hydro Clients**
VPR	VPR Risk Level (ref=low) Medium High	 1.28 (1.11 - 1.47) 2.23 (2.02 - 2.40)	 1.00 (0.80 - 1.25) ns 2.25 (2.00 - 2.54)
	Exposed (ref=no)	0.66 (0.61 - 0.72)	0.76 (0.68 - 0.86)
	Age (ref= 18-64) 65-74 75-84 85+	 1.87 (1.49 - 2.34) 2.71 (2.23 - 3.29) 3.21 (2.65 - 3.88)	 1.69 (1.18 - 2.41) 2.87 (2.11 - 3.89 3.45 (2.56 - 4.66)
	Gender (ref=female) Male	 1.02 (0.94 - 1.11) ns	 1.11 (0.98 - 1.24) ns
VPR Plus	VPR Plus Risk Level (ref=low) Medium High	 1.20 (1.01 – 1.42) 1.75 (1.61 – 1.91)	 0.94 (0.73 - 1.23) ns 1.82 (1.61 - 2.06)
	Exposed (ref=no)	0.67 (0.62 – 0.73)	0.77 (0.69 - 0.86)
	Age (ref= 18-64) 65-74 75-84 85+	 1.97 (1.57 - 2.47) 3.03 (2.49 - 3.68 3.69 (3.05 - 4.46)	 1.79 (1.25 - 2.56) 3.24 (2.39 - 4.40) 4.00 (2.96 - 5.39)
	Gender (ref=female) Male	 1.04 (0.95 - 1.13) ns	 1.12 (1.00 - 1.26)

ns = Non-significant at the 0.05 probability level

Table 5.20: Cox proportional hazards ratios for LTC admission with age, gender, VPR/VPR Plus level stratified by exposure status - in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas		Toronto Hydro Clients	
		Exposed	**Not Exposed**	**Exposed**	**Not Exposed**
VPR	VPR Risk Level (ref=low)				
	Medium	1.07 (0.85 - 1.35) ns	1.45 (1.20 - 1.73)	1.08 (0.78 - 1.49) ns	0.94 (0.69 - 1.27) ns
	High	2.23 (1.94 - 2.55)	2.18 (1.96 - 2.44)	2.48 (2.06 - 2.98)	2.09 (1.78 - 2.45)
	Age (ref= 18-64)				
	65-74	1.36 (0.94 - 1.97) ns	2.23 (1.68 - 2.97)	1.75 (0.99 - 3.08) ns	1.66 (1.04 - 2.63)
	75-84	2.01 (1.48 - 2.74)	3.22 (2.51 - 4.15)	2.62 (1.61 - 4.26)	3.08 (2.08 - 4.56)
	85+	2.72 (2.01 - 3.66)	3.51 (2.74 - 4.49)	3.39 (2.11 - 5.45)	3.49 (2.37 - 5.13)
	Gender (ref=female)				
	Male	1.10 (0.96 - 1.26) ns	0.97 (0.87 - 1.08) ns	1.12 (0.94 - 1.34) ns	1.09 (0.93 - 1.28) ns
VPR Plus	VPR Plus Risk Level (ref=low)				
	Medium	0.99 (0.75 - 1.31) ns	1.38 (1.11 - 1.72)	0.98 (0.67 - 1.44) ns	0.92 (0.64 - 1.33) ns
	High	1.88 (1.63 - 2.15)	1.67 (1.50 - 1.87)	2.10 (1.75 - 2.53)	1.62 (1.38 - 1.91)
	Age (ref= 18-64)				
	65-74	1.45 (1.00 - 2.10)	2.34 (1.76 - 3.10)	1.87 (1.06 - 3.30)	1.75 (1.10 - 2.78)
	75-84	2.28 (1.68 - 3.11)	3.58 (2.79 - 4.61)	3.00 (1.85 - 4.89)	3.44 (2.32 - 5.09)
	85+	3.15 (2.34 - 4.25)	4.02 (3.14 - 5.15)	4.01 (2.49 - 6.46)	3.97 (2.70 -5.84)
	Gender (ref=female)				
	Male	1.11 (0.97- 1.27) ns	0.99 (0.89 -1.11) ns	1.13 (0.94 - 1.35) ns	1.11 (0.95 - 1.30) ns

ns = Non-significant at the 0.05 probability level

Table 5.21: Cox proportional hazards ratios for hospitalization with age, gender, VPR/VPR Plus level and exposure status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas	Toronto Hydro Clients
VPR	VPR Risk Level (ref=low)		
	Medium	0.83 (0.67 - 1.02) ns	0.86 (0.67 - 1.11) ns
	High	1.29 (1.15 - 1.45)	1.24 (1.07 - 1.44)
	Exposed (ref=no)	0.82 (0.73 - 0.92)	0.83 (0.72 - 0.96)
	Age (ref= 18-64)		
	65-74	1.72 (1.35 - 2.19)	1.94 (1.38 - 2.73)
	75-84	1.61 (1.29 - 1.99)	1.68 (1.23 - 2.28)
	85+	1.72 (1.39 - 2.12)	2.01 (1.49 - 2.72)
	Gender (ref=female)		
	Male	1.27 (1.13 - 1.42)	1.33 (1.15 - 1.54)
VPR Plus	VPR Plus Risk Level (ref=low)		
	Medium	1.01 (0.80 - 1.28) ns	1.07 (0.81 - 1.43) ns
	High	1.20 (1.07 - 1.35)	1.18 (1.02 - 1.37)
	Exposed (ref=no)	0.82 (0.73 - 0.92)	0.83 (0.72 - 0.96)
	Age (ref= 18-64)		
	65-74	1.76 (1.38 - 2.25)	1.98 (1.41 - 2.79)
	75-84	1.68 (1.35 - 2.09)	1.74 (1.28 - 2.37)
	85+	1.80 (1.46 - 2.22)	2.09 (1.55 - 2.82)
	Gender (ref=female)		
	Male	1.27 (1.13 - 1.42)	1.34 (1.16 - 1.55)

ns = Non-significant at the 0.05 probability level

Table 5.22: Cox proportional hazards ratios for hospitalization with age, gender, VPR/VPR Plus level stratified by exposure status in all selected areas and amongst Toronto Hydro clients in the year of the outage (December 31st 2013 – June 30th 2014; N=20,878 resp. N=13,525)

		All Selected Areas		Toronto Hydro Clients	
		Exposed	**Not Exposed**	**Exposed**	**Not Exposed**
VPR	VPR Risk Level (ref=low) Medium High	 0.83 (0.62 - 1.11) ^{ns} 1.13 (0.94 - 1.35) ^{ns}	 0.81 (0.60 - 1.09) ^{ns} 1.44 (1.23 - 1.68)	 0.69 (0.47 - 1.02) ^{ns} 1.06 (0.85 - 1.32) ^{ns}	 1.03 (0.74 - 1.46) ^{ns} 1.42 (1.16 - 1.74)
	Age (ref= 18-64) 65-74 75-84 85+	 1.78 (1.18 - 2.68) 1.74 (1.21 - 2.51) 1.93 (1.36 - 2.75)	 1.68 (1.24 - 2.27) 1.52 (1.16 – 2.00) 1.58 (1.21 - 2.06)	 1.67 (1.00 - 2.80) 1.40 (0.88 - 2.21) ^{ns} 1.83 (1.18 - 2.86)	 2.15 (1.36 - 3.38) 1.90 (1.26 - 2.88) 2.13 (1.42 - 3.19)
	Gender (ref=female) Male	 1.25 (1.05 - 1.48)	 1.27 (1.09 - 1.48)	 1.42 (1.15 - 1.76)	 1.26 (1.03 - 1.54)
VPR Plus	VPR Plus Risk Level (ref=low) Medium High	 0.99 (0.73 - 1.36) ^{ns} 1.01 (0.84 - 1.20) ^{ns}	 0.99 (0.70 - 1.41) ^{ns} 1.37 (1.17 - 1.60)	 0.83 (0.55 - 1.25) ^{ns} 0.96 (0.77 - 1.20) ^{ns}	 1.38 (0.94 - 2.04) ^{ns} 1.42 (1.16 - 1.75)
	Age (ref= 18-64) 65-74 75-84 85+	 1.80 (1.20 - 2.72) 1.77 (1.23 - 2.55) 1.96 (1.37 - 2.79)	 1.74 (1.29 - 2.35) 1.63 (1.24 - 2.13) 1.70 (1.31 - 2.22)	 1.68 (1.00 - 2.83) 1.41 (0.89- 2.24) ^{ns} 1.85 (1.18 - 2.88)	 2.20 (1.40 - 3.47) 2.01 (1.33 - 3.04) 2.26 (1.51 - 3.39)
	Gender (ref=female) Male	 1.25 (1.05- 1.49)	 1.28 (1.10 - 1.49)	 1.43 (1.15 - 1.76)	 1.26 (1.03 - 1.54)

^{ns} = Non-significant at the 0.05 probability level

5.4. Discussion

The purpose of this chapter was to examine the person-level characteristics of home care clients exposed to the 2013 hydro outage. The chapter began by showing that the clients exposed by the outage had similar demographic characteristics as the non-exposed cohorts. However, the exposed and non-exposed clients did differ somewhat in clinical characteristics. More non-exposed clients had higher levels of health instability and complexity (higher CHESS), more symptoms of depression (higher DRS) as well as being at greater risk of adverse outcomes (higher MAPLe) while the exposed clients seemed to be more impaired in cognition, ADLs and IADLs.

The exposed and non-exposed cohorts in the outage year showed the most significant difference when comparing numbers of nursing and PSW visits, hospital admission and ED visits as well as mortality, LTC admission and hospitalization rates. Clients in the non-affected areas in the year of the outage were more likely to decline in DRS, CHESS and IADL. This is consistent with the higher rates of LTC admission and hospitalization within six months after the outage for non-exposed clients as well as higher frequency of nursing and PSW visits during and 30 days after the outage. However, within the areas affected by the Toronto Hydro outage, exposed clients were more likely to be admitted to LTC and hospital six months after the outage.

A major challenge in doing research during and after an emergency is the collection of data due to ethical and technical difficulties and the accuracy of the data (Evans, 2010). This chapter experienced these same challenges. As the University of Waterloo uses depersonalized information and only collects Forward Sortation Areas (FSA) (only includes the first three letters of the postal codes) it is impossible to pinpoint exact client locations. This limitation was accentuated by the fact that Toronto Hydro identifies outage areas by street boundaries that do not necessarily follow FSA boundaries. Further, including clients living in affected areas such as Mississauga without knowing whether or not all clients living in these areas were indeed without power, broadened the study population but may have diluted the results.

Despite these limitations, some interesting results are evident. The literature has shown that a longer term power outage may have adverse effects on a subpopulation of clients depending on hydro for health care reasons such as oxygen machines and refrigeration of medications resulting in increased emergency department (ED) visits and hospitalization (Greenwald et al., 2004; Jan & Lurie, 2012; Jenkins et al., 2014; Prezant et al., 2005). The analysis showed that exposed clients on oxygen were indeed more likely to be hospitalized or visit an ED than unexposed clients on oxygen.

The analysis further presented results showing that contrary to the expectation that exposed clients would do worse during and after the outage, the opposite was in fact the case. Exposed clients seemed to show less health decline than non-exposed clients for many outcomes of interest.

The same results were found after the 1997 Red River flood in Manitoba. Lindsay and Hall (2006) examined the consequences of the flood and concluded that those older study participants affected by the flood seemed to have improved in self-rated health and cognitive performance (Lindsay & Hall, 2006). Those positive health outcomes may be attributed to increased attention from medical staff, treatment of pre-existing conditions, which may have remained untreated otherwise, a sense of community, reconciliation with family and challenges intellectually (Gutman, 2007; Lindsay & Hall, 2006).

In response to the outage in Toronto, reception centres were opened, and meals and showers were provided. Toronto police and city staff performed door-to-door wellness checks. The Toronto Central CCAC followed up with all clients in affected areas to assess well-being. One might conclude that some clients may have received *more* support than before the outage resulting in a positive health outcome.

This is interesting in the perspective of the conceptual framework used in this dissertation, the interaction between person and environment. The power outage increased the environmental stress that was put on the individual clients, but this stress may have been lowered by increased support from agencies responding to the outage. This is one of the adaptive strategies introduced by Lawton & Nehamow (1973). By increasing the support the fit between increased environmental stress and the coping capabilities of the individual may have been balanced.

However, the higher risk of health decline for unexposed clients could also be evidence for the “healthy survivor”. The analysis showed that exposed clients were more likely to die than non-exposed clients living in the same area one year prior. The analysis in this chapter has further shown that the VPR and VPR Plus algorithms were useful in predicting death and LTC admission in the context of an emergency. When comparing people that were affected by the outage and those unaffected, the exposed clients with a high-risk rating based on the VPR/VPR Plus were more likely to die or to be admitted to LTC than those unexposed high-risk clients. This means that despite the increased efforts of responding agencies, the risk of death and LTC admission actually increased for the most vulnerable group.

When modeling death with age, gender, VPR/VPR Plus stratified by exposure status further showed that the difference between medium and high-risk clients was not significant in both the total affected areas as the Toronto Hydro service area. In fact, high-risk VPR clients were equally at risk for death compared to medium risk clients in the affected Toronto Hydro area. This might mean that the social isolation variables didn’t increase the risk for death but that health instability, cognitive functioning and ADL impairments included in the decision support algorithms seemed to guide the risk for death during a power outage.

6. General Discussion and Summary

In May of 2016, during the writing of this dissertation, the Alberta town of Fort McMurray was threatened by a large wildfire that led to the evacuation of over 80,000 people. Amongst the evacuees were 350 active Home Care (HC) clients, of whom over 250 were expected to need regular care (Whitridge, 2016). As it is still early days after the evacuation, it remains unknown how many evacuees required assistance during the evacuation and in the evacuation centres, but one might conclude that knowing who would have been most vulnerable during this disaster would have been beneficial.

This dissertation has shown that adverse health outcomes of vulnerable clients may be prevented by targeted strategies before, during and after emergencies. These strategies are aimed at balancing the misfit between increased environmental stress as a result of an emergency and the individual coping capacity of vulnerable home care clients. interRAI assessment information can be used for the identification of vulnerable populations before, during and after emergencies. These clients are highly vulnerable to increased environmental stress and can therefore benefit from interventions that can re-establish the fit between environment and individual coping mechanisms.

This dissertation focused on the development of an evidence informed decision support algorithm that is predictive of vulnerability during large-scale emergencies and disasters. The following research questions were addressed in order to facilitate this development:

1. What are the implications of applying the Canterbury algorithm and variations to the algorithm to the Ontario Home Care client database?
2. What are the determinants of Emergency Response Level (ERL) designation within the Toronto Central (TC) and Hamilton Niagara Haldimand Brant (HNHB) Community Care

Access Centres (CCAC) and how do the ERLs compare to the chosen decision support algorithms, the Vulnerable Persons at Risk (VPR) and VPR Plus algorithms?

3. What were the health effects of the power outage after the December 2013 Ice Storm including emergency department (ED) visits, hospitalization, long term care admissions, death and service utilization?

The results of this dissertation have implications for policy, the emergency management field and further research and implementation requirements.

6.1 Implications for Policy

The elderly are not a homogeneous population. Differences in physical frailty status and cognitive limitations as well as socioeconomic status, social and family connectedness, mental health, living situation, gender and geographic location make it difficult to consider older adults as a single entity when responding to their needs during and after disasters (Banks, 2013; Ngo, 2001). However it is possible to identify common characteristics that lead to higher vulnerability to disaster impacts.

Poor health outcomes may be prevented and mitigated through proper prevention and mitigation interventions by health and community care providers, emergency planners and first responders. The ability to identify those most vulnerable older adults pre-disaster, engage in collaborations and preparedness efforts, and encouragement of individual preparedness are some strategies towards preventing and mitigating adverse consequences as a result of disasters, and breaking the cycle of mortality among elderly disaster victims.

Since 2007 the CCACs in Ontario have assigned Emergency Response Levels (ERL) to their clients in order to determine emergency vulnerability of their clients. The designation is based on the assessment of the care coordinator, but the designation has never been tested for validity or reliability. The strength of the interRAI assessment tools is that the items within the tools and the scales have been extensively tested for reliability and validity, and one would expect that a decision support algorithm derived from the interRAI assessment that determines disaster vulnerability would achieve a similar standard. This is important as the assessment information collected determines the speed of assistance that a client receives during an emergency, and a validated priority system could be a matter of life and death.

Further, as the current system relies upon the manual update of assigning an ERL code, the designations may become obsolete. Many clients received only one ERL despite having multiple HC assessments and their change in health status.

A decision support algorithm that has been validated, that can be applied consistently across care settings, and which is automatically updated upon every assessment, allows for a comprehensive system of assigning priority. In addition to preventing unnecessary death or heath deterioration during emergencies, it may also prevent possible litigation when a low priority status has been arbitrarily and inappropriately assigned. It is therefore recommended that the VPR and VPR Plus decision support algorithms are implemented within the RAI assessment system to identify vulnerable populations in the response phase, replacing the ERL codes.

As the population ages and the number and intensity of emergencies and disasters increase, it is essential that the health care system adopts a method of prioritizing amongst home care clients that is reliable and provides for an up-to-date lists of high needs clients. It is only then that health care providers are able to deliver services to the right person at the right time, including during emergencies. A decision support system that employs the algorithms developed in this dissertation can achieve this, and it provides for a more consistent alternative to the ERL designations. Care coordinators will no longer need to separately assess for disaster vulnerability of clients because a decision support algorithm will automatically generate this information with the completion of the routine clinical assessment (RAI-HC).

This system of decision support algorithms is highly dependent on the timing of the RAI-HC assessment as well as on data quality. It is crucial that RAI-HC assessments are completed at least at six-months intervals in order for the data to provide for a current list of high needs clients during emergencies and disasters. Out-of-date information may lead to identification of the 'wrong' priority clients. Similarly, poor data quality may also lead to the misclassification of clients. Any decision support algorithm is only as good as the data it is based on. CCACs should ensure that RAI-HC assessments are completed competently, in accordance with international interRAI standards, and at appropriate re-assessment intervals.

To accomplish the automatic use of the VPR and VPR Plus algorithms in RAI-HAC assessment practice, these decision support algorithms require the adoption by the interRAI group of researchers as a new interRAI application. When adopted, the algorithms require implementation by the software vendors providing services to CCACs and other provinces and territories.

6.2 Implications for Emergency Management

The objective of emergency management is to make the community and its residents as safe as possible from untoward events, and as resilient as possible to their effects (Ferrier, 2009). The pre-disaster identification and registration of frail adults residing in community dwellings is a critical prerequisite for an effective emergency response during disasters (Baylor College of Medicine & American Medical Association, 2006; Centers for Disease Control and Prevention, 2012; Fernandez et al., 2002; Smith et al., 2009; World Health Organization, 2008). When older people are invisible to first responders it is often a result of failures in the preparedness phase to identify this most vulnerable group (Powell et al., 2009).

The results of this dissertation provide emergency managers with an opportunity to identify those most vulnerable before, during and after emergencies. It may enable emergency managers to have an understanding of the size of the population that may require assistance during an emergency and to develop targeted strategies to assist that population before the emergency occurs. They may come to an understanding that the current resources are insufficient in the event of an emergency as the group of individuals that are most vulnerable is larger than initially expected.

The analysis in chapter 3 showed the sizable numbers of high priority clients in Ontario as well as in some provinces and the Yukon Territory, depending on which algorithm is applied. The VPR and VPR Plus algorithms were highly predictive of mortality, LTC admission and hospitalization and were therefore chosen as the most appropriate algorithms. When comparing the algorithms with the ERL, as was done in chapter 4, the VPR and VPR Plus remain to be the preferable prioritizing mechanism.

Chapter 3 and 4 showed that the clients identified by the VPR and VPR Plus algorithms are considerably impaired. These clients are highly dependent on ADLs and IADLs, may have cognitive impairments and have higher levels of health instability. This rich health information in combination with a GIS application can provide for a visual display of areas with high density of vulnerable populations and their needs. The addition of geo-specific information which reflects hazard risks (e.g. flood plains) can equip emergency managers with the means to estimate required personnel, equipment and health care resources needed during the response and prioritize resources for those who may need them the most(Centers for Disease Control and Prevention, 2012; Smith et al., 2009).

Sharing of information is crucial to assisting the emergency managers in the development of strategies and building response capacity, including targeted response and recovery efforts. This dissertation has shown how valuable the information collected by CCACs through HC assessments can be for emergency managers. However, if this information does not reach the right partners at the right time, the data is underutilized. CCACs, emergency managers as well as other partners such as the Canadian Red Cross, should recognize the potential of a partnership and work together in the use and improvement of priority algorithms. The Canadian Red Cross is responsible for providing disaster support in many areas of Canada. In several municipalities the Red Cross is responsible for the registration of and providing assistance to victims of mass evacuations (e.g. forest fires in North Ontario) and smaller evacuations of buildings. The Canadian Red Cross is an important partner in providing the assistance to vulnerable individuals. Collaborative partnerships between these organizations would enable the development of a comprehensive planning, response and recovery system for addressing the needs of frail older adults.

Privacy legislation may be perceived as an obstacle to the disclosure of client information before, during and after emergencies. This may be overcome by seeking client consent to share their information during emergencies and disasters at the same time as the RAI assessment process. Further, privacy laws in Canada-and specifically in Ontario- provide for opportunities for the use and disclosure of personal information in the event of an emergency (Office of the Privacy Commissioner, 2013). A thorough assessment of the limitations due to privacy legislation is recommended.

Even the most frail elderly persons should be encouraged to engage in individual preparedness activities such as preparing an evacuation kit including a list of medications, medication allergies and sensitivities, an emergency contact list and an evacuation and transportation plan as well as a disaster supply kit with at minimum a seven day supply of all essential medication, water, food and flashlight (Lamb et al., 2008). Older persons with hearing impairments should plan for alternate ways of receiving warning notices, including adapted telephones or a support person that can provide the warning (Lamb et al., 2008).

The role of the primary caregiver and family members in times of emergencies as well as in assisting their loved-ones preparing for adverse conditions should also be acknowledged. When a client has been identified as high priority, it may be beneficial to inform primary caregivers and family members of this assessment result. Emergency preparedness is foremost an individual responsibility and family members caring for a high priority client should make arrangements to ensure he or she will receive assistance when disaster strikes.

It should however be noted that before, during and after disasters the pressure for informal caregivers to look after their loved-ones may be extremely high, and caregiver support may be needed in order to ensure their continued ability to assist their family members in disaster preparedness, response and recovery (Adams et al., 2011). Service providers should be encouraged to view informal caregivers as a vital member of the care team (Smith et al., 2009), and the establishment of communication channels with those caregivers is vital to the continuous welfare of the client.

Home care providers and community support services also have an important role in helping older adults prepare for emergency situations. It is recommended that these agencies develop policies and procedures for providing this assistance as well as reviewing the status of the client's personal disaster plan (Lamb et al., 2008). Education programs tailored to the needs of the elderly should be developed to encourage them to engage in individual disaster planning, and to view assistance from the disciplines of social work and psychology as a step towards regaining independence after a disaster rather as a threat and step towards institutionalization (Ngo, 2001).

As frail community dwelling adults often rely on home health care and community support services to maintain their independence and prevent adverse health outcomes, continuity of services should be maintained even in the most stringent of circumstances. During both the 1995 Chicago heat wave and 2003 French heat wave it was evident that organizations that provide services for the elderly were unable to transition from standard operational service delivery to crisis mode (Smith et al., 2009). "A lack of healthcare surge capacity and preparation by health care staff can leave older adults without care" (Banks, 2013, p. 96). Home health care and community service providers should therefore be encouraged to engage in pre-disaster planning activities. This would include pre-disaster knowledge of accessing help in disaster zones during shelter in place as well as integrating their services into evacuation and shelter management. If the special needs of frail older adults are not included in the planning efforts of home health care services, community service providers as well as traditional emergency management and response agencies, the critical needs of this vulnerable group may continue to go unmet (Fernandez et al., 2002).

6.3 Implications for Research

Further research should be conducted to examine the relationship between environmental stress as a result of an emergency, the health outcomes for sub-populations of clients, and the effect of rapid identification of and assistance provision to those most vulnerable. This information can be used to evaluate the VPR and VPR Plus as well as refine the decision support algorithms.

The 2016 Fort McMurrray wild fire and the Calgary floods in 2013 may provide further opportunities to conduct research using RAI-HC data. In comparison to the 2013 power outage in Southern Ontario both of these disasters were of longer duration and with more severe effects to the communities involved. Using the National Ambulatory Care Reporting System (NACRS) that contains data from hospital admissions and emergency department visits for post-disaster evaluation would also provide additional insight into the characteristics of clients in need of acute care during and after disasters.

It is important to note that any further research which may lead to the refinement of decision-support algorithms for use during disasters is contingent upon access to client-level data, and therefore highly dependent on the cooperation of health care providers in sharing detailed data. The data shared must include the exact location of clients during a disaster, the impact of the disaster as well as the services provided during and after the disaster. Only then can we thoroughly evaluate the health impacts of disasters and the reliability and validity of any priority algorithm.

It is recommended to implement the VPR and VPR Plus using a two-step approach beginning with integration in the RAI system for response, replacing the ERL, as earlier suggested. The second step would be to commence a pilot of the algorithms to examine applicability in <u>all</u> phases of emergency management, not only in the response phase. Once having identified good staff representation from a CCAC, these participants can evaluate the decision support algorithms in terms of practical applicability within the entire scope of emergency management, collaborating with municipalities and first responders, and with special attention to privacy legislation. Questions of particular importance include how can information be shared before, during and after emergencies between CCACs, emergency management professionals, municipal workers, hydro companies and first responders? What are the practical implications of the implementation of any decision support algorithm in sharing information, including technical implications, timing of sharing and the nature of the information shared?

It is important to acknowledge that there will always be persons that are not assessed by any RAI assessment instrument, but still be considered vulnerable based on the VPR and VPR Plus criteria. To avoid having these individuals fall between the cracks, an option of a web-based registry using interRAI items from the VPR and VPR Plus algorithms should be considered. Further research should focus on how such a registry could be implemented and maintained up-to-date.

During and after an emergency it is essential that persons are quickly assessed for vulnerabilities. A quick screener based on the VPR and VPR Plus during shelter-in-place, could assist service providers and home care agencies to assess the needs of their clients by phone. Additionally a door-to-door screener developed for organizations such as the Red Cross may support a rapid needs assessment for community dwelling older adults. In shelters, a screening tool may help shelter workers to rapidly identify the frailest older adults and address their needs quickly (Baylor College of Medicine & American Medical Association, 2006). All screeners should cover all domains of frailty and should include mental health items to help assessors detect and recognize the presence of mental health difficulties (Brown, 2007).

Suggested questions for further research are as follows:

1. How well did the VPR and VPR Plus decision support algorithms perform in identifying the most vulnerable group of RAI-HC clients during severe large-scale emergencies or disasters?
2. What were the health outcomes of those clients and did targeted interventions have any effect in reducing adverse health outcomes?
3. Does privacy legislation permit the sharing of client information before, during and after emergencies between health care providers, emergency management professionals, hydro companies, first responders, volunteer agencies such as the Canadian Red Cross and other organization involved in emergency management?
4. How can client information practically be shared in a timely fashion and what information should be shared?
5. How can information regarding vulnerable persons that are not assessed by any interRAI assessment be included in prioritizing assistance (e.g. web-based registry)?

6. How can the decision support algorithms be used to facilitate the identification of persons that have become vulnerable as a result of the emergency or disaster or were not identified as such before the disaster (e.g. wellness checks, rapid evacuation centre assessments)?

6.4 Strengths and Limitations

A major strength of this research is the multi-phased approach. Firstly, in chapter 3 four different decision support algorithms were compared in relation to their strength in predicting mortality, LTC admission and hospitalization. The VPR and VPR Plus appeared to be most predictive. In the chapter that followed the Emergency Response Level (ERL) codes were examined by assessing which variables were determinants of the ERL level in the HNHB and TC CCACs. Subsequently mortality, LTC admission and hospitalization rates were calculated and compared to the VPR and VPR Plus. Both the ERL codes and the VPR were highly predictive. In addition, c-stats showed that models with VPR and VPR Plus were a better or equal fit compared to models with ERL codes. When including the VPR and the ERL codes in one logistic model to predict death, the c-stat only increased with a few points. In a further chapter the impact to HC clients of a real life emergency, the 2013 ice storm in Southern Ontario, was examined.

The fact that the RAI-HC is a comprehensive assessment instrument with well-documented validity and reliability is a significant strength. This is in contrast to the ERL codes. Decisions around ERL designation appear to rely heavily on care coordinator's assessments of which reliability and validity have not been tested.

There are also some limitations of this research. Firstly, using the RAI database from the University of Waterloo is limited because it is de-identified to only include the first three characters of the postal code. For this reason it is not possible to pinpoint exact locations of vulnerable home care clients using Geographic Information Systems (GIS), which was of particular concern when using the Toronto Ice Storm data. This limitation could be addressed by using the original databases hosted by the CCACs. This would make it possible to pinpoint the exact locations of vulnerable persons, as well as the location of specific hazards by mapping the spatial distribution of hazards in Ontario (Gibson et al., 2013).

It should also be acknowledged that the accuracy of the 2013 Ice Storm data is limited due to poor data collection and sharing. Further, it is not known fully what actions were taken by different municipalities and CCACs, which may have influenced the health trajectory of clients in the different areas affected by the Ice storm.

Finally, this dissertation has only examined home care clients in Ontario and not other vulnerable populations assessed through other RAI instruments. Therefore, the applicability of the algorithm has not been tested in other care settings such as Long Term care (LTC) or the mental health sector. As many of the interRAI assessment tools share common core items, the algorithm may be applicable across the health care continuum. Also, although home care clients should be considered vulnerable a priori, there may be vulnerable individuals in the community that do not receive services from CCACs and who will therefor not be included in the priority setting. Further, this research is based on Ontario data only, and therefore further research into the applicability of the VPR and VPR Plus in other provinces and countries should be conducted.

This dissertation was aimed at determining the most vulnerable home care clients by dividing the clients into low, medium and high-risk groups, regardless of the type of emergency. To compensate for specific vulnerabilities, the VPR Plus was developed by including wheelchair users and clients that are dependent on oxygen and/or dialysis. A very popular approach in the emergency management field is the all-hazards approach. This approach recognizes that the actions required to mitigate the effects of emergencies are essentially the same, irrespective of the nature of the event (Public Safety Canada, 2011). In other words, it is not the type of emergency that stipulates the response; it is the need for activation of specific actions, such as evacuation and public warning, which determines the response. This dissertation has adopted this all-hazards approach by identifying three levels of priority clients, regardless of emergency type. Further research may be able to determine the vulnerabilities of clients specific to different types of required actions (e.g. evacuation, search and rescue, shelter in place).

Despite these caveats, this study has demonstrated the potential benefit of repurposing comprehensive assessment information before, during and after disasters. The assessment-populated databases are updated regularly and therefore reflect real-time representation of those most vulnerable (older) adults. With valid and reliable decision support algorithms, the interRAI databases may prove to be the next generation vulnerable persons registry for first responders and emergency management professionals all over the world, without the burden of expensive maintenance.

6.5 Recommendations

This dissertation was aimed at producing decision support algorithms that are highly anticipated by many organizations. First responders (fire departments and paramedics), emergency management organizations (such as the Canadian Red Cross, Regional and Municipal Community Emergency Management Coordinators (CEMC)) and CCACs are among the myriad of organizations that could benefit from the findings. The following recommendations are made:

- Implement the VPR and VPR Plus as an indicator automatically generated by the RAI-HC assessment system, replacing the ERL codes, and provide CCACs with guidelines on how to use the resulting information during emergencies and disasters.
- Continue to test the algorithm(s) by applying it to HC datasets of clients living in an area affected by a large-scale emergency (e.g., the forest fires in Fort McMurray).

- Pilot the decision support algorithms with staff representation from one CCAC, in order to assess the usefulness of the data during all phases of emergency management (prevention/mitigation, preparedness, response, recovery) and collaborate with emergency management professionals and first responders to identify possible barriers for further implementation within the emergency management field, beyond the CCACs and the response phase.
- Encourage the collaboration between CCACs and Canadian Red Cross to provide a standard data collection method during large-scale emergencies and disasters.
- Add an item to the standard Red Cross assessment forms for evacuation centre intake that indicates whether the person is receiving CCAC or community support services.
- Continue the development of priority algorithms and distinguish between different types of emergencies and required actions.
- Introduce the data into Geographic Information Systems (GIS) to support decisions during, before and after emergencies.
- Examine the applicability of the algorithm(s) in other care settings.
- Continue research into the development of rapid assessment screeners for evacuation centres and door-to-door wellness checks.
- Based on VPR and VPR Plus criteria, implement a web-based registry for those vulnerable persons that are not captured by any interRAI assessment, and investigate how such a system can be implemented (including information sharing with first responders) and kept up to date.
- Develop a care planning protocol triggered by the VPR (Plus) algorithm to provide guidance to health care providers on how to deal with emergencies involving vulnerable persons.

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