The distribution and determinants of hospital readmission among people living with HIV/AIDS in British Columbia, Canada

by

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M.Sc., California State University, East Bay, 2013

Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

in the
Master of Science Program
Faculty of Health Sciences

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SIMON FRASER UNIVERSITY

Spring 2018

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Abstract

Unplanned hospital readmissions are costly and common among people living with HIV/AIDS (PLWHA). However, factors associated with readmission remain poorly understood. The purpose of this study was to examine the distribution and risk factors of 30-day readmission among the population of PLWHA in British Columbia, Canada. A retrospective cohort study using linked administrative data was executed with multivariable logistic regression models to identify risk factors of readmission. Approximately 14 percent of all hospitalizations resulted in 30-day re-hospitalization, 5.5% higher than the readmission rate for the general population in Canada. Four enabling factors (longer length of stay in the index hospital admission, admission via emergency departments, leaving against medical advice, transferring between hospitals); one need factor (latest CD4 count prior to admission) and one predisposing factor (diagnostic category) were associated with an elevated odds of readmission. Policymakers should develop strategies focusing on modifiable risk factors to decrease hospital readmission among PLWHA.

Keywords: HIV/AIDS; hospital readmission; quality of care; British Columbia; Canada

Dedication

To my love, Arash, who always inspires me and believes in me.

Acknowledgements

I would first like to thank my supervisor, Dr. Bohdan Nosyk for his continuous support for my thesis and for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. This thesis would not have been possible without his support.

I would like to thank my thesis supervisory committee, Dr. Lawrence McCandless, Dr. Robert Hogg, and the former supervisor Dr. Charles Goldsmith who have generously given their time and expertise to improve my thesis by their valuable comments and questions. I would also like to thank Dr. Stuart Peacock for his generous time and support.

I am grateful to many persons in the BC Centre for Excellence in HIV/AIDS (BCCfE), especially Guillaume Colley, Shahab Jabbari and Jeong Eun Min to share their experience on data analysis, and all other BCCfE employees who made me feel so comfortable when I commenced my thesis there. I am grateful too for support of this thesis by the Canadian Observational Cohort Collaboration (CANOC).

Last but certainly not least, I would like to express my gratitude to my family: to my mother, to my husband, and to my sister and brothers whose generous support always motivated me to take one more step in my life.

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List of Acronyms

AHRQ	Agency for Healthcare Research & Quality
AIC	Akaike Information Criterion
AIDS	Acquired Immunodeficiency Syndrome
ALC	Alternate Level of Care
AMA	Against Medical Advice
AMI	Acute Myocardial Infraction
ARV	Antiretroviral
ART	Antiretroviral Therapy
BC	British Columbia
BCCfE	BC Center for Excellence in HIV/AIDS
CANOC	Canadian Observational Cohort Collaboration
CI	Confidence Interval
CIHI	Canadian Institute for Health Information
CMG	Case Mix Group
CMS	Centers for Medicare and Medicaid Services
DAD	Discharge Abstract Dataset
DRG	Diagnosis Related Groups
ED	Emergency Department
ECFAA	Excellent Care for All Act
GEE	Generalized Estimating Equation
GLM	General Linear Model
HA	Health Authority
HAART	Highly Active Antiretroviral Therapy
HCUP	Healthcare Cost and Utilization Project
HIV	Human Immunodeficiency Virus
HSDA	Health Service Delivery Areas
ICD	International Statistical Classification of Disease and Related Health Problems

ICD-9-CM	International Statistical Classification of Diseases and Related Health Problems, Ninth Revision, Clinical Modification
ICD-10-CA	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada
LACE	Length of stay, Acuity of illness, Charlson comorbidity score, Emergency department visits
LHA	Local Health Areas
LOS	Length Of Stay
MCC	Major Clinical Categories
MDC	Major Diagnostic Categories
MedPAC	Medicare Payment Advisory Commission
NCQA	National Committee for Quality Assurance
NQF	National Quality Forum
NSQIP	National Surgical Quality Improvement Program
OR	Odds Ratio
PHAC	Public Health Agency of Canada
PHSA	Provincial Health Services Authority
PLWHA	People living with HIV/AIDS
PPR	Potentially Preventable Readmission
PQI	Prevention Quality Indicators
QIC	Quasi-likelihood under Independence model Criterion
QIP	Quality Improvement Plan
SAS	Statistical Analysis System
SD	Standard Deviation
SQLape	Striving for Quality Level and analyzing of patient expenses
SSI	Surgical Site Infection
STOP HIV/AIDS	Seek and Treat for Optimal Prevention of HIV/AIDS
TasP	Treatment as Prevention
UNAIDS	Joint United Nations Programme on HIV and AIDS
WHO	World Health Organization

Chapter 1. Introduction

Unnecessary hospital readmissions within 30 days after discharge have been receiving increased attention as a benchmark for quality of care[1,2]. Readmissions are common and impose a high cost to the healthcare systems. In Canada approximately one in 12 patients (8.8%) admitted to a hospital were readmitted within 30 days after discharge[3]. Readmission is even higher among people living with Human immunodeficiency virus (HIV) and Acquired Immune Deficiency Syndrome (PLWHA) than the general population[4]. In the United States, the readmission rate is 44% higher among PLWHA than among the general population (19.3% versus 13.2%, respectively)[4]. For HIV-infected people in the United States, approximately one in four hospital admissions were followed by a readmission within 30 days of discharge[5]. Among the 10 most frequent diagnostic categories of those admitted to hospitals, people with Acquired immunodeficiency syndrome (AIDS) defining illnesses had the second highest readmission rate[4]. Since a considerable number of readmissions are potentially preventable[6], a better understanding of risk factors associated with readmissions among PLWHA might support efforts to improve patient care, and to reduce healthcare costs.

Hospital readmissions are costly, and some of these readmissions are preventable. In Canada, hospital readmissions occurring within 30 days of discharge cost $1.8 billion in 2010[3], and prior studies have shown that anywhere from 9% to 59% of these readmissions are preventable[3]. In the United States, the overall cost associated with readmissions was approximately $41.3 billion in 2011[7], with preventable readmissions comprising more than half of that cost[8]. A systematic review by Van Walraven et al.[9] found that the median percentage of preventable readmissions was 27%, varying from 5% to 79%. According to the U.S. Medicare Payment Advisory Commission (MedPAC), the cost of avoiding 1 out of every 10 readmissions could save the U.S. healthcare system $1 billion in 2013[8]. For PLWHA, the rate of preventable readmissions is even higher. In a study focusing on 30-day hospital readmissions among 930 HIV-infected people and using electronic medical records Nijhawan et al.[6] found that approximately 50% of readmissions were potentially preventable. A single hospital admission

for a PLWHA was estimated to cost more than $15,000 in the U.S.[5], considerably higher than the average cost per hospital stay of $9,700[10] (Figures presented in 2012 USD) Reducing preventable hospital readmissions is therefore a key target for healthcare sustainability.

Hospital readmission may occur for many reasons such as actions taken or omitted during the initial hospitalization, incomplete treatment, and substandard quality of care[11,12]. Preventable readmissions may also reveal system-level issues related to “integration among healthcare providers“[13]. A report by the U.S. MedPAC suggested that approximately 75% of readmissions among Medicare fee-for-service beneficiaries can be avoidable because they result from a fragmented healthcare system[14,15] that has multiple decision makers[16]. In such healthcare systems, patients would be discharged with hospital complications, inadequate follow-up or post-discharge planning[15]. In Canada, the lack of an integrated healthcare system has resulted in high readmission rates[17,18]. The number of preventable hospital readmissions may be decreased if patients received the care they need at the appropriate time and place.

Hospital readmission is an important measure of quality of care which can serve as a basis for healthcare providers to improve healthcare quality and efficiency. Healthcare policymakers looking for ways of decreasing the costs of medical care need to have an understanding of the distribution and risk factors of hospital readmissions across different disease areas to evaluate any potential opportunities and strategies for improvement of healthcare quality and sustainability. Achieving these goals requires the identification of modifiable risk factors regarding patients, hospitals, and communities.

1.1. Background

1.1.1. HIV/AIDS: etiology

Human Immunodeficiency Virus (HIV) is a virus that attacks the immune system, the body’s natural defense system, in particular, the specific white blood cells called CD4 cells. CD4 cells help the immune system to fight off infection. Left untreated, HIV reduces the number of CD4 cells in the body, leaving the body vulnerable to infections and cancers. Unlike some other

viruses such as Hepatitis A and influenza viruses, HIV will remain in the human body for life. HIV can be transmitted from an infected person to another through direct contact of bodily fluids such as blood, semen, vaginal secretions, or breast milk. The most advanced stage of HIV infection is AIDS, which can take from 2 to 15 years to develop depending on the individual[19]. Although there is no effective cure for HIV, current treatments such as antiretroviral therapy (ART) have increased the life span of individuals diagnosed with HIV to equal that of people who do not have HIV[19]. HIV can be suppressed by combination ART consisting of three or more antiretroviral (ARV) drugs. By reducing the amounts of HIV in human body, HIV medicines also reduce the risk of transmitting the virus to others.

1.1.2. Global HIV/AIDS epidemiology

HIV is a global pandemic. Approximately 36.7 million people were living with HIV in 2015 worldwide, with 2.1 million people becoming newly infected in that year[19]. The vast majority of people living with HIV are in low-to middle-income countries. Sub-Saharan Africa is the most affected region with 25.6 million people living with HIV in 2015. This region also accounts for two-thirds of the global total of new HIV infections. Of all individuals living with HIV, approximately 4.9% were children (less than 15 years old), and children comprise 7.1% of new infections.

The most-affected populations are people who are more vulnerable to HIV infections such as individuals having unsafe sex, injection drug users, and men who have sex with men. World Health Organization (WHO) documented the HIV epidemic in men who have sex with men with an estimated median HIV prevalence varying from 4.3% to 14.9%. The estimated global HIV prevalence in prisoners, people who inject drugs, and transgender women is 3%, 13%, and 19%, respectively. Injection drug use accounts for approximately 10% of all HIV infections worldwide. Globally, female sex workers are 13.5 times more likely to be living with HIV than other women of reproductive age[20].

Efforts to prevent the spread of HIV/AIDS has helped to reduce HIV prevalence rates in a small but growing number of countries, including Kenya, Zimbabwe, and some countries in the Caribbean region. Changing in behaviour to prevent infections such as increased use of

condoms, delay of first sexual experience and fewer sexual partners have been major attempts in this decline[20]. To plan an effective HIV prevention response, some main keys should be considered. These include knowing the population groups at elevated risk of infection, the extent to which HIV is preventable among different populations, and the laws and policies which may affect the transmission of HIV. There are four different epidemiological scenarios asserted by the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the WHO: low level, concentrated, generalized, and hyperendemic. In a low-level epidemic, HIV has not spread to considerable levels in any sub-population and the prevalence of HIV infection has not consistently exceeded 1% in the general population nationally or 5% in any sub-population. In a concentrated epidemic, HIV has spread rapidly in one or more sub-populations (such as injection drug users or sex workers and their clients) but is not well established in the general population. In a generalized epidemic, HIV is firmly established in the general population and the majority of new infections occur due to HIV transmission in couples with mixed HIV status and multiple-partner relationships. In a hyperendemic epidemic, HIV is established in the general population. In this situation, additional strategies for effective HIV prevention are required owing to the differences in the level and risk factors of the epidemic. These categories are for the purpose of epidemiological surveillance, which is the ongoing systematic collection, recording, analysis, interpretation, and dissemination of data reflecting the current health status of a community or population.

1.1.3. The HIV/AIDS epidemic in Canada

In Canada, there were approximately 75,500 individuals living with HIV/AIDS at the end of 2014, reflecting a 9.7% increase since 2011[21]. The number of new HIV infections in Canada has decreased slightly from 2011 to 2014. British Colombia (BC) is one of the four most populous provinces in Canada, and has the third highest HIV prevalence rate among Canadian provinces. However, BC noted a 17.4% decrease in prevalence from 2011 to 2012. These four provinces together accounted for 93.3% of all positive HIV test reports since 1985 and 94.4% of all AIDS cases since 1979[22]. Based on estimates from the Public Health Agency of Canada (PHAC), there was a decrease in the number of new HIV infections in 2011 from the peak in 1985. Of the 75,500 individuals living with HIV in Canada, 21.0% were unaware of their HIV infections. However, the number of PLWHA in Canada is increasing. There are two reasons for

this increase: the decreasing number of HIV-related deaths after the introduction of antiretroviral medications, as well as continued HIV incidence[21,22]. Based on PHAC estimates, 2,570 new infections occurred in Canada in 2014, which is slightly lower than the number of new infections in 2011[21].

1.1.4. The treatment and prevention of HIV/AIDS

There is no cure for HIV infection. However, effective treatment can control the virus and help prevent transmission[19]. According to the WHO, by the end of 2014, 40% of all people living with HIV were on ART. HIV can be suppressed by ART, which consists of a combination of three or more antiretroviral drugs[19]. ART does not cure HIV infection but controls viral replication within a person's body and allows an individual's immune system to strengthen and regain the capacity to fight off infections. By decreasing the level of virus in an individuals' bloodstream and sexual fluids, ART results in prevention of the emergence of AIDS-related diseases and premature death[23].

Moreover, if an HIV-positive person adheres to an effective ART regimen, the risk of transmission through sexual contact can be reduced by 96%[19]. A considerable decrease in the number of newly-diagnosed cases was shown after the launch of ART in 1996. The BC Center for Excellence in HIV/AIDS (BCCfE) reported that in BC, implementing ART resulted in decreasing new HIV diagnoses by 60%, from 501 cases diagnosed in 1996 to 301 cases in 2010[23]. Population-level data as well as demographic and mathematical models in BC suggest that maximal coverage with ART could lead to the near-elimination of HIV transmission[24].

The number of HIV-infected individuals in Canada has been predicted to increase in the coming years, which means an increase in the demand for healthcare[21]. Frequent hospitalization is not only common and costly for HIV/AIDS patients but also for the healthcare system[4,5,25]. In Canada, inpatient care for PLWHA accounts for 19% to 68% of total healthcare cost, which varies based on the stage of the illness[26]. The overall acute care inpatient cost was $17 billion for 2004-2005 in Canada[27]. A single admission for HIV in the United States cost more than $15,000 in 2004[28]. However, a portion of the imposed costs can be saved because some readmissions are preventable. The cost of unplanned readmissions (which may or may not be

preventable) is also substantial. In 2004, approximately 17% of the total U.S. Medicare budget for hospital payments was spent on unplanned readmissions[29].

1.1.5. Hospital readmission, a marker of quality of care

Hospital readmission rates have been used as one indicator of the quality of care provided by hospitals for several reasons[30,31,32]. First, the risk of readmission is increased by a lower quality of inpatient care during the initial hospital stay[33,34]. Ashton et al.[34] in a study on patients with heart failure, diabetes, or obstructive lung disorders found an association between the quality of care during the primary admission and readmission within 14 days. They showed the risk of unplanned readmission was increased by a lower quality of inpatient care (some aspect of the process of inpatient care including substandard, normative, and exceptional care) at index admission[34]. Second, readmissions are common[30] and can happen for a wide variety of reasons[30]. The factors that are important in readmission include patient-related factors such as sociodemographic factors, disease severity and treatment, or healthcare utilization. Finally, it is possible to calculate and adjust readmission rates because the required data are routinely collected electronically for administrative and reimbursement purposes in Canada.

In Canada, the website of the Canadian Institute for Health Information (CIHI) provides information on several indicators including the quality of care, including nine measures of hospital readmission[35]. Similarly, the Centers for Medicare and Medicaid Services (CMS) in the United States provides a Hospital Compare tool which assists patients in making decisions about their healthcare. A hospital's readmission rate adjusted for patient characteristic (e.g. age, past medical history, and other diseases or conditions) is one of the indicators of this tool to identify how well hospitals provide care to their patients. In the United States, the Hospital Readmission Reduction Program, initiated in 2012, requires Medicare and Medicaid Services to reduce payments to acute care facilities with high 30-day readmission rates on heart failure, pneumonia, and acute myocardial infarction (AMI)[15]. It means that hospitals, to avoid being penalized, need to show evidence of improving quality of care, measured in part by their readmission rate.

In Canada, fragmented care (the lack of care integration such as poor provider / information continuity) has several undesirable effects on quality of care, patient health, and waiting times for services[18,36]. An example of fragmented care is a lack of information from a patient's previous visits being available to physicians. A study by Van Walraven et al.[37] showed that visiting one of the regular physicians after being discharged is associated with a lower risk of hospital readmission. The current lack of integrated information systems across hospitals in Canada has resulted in errors and delays in transferring patients between healthcare providers[18]. A study by CIHI revealed that the unplanned readmission rate was approximately 8.5% among all acute care patients in Canada during the year of the study, indicating that approximately one in 12 acute care patients returned to the hospital within 30 days of discharge[3].

In BC, primary and community care services are distributed through a variety of different healthcare providers including general practitioner (GP) offices and hospitals[38]. There are several resources for primary care which are often uncoordinated. For example, patients with a family physician have ready access to primary care services, but patients who receive occasional care through a walk-in clinic or an emergency room because they do not have access to a family doctor may not be as well connected to the healthcare services they need.

Health services for HIV care in BC are also fragmented. While HIV testing services might be provided by public health services, HIV treatment and support might be provided through clinics and community services, respectively. This fragmentation results in less connection in provided care from one service to the next. To have an effective response, HIV prevention and treatment need to be integrated because HIV prevention, diagnosis, treatment, and support are all critical in reducing HIV-related morbidity, mortality and transmission[39].

1.1.6. Risk factors of hospital readmission

Hospital readmissions are influenced by several factors, including the patient as well as hospital and community effects[3]. Factors associated with the risk of readmission in general inpatient populations have been assessed by a number of different studies[5], yet analyses on

factors associated with the 30-day risk of readmission among PLWHA are relatively scarce[4,5,6,25,40].

Several different conceptual frameworks have been used to identify the risk factors associated with readmission. Some studies used a conceptual framework based on clinical expertise on medical co-morbidities and therefore categorized the factors in terms of clinical and nonclinical factors[5]. A study on risk factors of unplanned readmissions in cancer patients[41] adopted the conceptual readmission model (Appendix B). The study framework considered patient characteristics including fixed (e.g. age) and modifiable (e.g. drug or alcohol use) characteristics, clinical characteristics (e.g. comorbidity and pain), hospitalization (e.g. length of stay [LOS]), and discharge planning (e.g. discharge disposition) as components related to high readmission rates. In the original framework (developed by Anthony et al., 2005), hospital characteristics were also considered. Another conceptual framework which has been widely used is Andersen's behavioural model of health services utilization[41,42]. We describe this theoretical framework and how it supported our effort to identify risk factors associated with hospital readmission, particularly those amenable to direct intervention.

1.1.7. Theoretical framework: The Andersen behavioural model

The Andersen model is one of the most widely used theoretical frameworks to predict healthcare utilization[43]. The model is attractive for its high level of flexibility in selecting relevant risk factors as well as its usefulness for health services research[42].

The initial model was developed in the 1960s, with the intention of providing an overarching theory to describe the factors that lead to the use of health services. The Andersen model was designed to fulfill three aims: first to understand why families use health services, second to define and determine the equality of access to healthcare, and third to assist in improving policies to provide equal access to healthcare services. Later, the unit of analysis, family, was changed to individuals because measuring some indicators such as the status of health was difficult in a family-level unit. The model defines healthcare utilization (such as hospitalization and subsequent readmission) as a function of three components: predisposing characteristics, enabling resources, and need factors. The ability of the model's components to

explain the outcome differs based on what type of service is scrutinized. For example, hospital services for more serious conditions would more likely be explained by demographic and need factors, while optional health services such as dental services are likely explained by socioeconomic status, health beliefs, and enabling characteristics[44].

The first component of the theoretical model, which delineates the individual's predisposition for the use of services, includes demographic factors, socioeconomic status, and health beliefs. Demographic characteristics such as age and gender, which mostly indicate biological requirements, suggest the probability of the need for healthcare utilization. Social and structural factors, including education and ethnicity, suggest the status of the individual in the community, individual capabilities, and resources to manage current problems. The last subset of this group, health beliefs, includes the individual's knowledge and attitude toward health and health service use which might influence the individual's desire to use health services. In fact, the effects of socioeconomic status on enabling resources, perceived needs, and utilization can be described by health beliefs.

The second component of the model is personal and community enabling resources. If a person has a predisposition to use healthcare services, certain means are needed to enable the individuals to use services. The individual must have sufficient resources such as income, regular healthcare providers' visits, and the ability to travel to be able to access services. Community resources such as health insurance, health facilities and health service providers are the resources available within the community for health services. Means of transportation, travel time to and waiting time for healthcare are also considered as enabling factors because they enable the individuals to use health services.

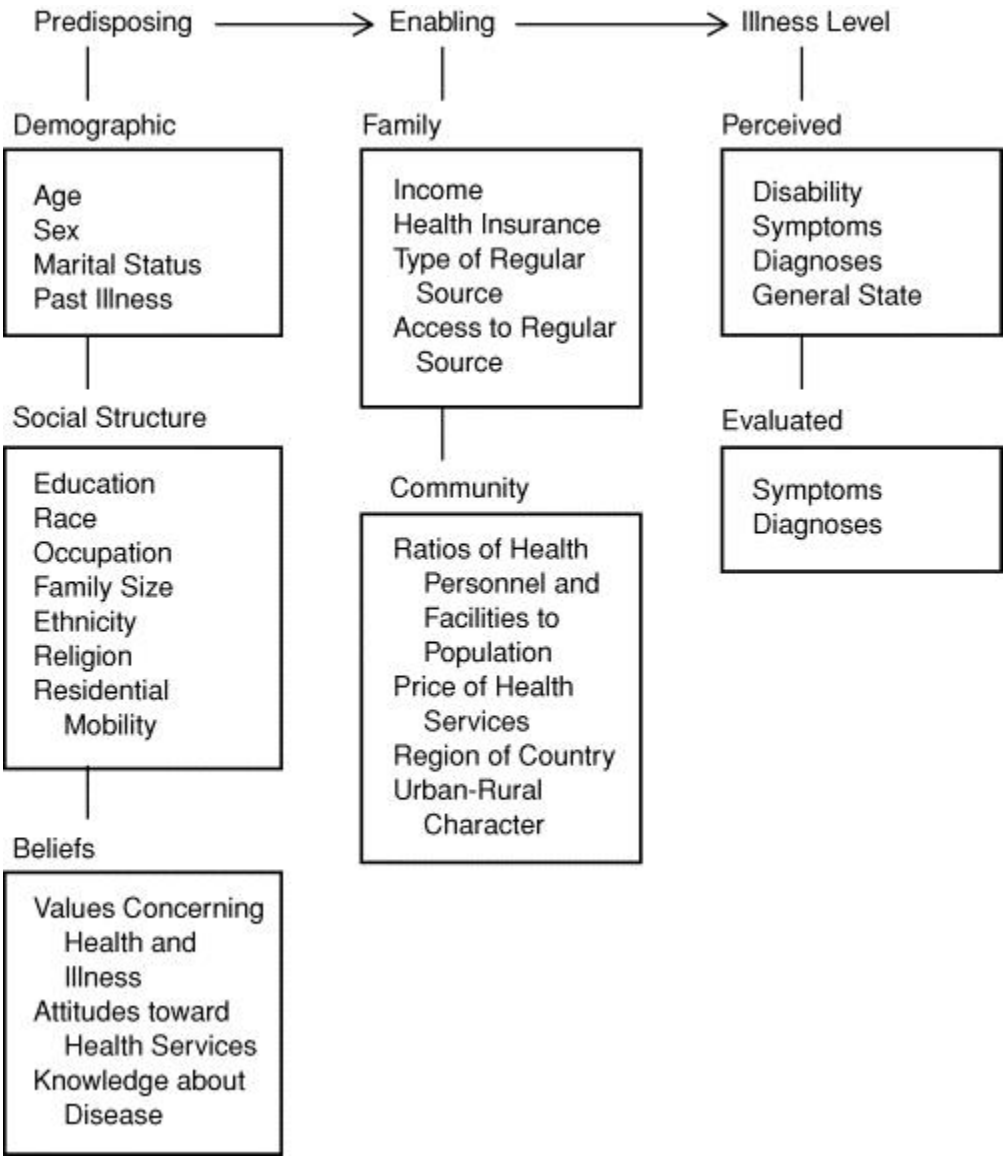
The last component of the model, need factors, include perceived/evaluated needs. To use a healthcare facility, it is important to consider the effects of the evaluation of the health status of the person. This evaluation can be based on the person's view of his/her status of health (perceived need) or a professional evaluation of the individual's health status and the individual's need to use the healthcare services (evaluated need). The symptoms of disease which are experienced by the individual affect the person's decision on looking for healthcare utilization which is considered in the model as perceived need. Socioeconomic status and

health beliefs also account for an individual's need to seek services. However, need factors can also be explained by biological effects. In the model, perceived need reflects an understanding of the individual's seeking of care and adherence to a medical regimen, whereas evaluated need sheds light on the type and amount of the required treatment for the person as a patient.

The last point about the Andersen model is the concept of mutability. Mutability is defined as the degree to which a factor may change and thus bring about health services' distribution change. For the model, the degree of mutability is categorized in three levels: low, moderate, and high. Predisposing factors are considered low-mutability factors because these factors cannot be changed to alter healthcare utilization. Factors such as education in the socioeconomic status set can be changed but only in the long-term; therefore, they are considered to have low mutability. Enabling factors are considered to have a high degree of mutability because some of them which are strong factors leading to the use of health services, e.g. healthcare insurance, can be modified in the short term. Finally, need variables are also judged as mutable variables because both perceived and evaluated need may be altered. For instance, an individual's perceived need for seeking help may increase or decrease according to other factors such as changes in an individual's resources.

As it mentioned before, the Andersen behavioural model of healthcare utilization (Figure 1.1) includes three groups of factors that also affect the individual use of health services. Any individual, contextual risk factors of health service use can be categorized in one of the three groups[42]. Hospital- and neighbourhood-level characteristics which may affect readmissions are also categorized in one of the three categories of the model using other related studies. Therefore, the model can be properly adopted, revised, or expanded to study the risk factors of hospital readmission for PLWHA as one aspect of health service utilization. The model defines the mutability of each level that allows us to identify potentially changeable factors to reduce readmission.

Figure 1.1. Individual-Level determinants of health service utilization



Source: Andersen R, Newman J. Societal and Individual Determinants of Medical Care Utilization in the United States. Milbank Q. 2005 Dec; 83(4):1-28.[45] Copyright © 2005 Milbank Memorial Fund

1.2. Rationale for this research

Hospital readmissions are common and costly for healthcare systems and impose excessive stress on patients and their families[25]. HIV-infected people admitted to the hospital are at higher risk for readmission than other patients[4,25]. Although highly effective treatment regimens were developed for HIV/AIDS in 1996, readmission rates among this population remain high. In addition, PLWHA are at higher risk of developing an infection by "cross-contamination in the healthcare setting" due to their weakened immune systems[46]. Therefore, PLWHA are more vulnerable to adverse events due to low quality of care.

A study by the Agency for Healthcare Research and Quality (AHRQ) showed that among Medicaid patients, PLWHA had the highest readmission rates at 17%[47]. All other illnesses had much lower rates than those of PLWHA; the second and third highest rates belonged to patients with blood-related disorders at 14% and alcohol or substance abuse patients at 13%, respectively.

In BC, the BCCfE has been successfully implementing its aims to enhance finding cases of HIV infection, extending access to ART, and monitoring HIV incidence and HIV/AIDS-related mortality and morbidity[48]. To fulfill its aim of evaluating the impact of expansion of ART access on the number of new infections (HIV incidence) in BC over 5 years, the BCCfE, in collaboration with other provincial partners, devised the Seek and Treat for Optimal Prevention of HIV/AIDS (STOP HIV/AIDS) provincial program.

The STOP HIV/AIDS program began as a pilot project to extend HIV testing and support services to medically eligible people in the Vancouver Coastal and Northern Health Authorities in 2011[48]. It was expanded to the entire province in 2013. The program provides services for vulnerable populations dealing with access to HIV treatment and care. Implemented with the support of the provincial government and each of the health authorities, the program has increased HIV testing as well as ART coverage among people diagnosed with HIV/AIDS. Expanding access to ART not only reduces HIV-related morbidity and mortality, but also prevents HIV transmission. Expanding access to ART is therefore a highly cost-effective approach to reducing the public health burden of HIV/AIDS[49].

Analyzing readmissions among PLWHA is in line with the STOP HIV/AIDS provincial program to identify detailed information on one critical aspect of quality of care that may be potentially actionable by policymakers and healthcare providers. The increase in the quality of care of this population means a longer life for HIV infected people. The Epidemiology and Population health program at the BCCfE monitors the impact of HIV/AIDS epidemic in BC.

1.3. Purpose of the research

The primary purpose of this research was to determine hospital readmission rates and to identify risk factors associated with hospital readmission among PLWHA in BC, Canada. By doing so, we hoped to identify actionable policy recommendations to reduce the risk of hospital readmission, thus improving the quality of care for PLWHA and contributing to the control of the HIV/AIDS epidemic in BC.

1.4. Research objectives

This research had two core objectives for which specific questions were addressed:

Objective 1: To identify the distribution of 30-day readmission among PLWHA over time.
Objective 2: To identify the factors associated with readmission at the patient, hospital, and community levels among PLWHA.

Using the Andersen behavioural model, the mutable variables which explain readmissions will be examined. Based on the literature review in chapter 2, we hypothesize a high all-cause 30-day hospital readmission rate among PLWHA, with several mutable variables with which to inform public health response.

1.5. Thesis outline

Chapter 1 presents a brief review of the topic as well as a description of the objectives of the research. Chapter 2 provides further explanation of the topic based on a literature review of

hospital readmission patterns, terms and definitions, preventable readmissions, and factors associated with hospital readmissions. In chapter 3, first data sources, study population, outcome/explanatory variables, and calculating readmission rates are described. Next, in the statistical analysis section, the univariable/multivariable analysis of the outcome and proposed risk factors are explained. Chapter 4 is devoted to presenting the results of the study based on descriptive and logistic regression analysis. Discussion, conclusions, and recommendations are presented in chapter 5, based on the findings and interpretation of the results from chapter 4.

Chapter 2. Literature review

The following chapter presents a review of the literature relevant to our study population and objectives. First, readmission patterns are discussed; next, definitions and terms used for readmission analysis are explained. The theoretical framework of the study and known determinants of hospital readmission are also explained in this chapter. For the literature review, the PubMed database and Google Scholar were searched using keywords: HIV/AIDS, hospital readmission, quality of care, BC, and Canada. To find relevant literature, a combination of keywords and Boolean operators (such as OR and AND) and search operators (such as asterisks and quotation marks) were used. Articles in PubMed were reviewed for relationships to hospital readmissions, hospital readmissions among HIV-infected people, or preventable readmissions. Further, priority was given to articles using Canadian data and in relation to Canadian hospitals and the Canadian healthcare system. References of review articles, relevant documents in the form of scientific reports, and conference presentations were also included in the search.

2.1. Hospital readmission among PLWHA

A challenge in healthcare systems is to balance the quality of care with the cost of healthcare. Studies have shown that hospital readmissions may occur because of poor quality of care in the index admission[50]. Hospital readmissions within 30 days of discharge have been debated as a benchmark measure of quality of care, which affects healthcare resource utilization directly[14,27,51]. Mortality[52,53,54] as well as hospital admission rates for people with advanced stages of AIDS have decreased considerably following the introduction of ART[5]. However, inpatient admission rates among PLWHA remain high. Not all PLWHA admitted to hospital are treated with ART, for several reasons such as the patient's beliefs about the effectiveness of the treatment[5,55,56,57,58] and giving up the treatment due to the side effects[5,55,59,60]

or at the physician's discretion[55,61,62]. In a study from 2005 to determine the impact of ART on hospital readmission among PLWHA hospitalized at St. Paul's hospital in Vancouver, BC, Canada, Nosyk et al.[55] found that PLWHA who were not on continuous ART were more likely to be readmitted than those who were on continuous treatment of ART.

In addition, PLWHA may not choose ART due to having no access to the treatment[55], drug side effects, unexpected systemic complications[63], illicit drug use, being on ART for 31-60 months[64], fear of consequences, perceived lack of need by the respondent, and not being recommended by their physician[65]. There are two major barriers to accessing ART, including financial barriers and marginalization from the healthcare system which may be accountable for the issue[66]. Not all PLWHA in Canada benefit from free access to the treatment[66]. BC is the one province in Canada which offers ART to all PLWHA free of charge. Research shows that even in a setting offering free healthcare, the issue of not having ART still persists[66]. A previous study of female sex workers living with HIV/AIDS in Vancouver's Downtown Eastside in 2005 revealed that 91% of these individuals did not have access to ART for the following reasons: side effects, inability to follow a daily regimen, inability to attend follow-up medical appointments, and fear of revealing their illnesses[67]. Marginalization from the healthcare system is another barrier to access to ART. For example, a study among a Canadian cohort of HIV-positive injection drug users by Tapp et al.[68] indicated that females who inject drugs are less likely to access ART. The possible explanation is that they are street-involved and engage in survival sex, unlike most male injection drug users. In addition, utilization of ART reduces admission rates among PLWHA who were hospitalized due to AIDS-related issues but not for other reasons[6]. Although ensuring ART engagement following hospital discharge can decrease the risk of readmission[55], there are still PLWHA who do not wish to adhere to the treatment.

Readmissions are common for the general population; however, readmissions among PLWHA are consistently noted across settings as being more frequent[4]. In the United States, 19.7% (95% confidence interval [CI] 19.3-20.0%) of hospital admissions among PLWHA were followed by a readmission within 30 days, approximately 44.0% higher than that of the general population[4,40]. Compared with the uninfected, PLWHA have a higher readmission rate[5,40,69]. A study by investigators from the John Hopkins University School of Medicine found that the readmission rate for PLWHA in Baltimore was 59% higher than that of non-HIV-infected

people[70]**.** Thus, it is important to examine readmission rates among PLWHA, as they represent a large economic and public health burden to healthcare systems.

2.2. Hospital readmission, definitions and terms

Generally, hospital readmissions are defined as a return to hospital within a specific time interval after a discharge from a previous admission. Measuring hospital readmission is complicated because there are no uniform definitions of the index admission, readmission, and readmission rate[9]. However, studies frequently used the methodology of the CMS to define index admissions and 30-day readmissions[4,5,25].

The CMS measures of readmissions are well-known and have been used in numerous studies. The readmission measures of the CMS were also recommended by the National Quality Forum (NQF) in the United States for public reporting and quality of care improvement[51]. The definition of readmission is an admission to an acute care hospital within 30 days of discharge from an acute care hospital[71]. The index admission is defined as any eligible admission to an acute care hospital which is not a readmission, i.e., it does not occur within 30 days of a prior hospital admission. To be classified as an eligible index admission, a hospitalization has to have a discharge status of alive. Also, if the patient is transferred to another acute care facility upon discharge, the admission is not an index admission. The reason is that in an episode of care in which patient is transferred among hospitals, responsibility for the readmission is assigned to the final discharging hospital[71]. However, if a transfer happened during an episode of care, the discharging final hospital is responsible for any readmission. Admissions in which patients discharged against medical advice (AMA) are excluded from being an index discharge because hospital fulfilment of the patient's care was not possible. The CMS measures are considered all-cause unplanned readmissions[71]. Planned readmissions are not considered because they are not a signal of quality of care. In many studies also, unplanned readmissions were considered[3,72,29,32,41,71,73,74]. With these stipulations, CMS calculates hospital readmission rates as the number of readmissions divided by the number of index admissions for a given period.

The CMS's methodology was used in two studies of PLWHA conducted by Berry et al.[4,40]. They defined index admission as an admission which is either the first admission or any subsequent admission preceded by an interval of > 30 days with a discharge status of being alive. Readmission was defined as any admission occurring within 30 days of the previous discharge. Definition of index admission and readmission of two other studies on readmission among PLWHA[5,25] are also consistent with CMS methods.

The second definition is from the AHRQ, Healthcare Cost and Utilization Project (HCUP)[51]. HCUP defines a readmission as a subsequent admission in the same or a different hospital within 30 days of the original admission (or index stay). Every qualifying hospital stay is counted as an index admission. A hospital stay may be both a readmission from the prior stay and the index admission for a subsequent readmission. Three types of admissions were excluded as index admissions: admissions with a discharge status of died in hospital, admissions for which there are no data on the LOS, and admissions with a discharge date after the study period. There is no limitation for the number of index admissions for each patient unless there are 20 or more visits within 1 year. Any discharge from the hospital (index stays) for each patient is followed for 30 days. If a readmission to the same or a different hospital occurs within 30 days of discharge, the corresponding index stay is counted as an index stay with a readmission. If there is more than one readmission within 30 days of discharge, only the first readmission is counted. The readmission rate is defined as "the percentage of hospital admissions that had at least one readmission within 30 days"[51]. Transfers are not considered as readmissions. If more than one transfer has occurred, the transfers are combined into a single one and called a combined transfer. For example, if a transfer for a patient occurs within a hospital or to a different hospital on the same day, both transfers are combined into one.

A definition for readmission by CIHI considers all adjoining inpatient admissions and same-day surgery visits as an episode of care[3]. If an episode includes a within- or between-facility transfer, the entries are linked[75]. To build an episode, a transfer is considered to occur either within 6 hours of the previous discharge regardless of whether the transfer was being coded or not or between 6 and 12 hours within the previous discharge if the transfer was coded[76]. Qualified episodes are used to calculate the readmission rate[75]. The denominator of the readmission rate is an index episode. In general, eligible episodes for the denominator

(index episode) do not include episodes with discharge due to death or self-sign-out. The numerator of the readmission rate is the total number of episodes with a readmission within 30 days of discharge after the index episode[75]. Based on the CIHI methodology, the index admission refers to the initial admission[3]. Finally, readmissions occurring for any other reasons are recognized as all-cause readmissions[77].

2.3. Potentially preventable readmissions (PPRs), definitions and terms

While some readmissions are necessary because they occur due to the progress of disease, or they are scheduled for follow-up surgery or a procedure in the course of treatment, numerous studies from a variety of settings have indicated a substantial percentage are preventable. Hannon et al.[78] concluded that complications directly related to bypass surgery were accountable for 85 percent of readmissions following coronary artery bypass graft surgery. Ashton et al.[79] who worked on the association between the quality of inpatient care and early readmission, determined that patients who experienced readmission were 55 percent more likely to have had a problem with other aspects of quality of care during their index admission or prior healthcare contacts. Focusing on preventable readmissions is essential because preventable readmissions present a huge opportunity to improve quality of care and may reduce the associated costs.

There has been no agreement on defining preventable readmissions. The definition of PPR was initially based on the types of admission which were at higher risk to generate readmission[11]. The definition was then developed based on the relation between reasons for the initial admission and readmission. Several studies defined preventability based on a relationship between the reason for the readmission and the care rendered or missed in the initial hospital stay. Readmissions may occur for many reasons, and patients might experience unplanned readmission to a hospital which may or may not be related to the initial admission. A well-known method applied by 3M Health Information Systems explained that a readmission is typically considered to be a PPR if it is clinically related to a prior admission and occurs within the readmission time interval[80]. A clinical relation was recognized if the readmission occurred due to

the care provided during or immediately after a prior admission[11,80] or resulted from lack of follow-up with a primary care physician[80]. A clinically-related readmission may also have resulted from an incomplete discharge planning[81]. Goldfield et al.[11] also defined PPR based on the existence of a clinical relationship between the reasons for readmission and the initial admission. Another study which used the 3M definition for PPR was conducted by Gay et al.[82] to examine PPRs at children's hospitals.

Potentially preventable readmissions were defined as a subgroup of unforeseen readmissions for a previously known illness within a proper interval by Halfon et al.[30]. They categorized all readmissions based on being expected or not and also if the readmission occurred due to a new illness or a previously known illness. The last group was also reviewed (a systematic medical record review) to identify the main reason for readmission[30]. In a study on ischemic stroke by Lichtman et al.[83] preventable readmissions were defined based on the AHRQ prevention quality indicators (PQI). AHRQ developed PQI to identify preventable readmissions. They used PQI because they include most of the reasons for readmission after stroke. Some examples of PQI are diabetes-related indicators, chronic obstructive pulmonary disease indicators, and urinary tract infections admission indicators[84]. Another definition comes from a study by Johnson et al.[85], who defined PPR based on specified codes. Regarding this approach, if readmission occurred to any acute care hospital within 28 days of delivery and the most responsible diagnosis was one of the specified codes, the readmission was considered a PPR[85].

In a study by Gruneir et al.[73] in Canada, the LACE index (representing LOS, acuity of illness, Charlson comorbidity score, and emergency department [ED] visits) was used to identify patients at high or low risk of unplanned readmission. The LACE index is obtained by four factors including LOS for the index admission, acuity of illness at the time of the index admission, Charlson comorbidity score (number of co-existing medical conditions at the time of index admission as measured by the Charlson score), and the number of ED visits within 6 months prior to the index admission[73]. Medical admissions were defined according to the case mix group (CMG) classification system. This system was developed by the CIHI based on the diagnosis-related groups (DRG) which is used in the United States. The CMG is used to assign similar inpatient cases to a single group using the most responsible diagnosis. In fact, each

case is assigned to one of the 25 major clinical categories (MCC). Several studies used a panel of experts to identify the reasons for readmission. For instance, in a study by Yam et al.[86] to identify preventable readmission in Hong Kong, a team of eight physicians identified whether a readmission was preventable. Finally, a study by Landrum et al.[87] recommended that if a readmission could have been avoided by better clinical management or appropriate discharge/post-discharge planning, it would be considered a PPR.

The PPR rate is influenced by the selection of the time interval[11]. The time interval is the maximum number of days allowed between the discharge date of the prior admission and a subsequent admission[11]. The probability that a readmission is clinically related to a prior admission is reduced as the time interval increases[11]. In addition, the longer the time intervals, the more readmissions occur, according to Hannan et al.[11,78]. However, increasing the time between admission and readmission decreases the probability of preventable readmissions occurring[78]. A 30-day period is a common interval[88] that is also a clinically meaningful period for hospitals to make an effort in conjunction with their communities to reduce readmissions[11]. Table 2.1 lists the definitions of PPRs in different studies.

Table 2.1. Definitions of potentially preventable readmission

Title of the study	Definition
Potentially preventable Readmissions (PPR) Classification System[80]	A readmission (return hospitalization within the specified readmission time interval) that is clinically-related to the initial hospital admission. Definition of PPR is the same as the one used by 3M-Potentially Preventable Readmissions software
Identifying potentially preventable readmissions[11]	A subsequent admission which occurs within the readmission time interval and is clinically related to a prior admission
Rates and impact of potentially preventable readmissions at children's hospitals[82]	3M-Potentially Preventable Readmissions software (3M-PPRs) definition: a readmission (a return hospitalization within the specified readmission time interval) that is clinically related to the initial hospital admission. Readmission time interval: the number of days allowed between the discharge date of a prior admission and the admit date of a subsequent admission in order for the subsequent admission to be a readmission. Clinically related: if the reason for readmission is related to the care provided in or immediately flowing a prior hospital admission, the readmission is clinically related to the initial hospital admission.
Measuring potentially preventable hospital readmissions[30]	A subgroup of unforeseen readmissions for a previously known affection occurring within a specified time interval
Preventable Readmissions within 30 days of Ischemic Stroke among Medicare Beneficiaries[83]	Preventable readmissions were identified based on 14 Prevention Quality Indicators (PQI) developed by the US Agency for Healthcare Research and Quality. Many frequent reasons for readmission after stroke such as pneumonia, urinary tract infection have been included in common ambulatory care sensitive conditions in PQI. Inclusion Criteria: chronic lung condition indicators (chronic obstructive pulmonary disease; adult asthma), diabetes-related indicators (diabetes, short-term complications; diabetes, long-term complications; uncontrolled diabetes), cardiovascular-related indicators (hypertension; congestive heart failure; angina without procedure), and acute condition indicators (dehydration; bacterial pneumonia; urinary tract infection). Excluded readmissions for procedures that may represent planned continuation of treatment after discharge unless ICD-9-CM 433.×1 or 434.×1 (acute ischemic stroke) was listed as the principal discharge diagnosis for the readmission
Early discharge of Alberta mothers Post-delivery and the relationship to potentially preventable newborn readmissions[85]	A re-entering to an acute care hospital within 28 days of delivery for the following most responsible diagnosis: inadequate weight gain (ICD-9-CM[a] 783.2, 783.4); jaundice (ICD-9-CM 773.1, 774.2, 774.3x, 774.6, 774.7); dehydration (ICD-9-CM 276.0, 276.5, 775.5, 778.4); feeding problem (ICD-9-CM 779.3, 783.3); social reasons (V20.1, V650)
Unplanned readmissions after hospital discharge among patients identified as being at high risk for readmission using a validated predictive algorithm[73]	Patients at high and low risk of unplanned readmission were identified by the LACE index. Definition of Medical admission was based on the Case Mix Groups-2003 (CMG) classification system devised by CIHI
Preventable readmission in Hong Kong - system, clinician, patient or social factor?[86]	Preventable readmissions were identified by a panel of experts
Readmission data for outcomes measurement: identifying and strengthening the empirical base[87]	Readmission that could have been potentially avoided with better clinical management and stabilization prior discharge or after discharge on an outpatient basis, appropriate discharge planning, or provision of resources at home sufficient to meet the patient's needs

[a]: International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Clinical Modification

Although preventability has not always been clearly or easily defined, unplanned readmissions do not happen randomly[74]. That is, patients with a worse health status were at higher risk of hospital readmission. However, some unplanned readmissions are preventable.

Disparities in hospital readmission rates[12,80] and variation in readmission rates associated with hospital charcteristics[89], for example, indicate that readmissions are potentially preventable events. It should be noted that comparisons of readmission rates must be adjusted for case mix because the readmission rate can be influenced by a hospital's mix of patient types. The readmission rate is valuable as an indicator of the quality of hospital care because it may reflect poor coordination of services during hospitalization or during the post-discharge period[12], as some hospitals perform better than others. Hospitals with limited financial or clinical resources, hospitals located in low to median income areas had high readmission rates and, therefore, a lower performance status[90]. Other evidence is the running policy to penalize hospitals with high readmission rates in the United States. Most U.S. hospitals will receive less money for fiscal 2016 due to excessive 30-day readmissions[91]. In addition, despite the lack of specific criteria to identify a preventable readmission, there have been studies which indicate that a portion of unplanned readmissions are potentially preventable[11,81,92]. Agins et al.[69] for instance, showed that more than 50% of hospital readmissions within 30 days of discharge among people living with HIV are potentially preventable.

Undoubtedly, some hospital readmissions are anticipated and necessary[6,10,80,83]. Examples include planned readmissions which are a scheduled part of the patient's care plan[71]. Readmissions in which one of a pre-specified list of procedures took place are considered as planned readmissions. However, admissions for acute illness of complications of care are not considered as planned readmission[71]. Further, some readmissions are not preventable due to "onset of different conditions or health deterioration"[3]. However, a considerable number of hospital readmissions are preventable. Identifying those readmissions which are potentially preventable is necessary to provide a solution and reduce readmissions[6,11,25]. A better understanding of the underlying reasons for readmissions among HIV-infected patients could support the improvement in quality of care for these patients.

From the healthcare providers' perspective, it is important to know the quality and the cost of care delivered to the patients. In the United States, healthcare providers, mainly hospitals, risk being penalized on the basis of their readmission rates. Although the healthcare system in Canada is different from that of the United States, a high readmission rate is a challenge for hospitals. There have been several efforts to reduce readmission rates in

Canada[13]. The Excellent Care for All Act (ECFAA) was developed in 2010 by the government to improve the quality of Ontario's healthcare system. According to the ECFAA, all hospitals in the province are required to develop a quality improvement plan (QIP). The Trillium Health Centre in Mississauga in an effort to improve its readmission rate, as part of its QIP, identified reducing its 30-day readmission rates as "priority one"[13]. Trillium could reduce its 30-day readmission rates based on four major drivers including delivering complication-free care in the hospital, identifying patients at risk of readmission, effective transitions to the community, and effective chronic disease prevention and management. Thus, healthcare providers' strategies and practices are important in reducing readmission to enhance the healthcare quality of care.

In addition, Canada has developed a virtual ward program in three provinces: Ontario, Manitoba, and Quebec[93]. Generally, the aim of the virtual ward is to decrease readmissions through providing short-term transitional care for the patients who have been discharged from hospital recently and are at a high risk of readmission. The program in Ontario is in the process of conducting randomized trials to evaluate the impact of the virtual wards on readmission rates[93]. It is important to understand the factors associated with readmissions which are mutable among PLWHA. These mutable factors can be the targets for healthcare providers and policymakers with the aim of reducing unnecessary readmissions among PLWHA. More information gathered on the mutable factors provides for better decision making, resulting in better healthcare. This could result in a higher quality of care as well as decreased healthcare utilization costs, which benefits the patients as well as society in general.

2.4. Risk factors of hospital readmission

The Andersen model of health service utilization (developed in the 1960s) is the framework for organizing the discussion of the literature on readmission of PLWHA in this study. As noted in the introduction section, according to the Andersen model, use of health services is determined by three categories of factors: predisposing factors, enabling factors, and need factors[42,44]. Predisposing factors include demographics, socioeconomic status, and health beliefs; enabling factors include personal and community resources; and need factors include evaluated and perceived needs.

2.4.1. Predisposing factors

Predisposing factors include sociodemographic characteristics (e.g. age, gender, ethnicity, and race) and beliefs (e.g. knowledge about disease, health, and health services, using alternative medicine). Predisposing characteristics are certain individual characteristics which affect healthcare utilization. They may not be a reason for seeking healthcare. However, they affect healthcare utilization indirectly. For example, age is not a reason for an individual seeking healthcare, however people use healthcare services differently due to different types and level of illnesses[45]. Age has been shown as a risk factor of health service use in most related studies because of a strong negative relationship between age and health. However, studies on readmissions among PLWHA showed no association between age and readmission rate[4,5,6,25,94]. Many studies[4,5,6,25,94] showed that gender had no effect on readmission among PLWHA. Predisposing factors suggest the likelihood of individuals' need to use health services or their ability to cope with the health problems. Thus, use of health services predisposing factors is essential to identify when examining hospital readmission among PLWHA.

Three other factors commonly discussed in readmission studies as predisposing factors are history of mental health, substance abuse, and diagnostic category. Similar to health studies not related to readmission of PLWHA, mental health was identified as a risk factor of readmission in PLWHA[5,25]. A psychiatric disorder has also been shown as a predictor of readmission[5]. Mental health disorders have been identified as a risk factor of readmission among PLWHA[25]. Similarly, studies support the existence of a positive relationship between

substance abuse (alcohol or drugs) and readmission among PLWHA[5,25]. Finally, diagnostic category including AIDS-defining illnesses has been shown by many studies as a risk factor of readmission among PLWHA[4,25,40]. Past illnesses and diagnostic category are important in examining PLWHA readmissions due to considerable evidence which shows these factors increase the demands on healthcare utilization in the future.

Socioeconomic status indicators include the person's ability or status in the community reflecting the person's ability to use health services. The influence of ethnicity or race on readmissions was identified in health studies[92,95,96,97]. Social indicators such as race or ethnicity influence readmission among PLWHA, as studies have shown. One study found that black patients were at a higher risk of readmission than white patients[4]. Another study by Kanel et al.[98] on the Pittsburgh Regional Health Initiative (PRHI)[98] showed that among HIV-infected females, Caucasians were more likely to be readmitted (versus African Americans) within 30 days, while among male patients, African American men were more likely to be readmitted than the Caucasian men. However, social indicators such as race or ethnicity are typically a proxy for socioeconomic status and other measures of social marginalization and have no direct impact on using health services. Capturing socioeconomic status is important in examining hospital readmission because they are known to affect the individual behaviors in the presence of health problems and are consistently found to be related to the use of healthcare[94].

Health beliefs, another component of predisposing factors, are the attitudes and knowledge that people have toward healthcare utilization, staying at the hospital, and diseases[44]. An individual's perceptions about health may have an effect on healthcare service use. However, based on our literature search, little is known about the association between health beliefs and readmission rates among PLWHA. The reason might be that most studies on PLWHA used administrative data and the necessary data were not available. In behavioural models such as Andersen's, demographic factors and socioeconomic status are considered as having low mutability because they are not changeable enough to affect the outcome[44]. However, health beliefs are considered having medium mutability because they can be altered and change an individual's behaviour toward using healthcare services. In addition, it is noteworthy that predisposing factors might not be a direct reason for readmissions but do influence them in an indirect way[45].

Socioeconomic characteristics of individuals such as education, and employment status have been associated with higher levels of healthcare utilization in a number of studies in the general population[42,99,100]. A low socioeconomic status has been found to increase the likelihood of readmission due to congestive heart failure[99]. Living in the poorest urban neighbourhood can be considered a proxy for individual socioeconomic status which has been shown to be independently associated with an increased risk of early hospital readmission (14-day readmission) for PLWHA[94].

There are several hospital-level characteristics such as size, teaching status of the hospital, and hospital services (medical/surgical) which were found to explain hospital readmission[3,101,102,]. Hospital size is typically defined by the number of beds. A study by the CIHI[3] stratified hospitals based on the size of the index hospitals into four groups: small, medium, large, and teaching hospitals. Most patients are readmitted to the same hospital to which they were initially admitted[3]. The results showed that the highest readmission rate belonged to small hospitals. However, an earlier study by Ansari et al.[103] revealed that the unplanned readmission rate for hospitals with 200 or more beds was higher than that of hospitals with 100 or fewer beds. Another study by Joynt et al.[90] also found that large hospitals and teaching hospitals have higher readmission rates than smaller and non-teaching hospitals. Both medical and surgical hospital services have been also found to affect risk of readmission among patients 65 years of age and older[101]. Healthcare system factors which predict readmissions are important to determine for allocating sufficient personnel and resources.

In addition to the individual- and hospital-level factors, the socioeconomic status of the patient's neighbourhood also influences readmission rates[1,3,5,94]. The most commonly reviewed community-level effects, income, education, and labour force participation rate, have been identified as risk factors associated with readmissions. Some studies show that patients from low-income neighbourhoods[3,94] experienced readmissions more frequently. In addition, neighbourhoods with a low education, or low employment designation were associated with higher readmission rates[1]. However, one study by Nijhawan et al.[5] on PLWHA found no relationship between socioeconomic indicators and readmission rate. Community-level characteristics such as the percentage of the population below poverty level were included as predisposing factors in a study on healthcare utilization by Stockdale et al.[104]. These

characteristics are considered as predisposing factors in the current study because they reflect an inclination towards the use of healthcare system which exists prior to the onset of illness.

2.4.2. Enabling factors

The components of the enabling factors are personal and community resources such as personal resources, and health insurance status[42] which support or deny an individual's decision to use health services. A higher rate of inpatient care is another enabling factor which research showed results in a subsequent admission[3,5,25,69,105]. Nijhawan et al.[5] in their study of modeling 30-day readmission among HIV-infected inpatients showed that patients who had more inpatient admissions (a higher rate of hospital utilization) in the last 6 months were more likely to be readmitted to hospital within 30 days following discharge. Berry et al.[4] also revealed that PLWHA with a greater number of prior hospital admissions were more likely to be readmitted after discharge. The number of prior ED visits is another example of inpatient care which influences readmission[5,25].

Two other factors of acute care use in evaluating healthcare utilization are LOS and alternate level of care (ALC) days. Studies on the effect of LOS on readmission, in general, have shown conflicting results. Some studies showed that the longer the LOS, the greater the risk of readmission[105,106], while other studies suggested a negative relationship between LOS and the probability of subsequent readmission[107]. Studies of readmission in PLWHA also show conflicting evidence of LOS as a risk factor for readmission. While one study revealed that LOS influences readmission rates[4], other study showed no such relationship[6]. Zhang et al.[108] found that PLWHA stay in the hospital longer than individuals not infected with HIV/AIDS (an average LOS of 9 days versus almost 5 days). The LOS for PLWHA who are also diagnosed with another disease is different from that of PLWHA in general. Comparing PLWHA diagnosed with and without mental disorders, LOS for the population with mental disorders has been found to be shorter than that of the patients not diagnosed with mental disorders[108]. The reason might be that patients are transferred to other facilities or the process of treatment could not be fulfilled in hospitals owing to insufficient hospital resources[108].

Individuals occupying a hospital bed while awaiting discharge to a more appropriate setting are classified in the hospital discharge abstract database as ALC days[109,110]. While waiting in the hospital, patients risk exposure to other preventable, adverse events[111] and other health issues which may consequently lead to hospital readmission. A brief analysis by CIHI[110] showed that ALC accounted for a high number of hospitalizations, and 17% of ALC hospitalizations resulted in at least one readmission within 30 days after discharge. Most recently, Lavergne (2015)[109] revealed that in BC, approximately 84% of hospitalizations with ALC days were followed by an urgent readmission.

The number of physician/clinic visits in a specified time interval (e.g. within the past year) is another component of utilization history with unknown effects on readmission among PLWHA. While one study revealed that the history of missed clinic appointments influences the 30-day readmission[5], another study rejected the relationship between clinic visits within the past year and 30-day hospital readmission[6]. The other factors which have been identified as risk factors of readmission and can be likely categorized as enabling factors are leaving AMA, ART, acuity of admission, and insurance.

Leaving hospital AMA also reflects the likelihood of readmission among PLWHA, as studies have shown. Patients who leave AMA are more likely to be readmitted to hospital[94,112,113]. A study of PLWHA admitted with pneumonia found that leaving hospital AMA significantly increases early readmission[94]. Leaving hospital AMA rate is not low. A study on PLWHA admitted to St. Paul's Hospital in Vancouver found that approximately 13% of the patients left hospitals before the completion of medical treatment[67]. PLWHA who leave hospital AMA were found to be injection drug users and more likely leave hospital on the days they receive welfare cheques[112]. Inadequate management of independency disorders and perceived discrimination also have been found as reasons for leaving hospitals AMA[25]. Leaving hospital AMA need to be considered in analysing readmissions among PLWHA because this factor can have consequences including subsequent readmission to hospital.

The effect of ART on readmission in PLWHA is unknown. A study by Nosyk et al.[55] found that PLWHA who were not on ART were more likely to be readmitted to hospital than the ones on ART[55]. However, Nijhawan et al.[5], and Berry et al.[4] found no relationship between ART

and risk of 30-day readmission in PLWHA[4,5]. The difference may be because of the differences in study population, time frame, or the acuity of illness of the patients. In addition, the treatment histories of the study populations differed in different studies. In the study by Nosyk et al., two groups of HIV-infected (on ART and not on ART) were compared while in the study by Nijhawan et al., more than 50% of patients had no ART history. In the other study by Berry et al.[4], more than 30% of patients had no ART use at discharge or admission. As noted earlier, ART can prevent the growth of the virus. Therefore, identifying the effect of adherence to ART on readmission is important.

Acuity of admission and insurance are also categorized as enabling factors. Acuity of admission which indicates the urgency of admission, is associated with 30-day readmission among PLWHA[5]. A study by Nijhawan et al.[5] showed that elective index admission had an effect on 30-day risk of readmission. Insurance is also a factor which most health studies of healthcare utilization included on the list of risk factors of readmission. Similarly, studies of readmission among PLWHA showed that insurance status influences the risk of readmission[4,5,6,25,40]. However, in Canada, all Canadians and permanent residents may use public health insurance. Each province and territory has its own health insurance plan.

The type of prior admission (medical/surgical) also is a factor associated with readmission[114]. Although postoperative readmission rates are not as high as medical readmission rates, the readmission rate for several types of surgery is high[78]. A study by Lucas et al. using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database showed that 30-day readmission rates after surgery were 5.0% after basic general surgery (hernia, breast, gallbladder, appendix) and 12.6% for lower intestinal, 6.9% for upper intestinal, 15.8% for hepatopancreatobiliary, 11.9% for vascular, and 11.1% for thoracic surgeries[114].

Few studies have explored the causes of readmission after surgery. The most common reason for unplanned readmissions after surgery was surgical site infection (SSI)[115]. The reasons for readmissions in all surgical procedures and for six representative operations (bariatric procedures, colectomy or proctectomy, hysterectomy, total hip or knee arthroplasty, ventral hernia repair, and lower extremity vascular bypass) were determined by Merkow et al.[115].

They identified the 10 most frequent reasons for unplanned readmissions after surgery as: SSI, ileus or obstruction, bleeding, pulmonary, venous thromboembolism, dehydration or nutrition, sepsis, central nervous system or cerebrovascular accident, and pain. Kassin et al.[116] also identified an association between surgical procedures and higher readmission rates and identified the following reasons for readmissions after general surgery: gastrointestinal complication, surgical infection, failure to thrive/malnutrition, wound complication, genitourinary complication, vascular complication, pulmonary problem, cardiac problem, pain, fever, transplant complication, and neurologic problem. Alhilli et al.[117] also worked on the factors associated with readmissions after surgery. They found that the postoperative complications during the initial admission (by the Accordion Severity Grading System) were associated with the readmission rate. The length of postoperative stay and major postoperative complication were also shown to be associated with readmission rates after surgery[118].

Other classifications of surgical data have been used to study readmission rates. In a study by Kim et al.[119], for instance, 10 major operative procedures were used to identify hospital readmission after multiple major operative procedures among patients with employer-provided health insurance. The categories included abdominal and cardiovascular operations[119]. The first category consisted of esophagectomy, pancreatectomy, hepatectomy, colectomy, lung resection, and gastrectomy, and the second one included abdominal aortic aneurysm repair, coronary artery bypass grafting, carotid endarterectomy, and mitral/aortic valve replacement. Brooke et al.[120] also used the same classification for surgical data to study readmission after major surgery. Understanding the reasons of readmissions after surgery typically provides a base for enhancing the quality of care among PLWHA.

Geographic factors such as hospital location (whether hospital is located in an urban or rural area) or distance from hospital has been documented as a risk factor of readmissions by many studies[2,3,5,25]. The CIHI, in a study on all-cause readmission to acute care facilities showed that rural and urban readmission rates were significantly different; that is patients in rural areas were readmitted to hospitals more than their urban counterparts. Nijhawan et al.[5] claimed that living more than 13 miles (21 km) from a hospital increased the risk of hospitalizations of PLWHA. Unlike predisposing factors, enabling factors are quite changeable[44], which should be considered to decrease readmission rates and to improve the quality of care.

2.4.3. Need factors

The third component of the Andersen model, need factors, include both perceived and evaluated needs. Perceived need is based on self-judgement of the person's health status and his or her need to use health services, whereas evaluated need is based on professional evaluation of the individual's health. Both perceived and evaluated need might influence the use of health services.

For analyses on hospital readmission, evaluated need can be included in most clinical factors such as severity and treatment of illnesses, co-morbidities, and laboratory tests (e.g. CD4 counts & viral load). Studies show the factors CD4 count[4,5,6], viral load[4,5], and co-morbidities[25] as risk factors of 30-day readmission among PLWHA. For CD4 counts, several studies have indicated that lower CD4 counts were associated with higher readmission rates[4,5,55,94]. In addition, need factors may contribute to readmission more than demographic factors[4,116]. Berry et al.[4] found that compared with demographic factors, severity of illness (i.e. advanced HIV disease or AIDS) contributed more to readmissions. A study by Kassin et al.[116] also showed that postoperative complications are the most significant independent risk factor of hospital readmissions[116]. There have been no published studies on the independent effect of perceived need (the second component of need factors) for PLWHA. Thus, determining hospital readmission rates and to identify risk factors associated with hospital readmission among PLWHA is essential to provide information to decision makers for planning to address gaps between what is occurring and what larger system assumes is happening. Identifying gaps in hospital readmission rates and to identify risk factors associated with hospital readmission among PLWHA will inform policymakers, practitioners, and researchers on where to focus their attention.

Chapter 3. Methodology

This chapter describes the methodology used to investigate the risk factors of all-cause readmissions within 30 days of a discharge among PLWHA. The chapter includes information on the data source, study population, outcome and independent variables, and statistical analyses employed in this study.

3.1. Data sources

3.1.1. Patient-Level databases

The administrative patient-level data for this study were derived from two databases that were available through the BCCfE. The databases include the BCCfE's drug treatment program and laboratory databases and the Discharge Abstract database (DAD).

The BCCfE drug treatment program and laboratory disease registry database contains information of all PLWHA who receive ART in BC, ART history, HIV-related laboratory test results, and demographic information of the patients are included in the database, which is described further in prior publications[121]. The DAD, which was originally developed in 1963, contains demographic, administrative, and clinical information for acute, rehabilitation, and day surgery patients in acute care hospitals in BC. However, it does not include any information for outpatient services. All mentioned databases are available in BCCfE with de-identified patient indicators to protect the privacy of individuals and to ensure the security of their personal health information. Each patient's indicator (the ID number to which a patient is identified) is recoded. There is no personal patient information in the databases. Each patient was recoded by a unique number for the purpose of the study. Table 3.1 presents descriptions of the patient-level databases used for the analyses.

Table 3.1. Description of individual-level databases

Name	Description
BCCfE* drug treatment program and laboratory disease registry	Databases maintained by the BCCfE contain information on all PLWHA receiving antiretroviral therapy, including historical antiretroviral treatment records, demographics and mode of HIV transmission information, as well as HIV-related laboratory test records.
Discharge Abstract Database (DAD)	It includes administrative, clinical and demographic information on hospital discharges (including deaths, sign-outs and transfers) in acute care hospital in BC. It does not include records for outpatient services. All hospital discharges records are from the BC Ministry of Health.

* BC Center Centre for Excellence in HIV/AIDS, Source: Nosyk B, Colley G, Yip B, Chan K, Heath K, Lima VD, Gilbert M, Hogg RS, Harrigan PR, Montaner JS. Application and Validation of Case-Finding Algorithms for Identifying Individuals with Human Immunodeficiency Virus from Administrative Data in British Columbia, Canada. PLoS ONE. 2013; 8(1): e54416. doi:10.1371/journal.pone.0054416[122]

3.1.2. Hospital-Level data

To examine the effect of hospital-level factors on readmissions among PLWHA, knowledge of certain characteristics of the BC hospitals was required. To create a hospital-level database of characteristics of the BC hospitals, data from CIHI (2013-2014), available at the health authority (HA) level, were used. Administration of health in BC occurs within geographical categories. Local health areas (LHA) are subsumed into health service delivery areas (HSDA) which are in turn aggregated in a HA. BC has six health authorities that, in conjunction with the Ministry of Health, manage and deliver most publicly funded health services in the province. The five regional health authorities (Fraser Health, Interior Health, Island Health, Northern Health, and Vancouver Coastal Health) are responsible for local health services such as home and hospital care within their geographic areas, while responsibility of providing province-wide specialized services rests with the sixth health authority, the Provincial Health Services Authority (PHSA). PHSA is not a geographical division. It provides healthcare and services through provincial specialized hospitals and centers and is responsible for supporting the regional health authorities with their service delivery.

Hospitals in the DAD are listed based on health authorities 1 through 6, whereas the data from the CIHI are based on health authorities 1 through 5. To be able to link the hospital-

level database with the patient-level database, hospitals of the sixth health authority in the DAD were assigned to the related HA in the CIHI database. CIHI data included size, teaching status, and type of hospital. Matching with 106 hospitals in the DAD, seven hospitals had no available data on size, including three hospitals which were already closed. We considered all these hospitals as small hospitals because non-small hospitals are rarely closed or have no available data. Previous studies have shown that large and teaching hospitals have higher readmission rates than small and non-teaching hospitals[90].

3.1.3. Community-Level data

Neighbourhood-level characteristics were derived from BCStats[123]. BCStats is the central statistics agency of the province of BC. All data from BCStats were prepared based on Statistics Canada's 2006 Census and provided at the LHA level. However, the following four LHAs were excluded due to the small numbers of measures: LHA 51 (Snow Country), LHA 83 (Central Coast), LHA 87 (Stikine), and LHA 94 (Telegraph Creeks). The neighbourhood characteristics file was built at the LHA level and consisted of three measures of neighborhood-level socioeconomic status: the labour force participation rate, the prevalence of low income after tax, and the non-high school graduation rate.

3.2. Study population

This retrospective cohort study consisted of all PLWHA admitted for any reason as an inpatient to any acute care BC hospital between April 1, 2001 and March 31, 2014. Although DAD included all admissions from February 1994 onward, we needed to exclude the admissions before April 2001 because the patients' discharge status before 2001 was recognized by only one code, which did not distinguish between the patient being discharged or transferred. Patient-level data are based on the DAD and include information on all PLWHA admitted at least once to a BC hospital. The DAD by the CIHI includes all discharges from acute care and day surgery within a fiscal year from April 1 to March 31. CIHI ensures that the data of DAD are accurate by checking completeness of data submission using a number of reports. In addition, Quality of data is controlled through: CIHI Production System Edits and Correction Process,

Abstracting Software, Annual Database Change Cycle, Advisory Groups, Quality Service Representatives, CIHI Education Program, and Special Studies[124].

3.3. Inclusion and exclusion criteria

3.3.1. Patient inclusion and exclusion criteria

All people of all ages living with HIV/AIDS (PLWHA) admitted to a hospital in BC during the study period with any primary diagnosis as the reason for admission were included in this study. Furthermore, admissions with illogical dates (e.g. admissions beginning within the duration of another admission) were excluded[15].

3.3.2. Inclusion and exclusion criteria for index admissions

The following admissions were excluded as index admissions: 1) admissions with discharge status of death; 2) admissions in which the patients were transferred out of the province (because the readmission could not be traced if any occurred); and 3) admissions with a discharge date on or after the last month of the study period. Admissions in which patients left hospital AMA were not excluded from being an index admission; unlike the CMS methodology. The reason is that leaving AMA rate among PLWHA is not low. An admission is considered as a readmission as long as it meets the eligibility condition of readmissions. An index admission may be followed by more than one readmission within 30 days of discharge (chain readmission). Multiple admissions on the same day for a patient were merged. Three types of transfers were identified: transfers within the previous stay at a hospital, transfers on the discharge date, and transfers after the pervious discharge. All transfers were combined. Transfers among BC hospitals were considered eligible to be index admissions. The reason is that this study examines readmissions among all BC hospitals rather than one specified hospital. For transfers between hospitals, the final discharge hospital was considered responsible for any possible readmissions.

To identify the study cohort, each hospitalization was categorized as either a potential index admission (defined as an admission which was capable of having a readmission) or a readmission. For this study, an index admission was defined as either a first-ever hospitalization or a hospitalization which occurred > 30 days after the most recent previous hospitalization. Readmission was defined as an admission which occurred ≤ 30 days after discharge from a previous hospitalization. Based on exclusion criteria, hospitalizations which did not meet the conditions were then identified and excluded as index admissions.

3.4. Outcome variable: all-cause readmission

The study had one outcome of interest, all-cause readmission. Readmission was defined as an inpatient admission which occurs ≤ 30 days after discharge from a previous admission. Readmission was defined as a readmission which occurred for any cause. However, only unplanned readmissions were considered. Unplanned readmission is a non-elective (unplanned) admission to hospital within 30 days after discharge from a prior hospital admission[125]. In DAD database, non-elective admissions were identified through ”the urgency of admission” variable with “urgent” code[125]. In fact, readmission and all-cause readmission have the same definitions in this study.

3.5. Independent variables

Independent variables were selected for the patient, hospital, and community levels. To select patient-level factors which might influence readmissions among PLWHA, covariates were considered for inclusion on the basis of Andersen’s healthcare utilization model[44,45] and also informed by previous studies on the risk factors of hospital readmission[3,4,5,6,11,25,41,74,78,94,99,100,103,126,127]. However, hospital and community characteristics hypothesized to influence readmission were chosen based on the literature review in this study. Continuous variables were categorized considering the literature review and the distribution of each variable. Three classes of independent variables including predisposing, enabling, and need factors were considered.

3.5.1. Predisposing factors

Predisposing factors, at patient level, include age (all ages were included) at admission (age < 30, 30-39, 40-49, or ≥ 50 years), gender, diagnostic category (codes based on ICD-9/10), and the year of hospitalization. None of the predisposing factors were the focus of the study for suggestions on changes to improve the quality of care of PLWHA.

In addition, at the hospital level, size (number of beds staffed and in operation) and teaching status of hospitals (teaching or non-teaching) were analyzed. The size of a hospital was defined as the number of inpatient beds. A teaching hospital is generally a hospital that provides clinical education and training to future and current health professionals. Based on a definition suggested by the CIHI and the Hospital Report Research Collaborative[128]: "teaching hospitals are acute and pediatric hospitals which are members of the Council of Academic Hospitals of Ontario". These hospitals not only provide post-graduate training in collaboration with medical/health sciences schools but also offer complex care for patients. Hospital services are defined as medical/surgical services.

Community-related factors comprise the labour force participation rate, the prevalence of low income after tax, and the non-high school graduation rate. The labour force 2006 participation rate is the ratio of the labour force (employed and unemployed) as a percentage of the non-institutional population. The prevalence of low income after tax is the percentage of economic families (i.e. the family members are related by blood, marriage, common-law, adoption or a foster relationship) or persons not in economic families in a given classification below the low income after tax cut-offs[129]. Statistics Canada defines the prevalence of low income as the percentage of economic families or persons not in economic families who spend 20% more of their after-tax income than the average on food, shelter, and clothing[129]. Prevalence rates are calculated from estimates of economic families and persons 15 years of age and over not in economic families prior to rounding. To calculate low income cut-offs, first a regression line is fitted to the distribution of actual proportion of income spent by specified-size families in a specified community size on necessities. The data are adopted from Family Expenditure Surveys in Canada. Then 20 percentage point margin is added to the line of average percentage of after-tax income that all families (regardless of size) spent on food,

shelter and clothing. The intersection of this line and the fitted curve gives the low income after tax which is in Canadian dollars[130]. The non-high school graduation rate is the percentage of 18-year-olds who did not graduate. It is calculated as the population of 18-year-olds minus the number of high school graduates divided by the number of 18-year-olds in the population. It is used as an indicator of the high school dropout rate. Data are the average over 3 school years.

3.5.2. Enabling factors

Enabling factors include LOS (0, 1-3, 4-5, 6-8 or ≥ 9 days), ALC days (0 or ≥ 1), acuity of admission (urgent, not urgent), number of prior admissions in last 12 months (0, 1-2, ≥ 3), number of emergency department visits in last 6 months (0, 1-3, ≥ 4), admitted via emergency department (yes, no), Status of patient upon leaving hospital (Transferred to another facility (inpatient hospital care/long term care), discharged to a home setting with support services, discharge home, left against medical advice, others), leaving AMA (yes, no), level of care (acute care, day surgery, free-standing rehabilitation), responsible payer for hospitalization (federal/province/territory government, Canadian/other country resident self-pay), type of hospitalization (medical, surgical), transferred within hospital (yes, no), transferred between hospitals (yes, no), hospital location (urban, rural), and surgical index admission. The surgical admissions were classified into four groups: HIV complication including HIV infections/ other infection/ fever or wound/ leukemia/ chemotherapy, respiratory/ heart/ pulmonary complications, gastrointestinal complications, and other complications. Several levels were collapsed into one level owing to their low frequency (recoding). We selected the given categories because there was no access to detailed procedure codes of ICD-10-CA on DAD; to classify the reasons for hospitalizations when the patient underwent surgery, the MCC and CMG from the CIHI were used. Missing values for the study variables were rare, as described in detail in Appendix A.

3.5.3. Need factors

The need factors of this study included CD4 counts (≤ 50, 51-200, 201-350 or ≥ 351 cells/µL, up to 12 weeks before admission). As mentioned earlier, need factors are of interest because they are potentially changeable. If the need factor of CD4 counts statistically affect

readmissions, the variable will be included in the set of the suggested variables to be considered in the quality of care.

3.6. Calculating readmission rates

All-cause readmission rates were calculated by dividing the total number of index admissions with at least one readmission (readmission chain) by the total number of index admissions in a given time period or other stratification[4].

3.7. Statistical analysis

This study is based on retrospective longitudinal data, as there may be multiple index hospitalizations for each patient during study follow-up. Therefore, statistical methods are needed to adjust for the intra-individual correlation in repeated index hospital admissions[131]. The approaches which have been used to determine the final multiple regression models to address the stated study objectives are explained in this section, which provides information on the process of creating model identifying risk factors for hospital readmission. All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC), and a threshold significance of $p \leq 0.05$ was used. The process of model building involved two steps: univariable analysis and multivariable analysis.

3.7.1. Univariable analysis

As a first step, an indicator dependent variable was considered for each index admission, coded 0 if there was no readmission within 30 days or 1 if at least one readmission within 30 days occurred. Analyses were started by reviewing the frequency and the missing values of each variable. Then univariable analyses were run through logistic regression models to explore whether each of the patient-, hospital-, and community-level variables influenced the outcome variable. However, before that, we needed to identify the type of working correlation matrix because we used logistic regression with a generalized estimating equation (GEE). The

measure of quasi-likelihood under independence model criterion (QIC) by Pan[132] can be used to select the correlation structure. Therefore, QIC from fitting models with different working correlation structures are checked and the appropriate structure is selected. The correlation matrix with the smallest QIC is the best choice. However, theoretical considerations should primarily drive the choice of correlation structure[133]. The QIC criterion was also considered in creating the final model. QIC is a modification of the well-known Akaike information criterion (AIC). Another criterion, QICu, is a simplified version of the QIC. Since the QICu is calculated based on the assumption that the specification of the working correlation is correct, QICu cannot be used to select the working correlation structure.

For univariable analyses, logistic regression models using the logit link function were fitted for outcome and each of the predictor variables (univariable models) and checked to see whether each explanatory variable could predict all-cause readmission using a 5% significant level. For this, repeated-measures logistic models with GEEs with robust variance estimators were used[131,132]. In other words, adjusted repeated-measures logistic regressions were used for repeated index admissions using GEEs with robust variance estimators.

3.7.2. Multivariable analysis

After executing a univariable analysis, we assessed multicollinearity, or the correlation between the explanatory variables. Including several predictor variables in a model that are highly correlated with each other could result in inaccurate estimation of regression coefficients and corresponding significance tests[134,135]. Multicollinearity was assessed using Pearson's correlation coefficients. For this, a correlation matrix was created and a correlation coefficient greater than 0.6 was considered as indication of high correlation, and grounds for removal of the variable which explains less of the variation in the outcome[135].

The last step was to identify the final model and to identify the risk factors associated with all-cause readmission. Variables were added using a forward selection method (but not automatically), adding one variable at a time to the model. All variables found to be significant from the univariable models or confounders and were not highly correlated with each other were included in the model. However, based on Andersen's theory, to identify the mutable variables

(mostly enabling & need factors), all variables of these categories were included in the model except the ones that were highly correlated. Goodness of fit was tested by QIC.

Checking the validity of our analysis, the model had to satisfy the assumptions of logistic regression. The assumptions include independence of errors, linearity in the logit for continuous variables, and absence of multicollinearity among independent variables. To satisfy the first assumption, logistic regressions with GEE method will be used. With this method, correlated data are modeled as in the case of independent responses by considering a working correlation matrix. The second assumption is met because all independent variables were considered as categorical variables. To satisfy the third assumption, multicollinearity will be resolved by identifying correlated variables and excluding one of the two correlated variables in the models.

Chapter 4. Results

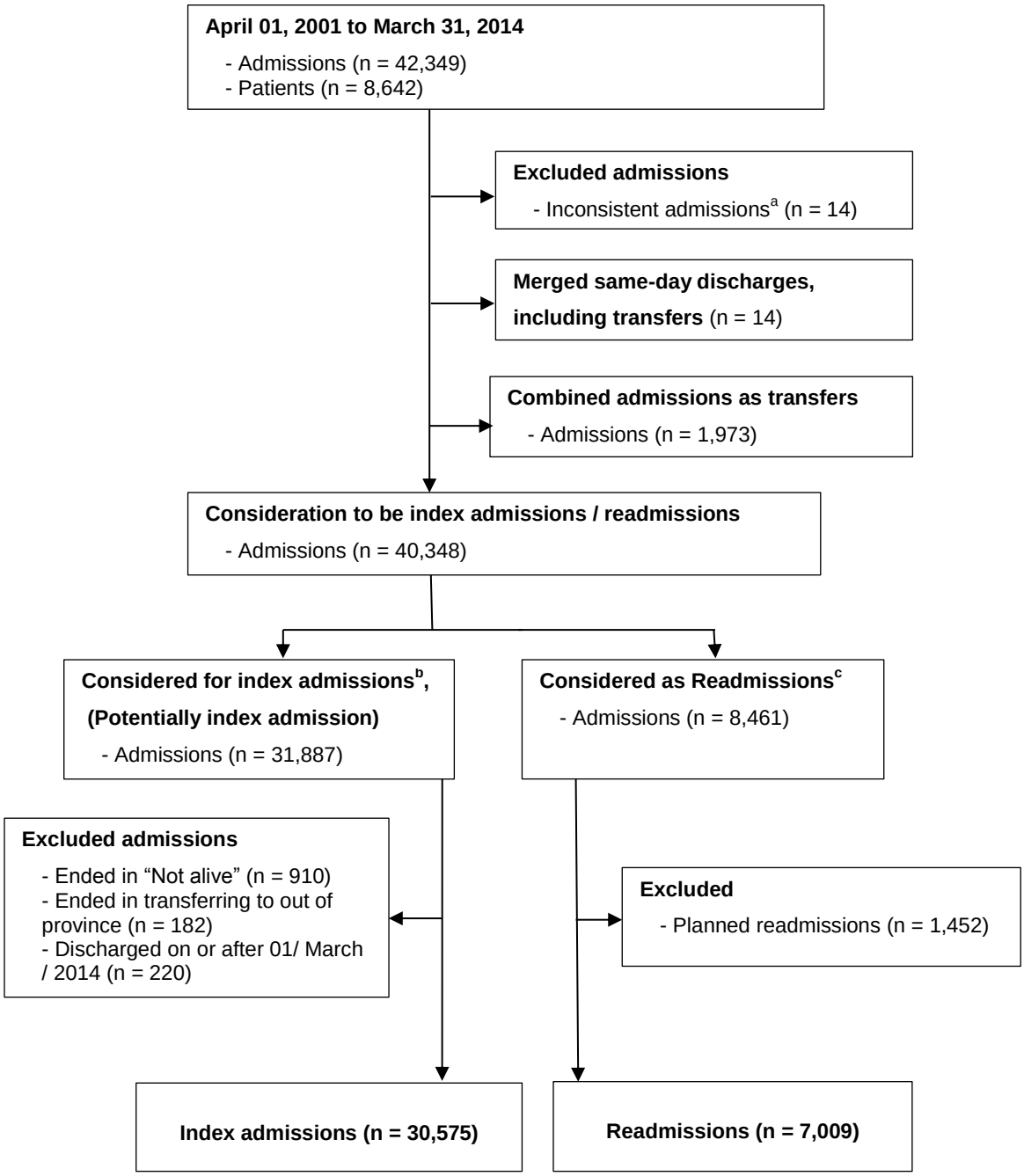
The primary objectives of this study were to describe the distribution of readmissions and to identify risk factors associated with readmission among PLWHA. In this chapter, the study cohort is described and then characteristics of the cohort are reviewed. This chapter also includes the results of univariable and multivariable analyses which identify the risk factors of readmission.

4.1. Description of the study cohort

There were 42,349 admissions to BC hospitals between April 1, 2001 and March 31, 2014 among 8,642 PLWHA. Of these hospitalizations, 14 (0.1%) were excluded because of inconsistency of admission dates (overlap), 14 (0.1%) were merged because of the same admission and discharge date (discharge or transfer), and 1,973 (4.7%) admissions were identified as transfers and were combined. Transfers among BC hospitals were considered eligible to be index admissions. Of the remaining 40,348 admissions, 31,887 (78.4%) admissions occurred > 30 days after a prior admission, and were thus classified as index admissions, while 8,461 (21.6%) admissions occurred within 30 days of discharge from the previous admission, and thus classified as readmissions. Of 31,887 index hospitalizations, 910 (2.9%) admissions with a discharge status of not alive were excluded. In addition, admissions in which patients were transferred outside of BC (n = 182; 0.6%) were not counted as index admissions because the BC hospitals could not have any influence on the patient's care process after the transfer. Finally, admissions occurring within the last month of the study (March, 2014) were excluded as index admissions (220, 0.7%) because a follow-up within 30 days of discharge is required. Finally, 30,575 (78.3%) hospitalizations were counted as index admissions with 8,461 (21.7%) considered as readmissions within 30 days. Excluding 1,452 (17.2%) planned readmissions, 7,009 (82.8%) unplanned readmissions remained.

Among the 30,575 index admissions included in our study, 4,368 were followed by subsequent readmission within 30 days, a 14.3% readmission rate (95% Confidence Interval [14.0%, 14.6%]). There were 26,207 index admissions in which no readmissions occurred. The majority of index admissions with at least one readmission were followed by a single readmission (69.4%). However, 18.3% were followed by two readmissions and 12.3% occurred followed by three or more readmissions.

Figure 4.1. Selection of study cohort



[a]: Inconsistent records: where two hospital admissions overlapped. [b]: Index admission: either a first-ever admission or an admission which occurs more than 30 days after the most recent previous admission. [c]: Readmission: an admission which occurs ≤ 30 days of the previous admission.

4.2. All-cause readmission over time

A review of all-cause readmission rates between 2001 and 2014 is shown in Table 4.1. Readmission rates among PLWHA increased from 14.9% in 2001 to 16.7% in 2006 and steadily decreased to 12.4% in 2014. One explanation of the reduction in the readmission rate in BC during recent years could be expansion of the implementation of the STOP HIV program throughout the province.

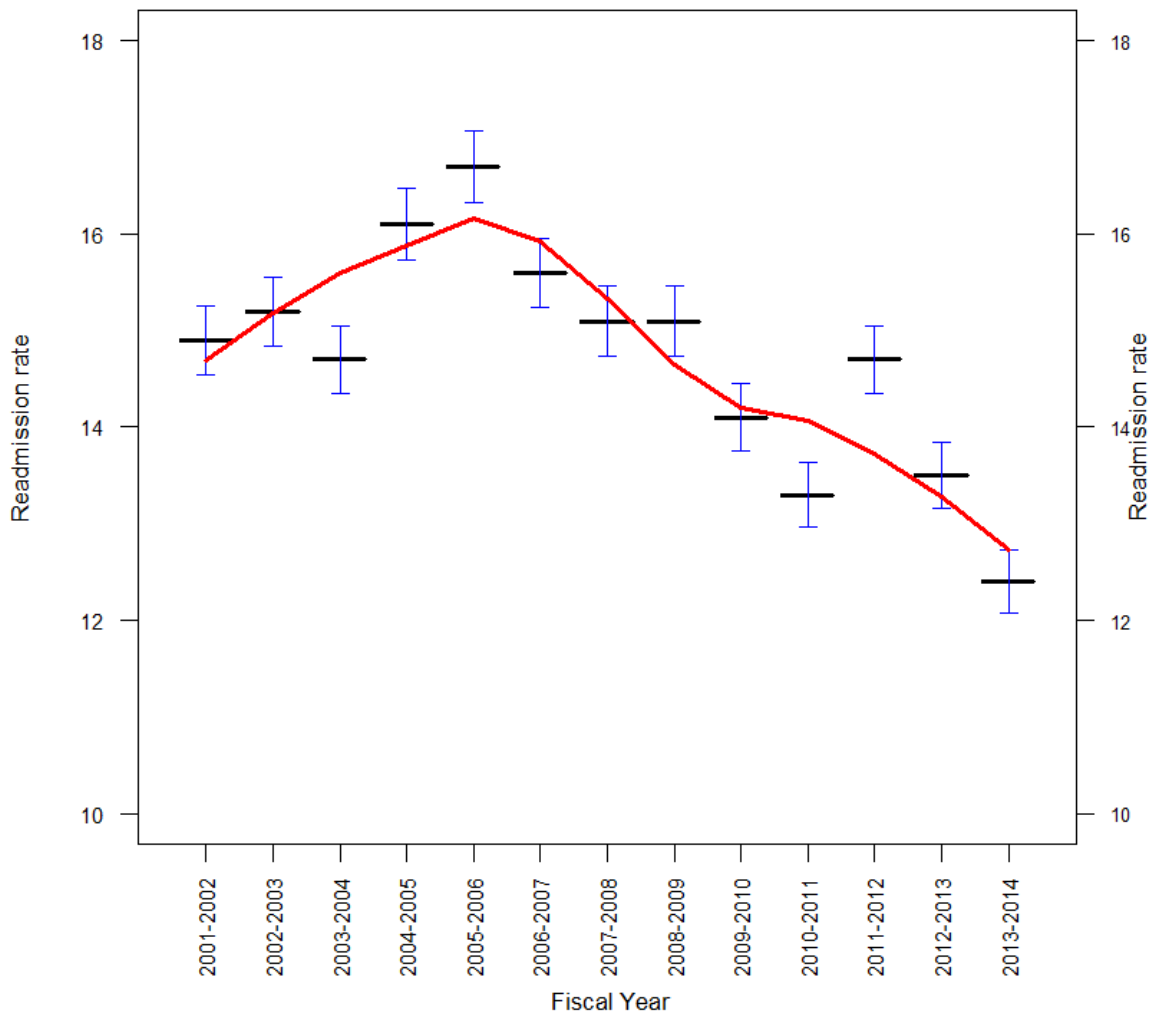
Table 4.1. All-cause readmission rates in 2001-2014

	Readmission rate[a]	
Fiscal Year	**(%)**	**95% CI**
2001-2002	14.9	(13.7, 16.1)
2002-2003	15.2	(14.0, 16.4)
2003-2004	14.7	(13.5, 15.9)
2004-2005	16.1	(14.9, 17.3)
2005-2006	16.7	(15.5, 17.9)
2006-2007	15.6	(14.4, 16.8)
2007-2008	15.1	(13.9, 16.3)
2008-2009	15.1	(13.7, 16.5)
2009-2010	14.1	(12.9, 15.3)
2010-2011	13.3	(12.2, 14.4)
2011-2012	14.7	(13.5, 15.9)
2012-2013	13.5	(12.3, 14.7)
2013-2014	12.4	(11.3, 13.5)

[a] (Cases within the denominator with at least one readmission within 30 days of discharge / the total number of index admissions between April 1 of the starting year and March 1 of the ending) x 100. For example, readmission rate for the fiscal year of 2001 to 2002 was calculated by dividing the number of index admissions with at least one readmission to the total number of index admissions between April 1, 2001 and March 1, 2002. Fiscal year is the period from April 1 of one year to March 31 of the following year. [b] confidence interval.

Figure 4.2 shows a loess smooth curve fitted to the readmission rates. While there has been a steady increase in readmission rate over the first five years of the study, readmission rate has declined afterward. In addition, there were 7319 admissions averted during the period of decline in the annual readmission rate.

Figure 4.2. Loess curve fitted to readmission rates with standard deviation error bars



4.3. Construction of independent variables

As described in section 3.5, continuous variables were also considered as categorical variables to understand the relationship between variables better. Alternative categories based on the variable distributions were examined using the data of our study, and the final categories of the independent continuous variables were identified. This was done to achieve more appropriate categories, so that no category had a low frequency (< 5). The variables included LOS, diagnostic category, age at admission, and CD4 counts. Eventually, all given variables were categorized based on the literature review of related studies, the frequency of the categories, and consideration of meaningful categories. Table 4.2 shows the details of the selection.

Table 4.2. Comparing categorizations of the continuous variables suggested by other studies

Length of stay(days)	N (%)
Total sample size	30,575 (100.00)
Berry et al. (2013)[4]	
Mean (SD) [a]	7.2 (20.3)
0	10,136 (33.15)
1-3	8,185 (26.77)
4-5	3,128 (10.23)
6-8	2,898 (9.48)
≥ 9	6,228 (20.37)
CIHI[b] (2012)[136]	
≤ 7	23,607 (77.21)
8-14	3,321 (10.86)
15-21	1,321 (4.32)
22-28	709 (2.32)
29-35	397 (1.30)
36-42	309 (1.01)
> 42	911 (2.98)
Halfon et al. (2002)[30]	
≤ 10	25,457 (83.26)
10 < and ≤ 20	2,632 (8.61)
20 < and ≤ 30	1,000 (3.27)
30 < and ≤ 40	471 (1.54)
> 40	1,015 (3.32)
Havens et al. (2016)[137]	
≤ 3	18,321 (59.92)
4-7	5,286 (17.29)
>7	6,968 (22.79)
Goncalves et al. (2013)[138]	
< 25	28,575 (93.46)
≥ 25	2,000 (6.54)

Diagnostic category	
Berry et al. (2013)[4], Berry et al. (2015)[40], Nijhawan et al. (2015)[6]	
Gastrointestinal/Liver	4,250 (13.90)
AIDS Defining Illness	4,167 (13.63)
Psychiatric	3,644 (11.92)
Injury/Poisoning	2,299 (7.52)
Pulmonary	2,064 (6.75)
Symptomatic	1,874 (6.13)
Cardiovascular	1,623 (5.31)
Renal/Genitourinary	1,581 (5.17)
Morbidity/affect health factors	1,575 (5.15)
Orthopedic	1,351 (4.42)
Dermatologic	1,251 (4.09)
Non-AIDS defining infection	1,183 (3.87)
Oncologic	1,159 (3.79)
Unclassified/Congenital/Perinatal	813 (2.66)
Obstetric/Gynecologic	712 (2.33)
Endocrine/Metabolic/Immune	373 (1.22)
Neurologic	367 (1.20)
Hematologic	284 (0.93)
Nijhawan et al. (2012)[5]	
Peptic Ulcer, hemorrhage, other spec. gastrointestinal disorders	4,250 (13.90)
HIV/AIDS	4,167 (13.63)
Other infectious diseases, including UTI	1,385 (4.53)
Oncology/chemotherapy	1,204 (3.94)
Pneumonia, pleurisy	1,051 (3.44)
Poisonings and allergic reactions	510 (1.67)
Congestive heart failure	79 (0.26)
Renal failure	6 (0.02)
Central nervous system infection	3 (0.01)
Cellulitis, local skin infection	0 (0.00)
Other causes combined	17,920 (58.61)
Feller et al. (2015)[25]	
AIDS-defining illness	4,167 (13.63)
Chronic kidney disease	177 (0.58)
Others	26,231 (85.79)

Palepu et al. (2003)[94]	
AIDS-defining illness	4,167 (13.63)
Others	26,408 (86.37)
Age at admission (years)	
PHAC[c] Surveillance report[139]	
Mean (SD)	45.8 (12.9)
Median(Q1,Q3)	45.0 (37,54)
< 30[d]	2,875 (9.40)
30-39	6,746 (22.06)
40-49	10,124 (33.11)
≥ 50	10,830 (35.42)
Berry et al. (2013)[4]	
< 18	196 (0.64)
18-34	5,419 (17.72)
35-44	9,218 (30.15)
45-54	8,714 (28.5)
55-64	4,590 (15.01)
≥ 65	2,438 (7.97)
Halfon et al. (2002)[30]	
0-15	122 (0.40)
16-35	6,173 (20.19)
36-55	17,874 (58.46)
56-75	5,739 (18.77)
≥ 76	667 (2.18)
CD4 counts	
Berry et al. (2013)[4]	
≤ 50	26,722 (87.40)
51-200	1,758 (5.75)
201-350	1,104 (3.61)
≥ 351	991 (3.24)
Nijhawan et al. (2012)[5]	
≤ 50	11,319 (37.02)
51-200	4,115 (13.46)
201-400	6,491 (21.23)
> 400	8,650 (28.29)

Nijhawan et al. (2015)[6]	
< 50	26,701 (87.33)
51-200	1,761 (5.76)
201-500	1,679 (5.49)
> 500	434 (1.42)
BCCfE[e] technical report[140]	
< 200	28,374 (92.80)
200-349	1,171 (3.83)
350-499	581 (1.90)
≥ 500	449 (1.47)

[a] Standard Deviation. [b] Canadian Institute for Health Information. [c] Public Health Agency of Canada. [d] The categories for PLWHA younger than 30 by PHAC included < 15; 15-19; and 20-29. However, these categories were combined due to the low frequency. [e] British Columbia Center for Excellence in HIV/AIDS.

Based on the frequency of categories of the variables in Table 4.2, the classifications according to Berry et al.[4] for LOS were deemed most appropriate for this study due to the even distribution of observations across categories and comparability in study designs and patient populations. For the same reason, diagnostic category classifications applied by Berry et al.[40] and Nijhawan et al.[6] were used. For age at admission classifications by PHAC and for CD4 counts, classification by Nijhawan et al.[5] were more appropriate.

In one further step, the effects of all alternative variables on the outcome variable were evaluated through univariable logistic regression and the goodness of fit for each case was reviewed (Table 4.3). Among distinct LOS variables, the classification by Berry et al.[4] showed the smallest value of QIC (24,114). Likewise, the classifications by Berry et al.[40] and Nijhawan et al.[6] were used for diagnostic category, the classification by PHAC[139] was used for age at admission, and the categorization by Nijhawan et al.[5] was used for the classification of CD4 counts. All the selected classifications resulted in the smallest QIC (24,531, 25,163, and 25,039 respectively).

Table 4.3. Univariable analysis of alternative categories of length of stay, diagnostic categories, age at admission, and CD4 counts

	Odds Ratio (95% CI[a])	p-value[b]	QIC[c]
Length of stay (days)			
Berry et al. (2013)[4]			24,114
Mean[d]	0.54 (0.49, 0.58)	<.0001	25,282
Median[e]	0.48 (0.44, 0.52)	<.0001	25,282
0	0.25 (0.22, 0.28)	<.0001	
1-3	0.66 (0.60, 0.72)	<.0001	
4-5	0.72 (0.64, 0.81)	<.0001	
6-8	0.83 (0.74, 0.94)	0.0030	
≥ 9	1.00 (Ref[f])		
CIHI[g] (2012)[136]			24,886
≤ 7	0.77 (0.62, 0.95)	0.0144	
8-14	1.46 (1.16, 1.83)	0.0013	
15-21	1.56 (1.22, 1.99)	0.0005	
22-28	1.60 (1.19, 2.13)	0.0015	
29-35	1.45 (1.03, 2.03)	0.0342	
36-42	1.52 (1.07, 2.16)	0.0195	
> 42	1.00 (Ref)		
Halfon et al. (2002)[30]			25,008
≤ 10	0.79 (0.65, 0.97)	0.0217	
10 < and ≤ 20	1.47 (1.19, 1.83)	0.0005	
20 < and ≤ 30	1.60 (1.24, 2.06)	0.0003	
30 < and ≤ 40	1.32 (0.96, 1.81)	0.0853	
> 40	1.00 (Ref)		
Havens et al. (2016)[137]			24,684
≤ 3	0.46 (0.42, 0.50)	<.0001	
4-7	0.77 (0.70, 0.85)	<.0001	
> 7	1.00 (Ref)		
Goncalves et al. (2013)[138]			25,237
< 25	0.71 (0.62, 0.81)	<.0001	
≥ 25	1.00 (Ref)		

Diagnostic category			
Berry et al. (2013)[4], Berry et al. (2015)[40], Nijhawan et al. (2015)[6]			24,531
Non-AIDS defining infection	2.09 (1.62, 2.69)	<.0001	
Cardiovascular	1.66 (1.30, 2.13)	<.0001	
AIDS Defining Illness	3.20 (2.60, 3.93)	<.0001	
Gastrointestinal/Liver	1.17 (0.94, 1.45)	0.1706	
Psychiatric	2.73 (2.20, 3.38)	<.0001	
Renal/Genitourinary	1.00 (0.76, 1.31)	0.9961	
Pulmonary	1.84 (1.45, 2.33)	<.0001	
Endocrine/Metabolic/Immune	3.10 (2.16, 4.45)	<.0001	
Injury/Poisoning	1.54 (1.22, 1.94)	0.0003	
Oncologic	1.30 (0.99, 1.70)	0.0586	
Neurologic	1.54 (1.03, 2.31)	0.0362	
Hematologic	2.63 (1.83, 3.78)	<.0001	
Orthopedic	1.84 (1.42, 2.38)	<.0001	
Symptomatic	2.07 (1.63, 2.61)	<.0001	
Obstetric/Gynecologic	1.81 (1.34, 2.46)	0.0001	
Dermatologic	2.48 (1.93, 3.18)	<.0001	
Unclassified/Congenital/Perinatal	0.67 (0.46, 0.97)	0.0354	
Morbidity/affect health factors	1.00 (Ref)		
Nijhawan et al. (2012)[5]			24,971
HIV/AIDS	1.76 (1.60, 1.94)	<.0001	
Pneumonia, pleurisy	1.09 (0.88, 1.34)	0.4273	
Central nervous system infection	13.94 (1.55, 125.21)	0.0189	
Other infectious diseases, including UTI	1.12 (0.94, 1.32)	0.1964	
Cellulitis, local skin infection	-	-	
Peptic ulcer, hemorrhage, and other specified gastrointestinal disorders	0.67 (0.59, 0.76)	<.0001	
Renal failure	2.04 (0.33, 12.69)	0.4466	
Poisonings and allergic reactions	0.97 (0.71, 1.33)	0.8688	
Oncology/chemotherapy	0.78 (0.64, 0.95)	0.0119	
Congestive heart failure	2.03 (1.16, 3.55)	0.0134	
Other causes combined	1.00 (Ref)		
Palepu et al. (2003)[94]			25,077
AIDS-defining illness	1.58 (1.68, 2.04)	<.0001	
Others	1.00 (Ref)		

Age at admission			
PHAC[h] surveillance report[139]			25,163
Mean[i]	1.19 (1.10, 1.29)	<.0001	25,207
Median[j]	1.19 (1.10, 1.29)	<.0001	25,208
< 30	1.39 (1.20, 1.62)	<.0001	
30-39	1.36 (1.22, 1.51)	<.0001	
40-49	1.25 (1.14, 1.37)	<.0001	
≥ 50	1.00 (Ref)		
Berry et al. (2013)[4], Berry et al. (2015)[40]			25,177
<.18	0.60 (0.32, 1.12)	0.1100	
18-34	1.33 (1.13, 1.58)	0.0007	
35-44	1.32 (1.13, 1.54)	0.0004	
45-54	1.17 (1.00, 1.36)	0.0554	
55-64	1.00 (0.84, 1.18)	0.9128	
≥ 65	1.00 (Ref)		
Halfon et al. (2002)[30]			25,206
0-15	0.47 (0.21, 1.05)	0.0667	
16-35	1.17 (0.90, 1.51)	0.2323	
36-55	1.07 (0.83, 1.37)	0.6165	
56-75	0.88 (0.68, 1.13)	0.3162	
≥ 76	1.00 (Ref)		
Gender			
Female	0.82 (0.75, 0.89)	<.0001	
Male	1.00 (Ref)		
CD4 counts			
Berry et al. (2013)[4]			25,202
≤ 50	0.86 (0.70, 1.05)	0.1337	
51-200	1.37 (1.07, 1.74)	0.0112	
201-350	1.05 (0.80, 1.37)	0.7283	
≥ 351	1.00 (Ref)		
Nijhawan et al. (2012)[5]			25,039
≤ 50	1.66 (1.49, 1.85)	<.0001	
51-200	1.94 (1.72, 2.20)	<.0001	
201-400	1.22 (1.08, 1.37)	0.0015	
> 400	1.00 (Ref)		

Nijhawan et al. (2015)[6]			25,197
≤ 50	0.89 (0.65, 1.22)	0.4823	
51-200	1.44 (1.03, 2.03)	0.0351	
201-500	1.10 (0.78, 1.56)	0.5783	
> 500	1.00 (Ref)		
BCCfE[k] technical report[140]			25,280
< 200	0.94 (0.69, 1.28)	0.6938	
200-349	1.11 (0.78, 1.57)	0.5779	
350-499	1.11 (0.76, 1.62)	0.6014	
≥ 500	1.00 (Ref)		

[a] Confidence Interval. [b] the variable or variable category was statistically significant if p-value is less than 0.05 [c] Quasi-likelihood under Independence model Criterion. [d] Los > mean (7.2 days) was considered as reference level (LOS > 7.2 was coded as 1; otherwise was coded as 0). [e] Los > median (2 days) was considered as reference level (LOS > 2 was coded as 1; otherwise was coded as 0). [f] Reference level. [g] Canadian Institute for Health Information. [h] Public Health Agency of Canada. [i] Age at admission ≥ mean (= 45.8 years) was considered as reference level (age >= 45.8 was coded as reference; otherwise was coded as 0). [j] Age at admission ≥ median (= 45 years) was considered as reference level (age >= 45 was coded as 1; otherwise was coded as 0). [k] British Columbia Center for Excellence in HIV/AIDS.

Finally, to categorize continuous variables, the following classifications were used based on the smallest QIC from Table 4.3. For LOS, the method by Berry et al.[4]; for diagnostic category, the classification by Berry et al.[4] and Nijhawan et al.[6]; for age at admission the classification by PHAC surveillance report; and for CD4 counts, the classification recommended by Nijhawan et al.[5] were used. In addition, for several variables including ALC days, the number of ED visits in last 6 months, and diagnostic category variables- collapsing some low frequency categories was considered. The final categories of the study variables are shown in Table 4.4.

Table 4.4. Categorizations of explanatory variables

Variable	Category
Gender	Female/Male
Age at admission	< 30, 30-39, 40-49, ≥ 50 years
Diagnostic category	Coded based on ICD10[a], 1 = Non-AIDS defining infection, 2 = Cardiovascular, 3 = AIDS Defining Illness, 4 = Gastrointestinal/ Liver, 5 = Psychiatric, 6 = Renal/ Genitourinary, 7 = Pulmonary, 8 = Endocrine/ Metabolic/ Immune, 9 = Injury/ Poisoning, 10 = Oncologic, 11 = Neurologic, 12 = Hematologic, 13 = Orthopedic, 14 = Symptomatic, 15 = Obstetric/ Gynecologic , 16 = Dermatologic, 17 = Unclassified/ Congenital/ Perinatal, 18 = Missing, 19 = Morbidity/ affect health factors, (levels 8, 11, 12, and 15 were collapsed in one level and levels 17 and 19 were combined in one level due to the low frequencies)
Non-high school graduation rate	≤ 20, 20-40, > 40
Prevalence of low income[b]	0,1,2,3-quantile
Labor force participation rate	< 63, 63-65, > 65
Hospital size	< 200 , 200-399, ≥ 400 beds
Hospital teaching status	Non-teaching, teaching
Year of hospitalization	2001-2004, 2005-2009, 2010-2013
Length of stay	0, 1-3, 4-5, 6-8 or ≥ 9 days
Alternate level of care days	0, ≥ 1 days
Acuity of admission	Urgent, not urgent
Number of prior admissions in last 12 months	0, 1-2, ≥ 3
Number of emergency visits in last 6 months	0, 1-3, ≥ 4
Admitted via emergency department	Yes, No
Status of patient upon leaving hospital	Transferred to another facility (inpatient hospital care/long term care), discharged to a home setting with support services, discharge home, left against medical advice, others
Leaving against medical advice	Yes, No
Level of care	Acute Care, Day Care Surgery, Free-standing rehabilitation
Responsible payer for hospitalization	Federal/province/territory government, Canadian/Other country resident self-pay
Type of hospitalization	medical, surgical
Surgical hospitalization reasons	HIV Complication/Other infection/Fever or Wound/Leukemia/ Chemotherapy, Respiratory/ Heart/ Pulmonary complications, Gastrointestinal complications, other complications[c]
Transferred within a hospital	yes, no

Transferred between hospitals	yes, no
Hospital location	urban, rural
CD4 counts	≤ 50,51-200, 201-400, > 400

[a] International Statistical Classification of Diseases and Related Health Problems, Tenth Revision. [b] The prevalence of low income data were divided into 4 quantiles using "Proc rank" in SAS. However, there is no method available in "Proc Rank" to ensure that each quantile will contain the same number of observations. The number of observations falling into each quantile group depends on the values of the ranking variable and the distribution of these values in the input data set. The groups were assigned values 0, 1, 2, and 3. [c] Source: http://support.sas.com/kb/22/399.html. The corresponding codes are presented in Appendix A.

4.4. Descriptive analysis

During the study period (2001 - 2014) there were 30,575 index admissions among 8,642 HIV-infected individuals. Characteristics of the sample cohort for all-cause readmission are presented in Table 4.5.

4.4.1. Predisposing factors

The mean age at admission was 46 (SD = 12.9) years and approximately three-quarters (71.7%) of all index admissions occurred among male patients. PLWHA were hospitalized mostly due to gastrointestinal/liver diseases (13.9%) or an AIDS-defining illness (13.6%) followed by psychiatric diseases (11.9%). Approximately half of the index hospitalizations were in hospitals located in a neighbourhood with a higher non-high school graduation rate (> 40.0%). In addition, 27.0% of the index admissions occurred in hospitals located in neighbourhoods in the lowest quarter of income, whereas hospitals located in neighbourhoods in the second and third quarters accounted for fewer index admissions (23.0% & 11.0%, respectively). The majority of hospitalizations occurred in large hospitals (≥ 400 beds) and teaching hospitals (64.0% & 63.0%, respectively). There were fewer hospitalizations recorded during the last 3 years of the study (2010-2013) than in earlier years (2005-2009 & 2001-2004) (29.2% vs. 35.5% & 35.4%, respectively).

Table 4.5. Characteristics of the selected cohort

	N (%)
Predisposing Factors	
Gender	
Male	21,929 (71.72)
Female	8,646 (28.28)
Age at admission	
Mean (SD)[a]	45.8 (12.9)
Median(Q1,Q3)[b]	45.0 (37,54)
< 30	2,865 (9.37)
30-39	6,726 (22.00)
40-49	10,125 (33.12)
≥ 50	10,859 (35.52)
Diagnostic category[c]	
Gastrointestinal/Liver	4,258 (13.93)
AIDS Defining Illness	4,167 (13.63)
Psychiatric	3,632 (11.88)
Injury/Poisoning	2,293 (7.50)
Pulmonary	2,062 (6.74)
Symptomatic	1,883 (6.16)
Endocrine/Metabolic/Immune, Neurologic, Hematologic, Obstetric/Gynecologic	1,738 (5.68)
Cardiovascular	1,618 (5.29)
Renal/Genitourinary	1,582 (5.17)
Orthopedic	1,351 (4.42)
Dermatologic	1,246 (4.08)
Non-AIDS defining infection	1,182 (3.87)
Oncologic	1,165 (3.81)
Unclassified/Congenital/Perinatal	2,398 (7.84)
Non-high school graduation rate (%)	
≤ 20	3,186 (10.42)
20-40	12,097 (39.57)
> 40	15,292 (50.01)

Prevalence of low income - Quantile[d]	
0	8,365 (27.36)
1	7,037 (23.02)
2	3,496 (11.43)
3	11,677 (38.19)
Labor force Participation rate (%)	
< 63	5,753 (18.82)
63-65	13,135 (42.96)
> 65	11,687 (38.22)
Hospital Size (beds)	
< 200	5,005 (16.37)
200-399	5,991 (19.59)
≥ 400	19,579 (64.04)
Hospital teaching Status	
Non-teaching	11,350 (37.12)
Teaching	19,225 (62.88)
Year of hospitalization	
2001-2004	10,812 (35.36)
2005-2009	10,845 (35.47)
2010-2013	8,918 (29.17)
Enabling factors	
Length of stay (days)	
Mean (SD)	8 (20.2)
0	10,179 (33.29)
1-3	8,160 (26.69)
4-5	3,113 (10.18)
6-8	2,891 (9.46)
≥ 9	6,232 (20.38)
Alternative level of care days (days)	
Mean (SD)	0.7 (7.3)
0	29,796 (97.45)
≥ 1	779 (2.55)
Acuity of admission[e] - The urgency of admission	
Urgent	19,764 (64.64)
Not Urgent	10,811 (35.36)

Number of prior admissions in last 12 months	
0	17,255 (56.43)
1-2	9,877 (32.30)
≥ 3	3,443 (11.26)
Number of emergency department visits in last 6 months	
0	24,024 (78.57)
1-3	6,136 (20.07)
≥ 4	415 (1.36)
Admitted via emergency department	
Yes	18,229 (59.62)
No	12,346 (40.38)
Status of patient upon leaving hospital	
Discharged home	24,503 (80.14)
Left against medical advice	3,763 (12.31)
Discharged to a home setting with support services	1,192 (3.90)
Transferred to another facility (inpatient hospital care/ long term care)	1,082 (3.54)
Other	34 (0.11)
Leaving against medical advice	
No	26,812 (87.70)
Yes	3,763 (12.30)
Level of care	
Acute Care	21,419 (70.06)
Day Surgery	9,085 (29.71)
Free-standing Rehabilitation	71 (0.23)
Responsible payer for hospitalization	
Federal/province/territory government	30,528 (99.85)
Canadian/Other country resident self-pay	47 (0.15)
Type of hospitalization	
Medical	21,662 (70.85)
Surgical	8,915 (29.15)
Transferred within hospital	
No	30,558 (99.94)
Yes	17 (0.06)
Transferred between hospitals	
No	29,695 (97.12)
Yes	880 (2.88)

Surgical hospitalization	
Non-surgical index admissions	21,662 (70.85)
Surgical index admissions	8,915 (29.15)
Gastrointestinal complications	1,168 (13.10)
Respiratory/Heart/Pulmonary complications	235 (2.64)
HIV complications including HIV infections/Other infections/Fever or Wound/Leukemia/Chemotherapy[f]	98 (1.10)
Other Complications	7,414 (83.16)
Hospital Location	
Urban	26,763 (87.53)
Rural	3,812 (12.47)
Need factors	
CD4 Counts (cells/µL)	
≤ 50	11,306 (36.98)
51-200	4,122 (13.48)
201-400	6,498 (21.25)
> 400	8,649 (28.29)

[a] Standard deviation. [b] Quantiles. [c] Diagnosis codes are based on ICD-10-CA-CIHI. [d] The prevalence of low income data were divided into 4 quantiles using "Proc rank" in SAS. However, there is no method available in "Proc Rank" to ensure that each quantile will contain the same number of observations. The number of observations falling into each quantile group depends on the values of the ranking variable and the distribution of these values in the input data set. The groups were assigned values 0, 1, 2, and 3. Source: http://support.sas.com/kb/22/399.html. [e] Admissions for "Newborn" were excluded (n = 13, 0.03%). [f] Other infections include Urinary tract infection, septic/ site, and other infections.

4.4.2. Enabling factors

People living with HIV/AIDS (PLWHA) stayed at hospitals approximately 8 days and were waiting approximately 1 day on average to be discharged from hospitals (Table 4.5). PLWHA were often admitted for a condition that was urgent. The number of admissions for an urgent condition was approximately twice that for non-urgent admissions (64.6% vs. 35.4%, respectively). More than half of index admissions occurred among individuals who had no previous hospital admissions. Approximately 80% of all admissions resulted in discharge to home whereas 12.3% ended in leaving AMA and 7.4% ended in discharge to care in a home setting or another facility such as a long-term facility. Hospitalized PLWHA mostly received acute care in contrast with other levels of care (70.1% vs. 29.9%, respectively). Most hospitalizations among PLWHA occurred due to a medical condition rather than a surgical one (71.0% vs. 29.0%). Among all surgical hospitalizations, gastrointestinal complications were the

most frequent reason (13.1%), followed by other complications. The majority of hospitalizations occurred in hospitals located in urban areas (87.5%).

4.4.3. Need factors

As stated, in Andersen model, perceived needs reflects an understanding of the individual's seeking of care and adherence to a medical regimen, whereas evaluated need sheds light on the type and amount of the required treatment for the person as a patient. For this study, the distribution of CD4 cell counts at index admission, the measure of evaluated need, revealed that 37.0% of the study population had a CD4 count less than or equal to 50 cells/µL, 13.5% had a CD4 cell count of 51 to 200 cells/µL, 21.3% had a CD4 count of 201 to 400 cells/µL, and 28.3% had a CD4 count of greater than 400 cells/µL. This reveals that about half of the PLWHA who admitted to hospital during the study period required a treatment as a patient.

4.5. Most responsible diagnosis at index admission of readmitted PLWHA

The most readmissions occurred for the PLWHA who were initially admitted due to an AIDS-defining illness (21.7%). Following that, PLWHA with a principal diagnosis of a psychiatric or dermatologic condition showed the highest readmission rate at 18.8% and 18.0%, respectively. With no considerable difference, PLWHA with a non-AIDS-defining infection had a 14.6% readmission rate.

Table 4.6. All-cause readmission rate by the most responsible diagnosis at index admission

Most responsible diagnosis at index admission	Readmission rate (%)
AIDS Defining Illness	21.73
Psychiatric	18.81
Dermatologic	17.99
Endocrine/Metabolic/Immune, Neurologic, Hematologic, Obstetric/Gynecologic	15.11
Non-AIDS defining infection	14.63
Symptomatic	14.23
Pulmonary	13.67
Orthopedic	12.88
Injury/Poisoning	11.41
Cardiovascular	11.08
Oncologic	8.98
Gastrointestinal/Liver	7.97
Renal/Genitourinary	7.15
Unclassified/Congenital/Perinatal, Morbidity/affect health factors	5.97

4.6. Identifying the working correlation matrix

Before starting the analyses, we needed to identify the type of working correlation matrix as we used logistic regression with Generalized Estimating Equations. The unstructured correlation matrix was selected for the analysis because the data of this study likely have within-subject correlation and the patterns in the variances and covariances are not reliable. An unstructured correlation matrix has no explicit pattern, but every correlation coefficient is allowed to be different. The QIC criterion for selecting the working correlation matrix was not applied because the QIC criterion does not work well when an unstructured correlation structure is included in a set of candidate models[141].

4.7. Univariable analysis

As the next step, the association of each explanatory variable with the all-cause readmission rate was tested through univariable analyses. However, before starting this step and to explore a preliminary idea about the association of the explanatory variables with all-cause readmission, contingency tables for all categorical variables with the outcome were created. There was no category with a frequency of zero or less than 5. The univariable analysis of all covariates including unadjusted ORs and 95% CI is shown in Table 4.7.

Table 4.7. Univariable analysis of risk factors of all-cause readmission

	Odds ratio (95% CI[a])
Predisposing Factors	
Gender	
Male	1.00 (Ref[b])
Female	1.21 (1.11, 1.32)[c]
Age at admission	
< 30	1.00 (Ref)
30-39	1.00 (0.86, 1.16)
40-49	0.88 (0.76, 1.01)
≥ 50	0.68 (0.59, 0.78)[c]
Diagnostic category	
Non-AIDS defining infection	1.00 (Ref)
Gastrointestinal/Liver	0.53 (0.43, 0.65)[c]
AIDS Defining Illness	1.58 (1.31, 1.92)[c]
Psychiatric	1.33 (1.08, 1.63)[c]
Injury/Poisoning	0.73 (0.59, 0.92)[c]
Pulmonary	0.91 (0.72, 1.13)
Symptomatic	1.00 (0.80, 1.25)
Endocrine/Metabolic/Immune, Neurologic, Hematologic, Obstetric/Gynecologic	1.06 (0.84, 1.34)[c]
Cardiovascular	0.77 (0.60, 0.97)[c]
Renal/Genitourinary	0.46 (0.35, 0.60)[c]
Orthopedic	0.87 (0.68, 1.11)
Dermatologic	1.22 (0.95, 1.57)
Oncologic	0.63 (0.48, 0.82)[c]
Unclassified/Congenital/Perinatal	0.41 (0.32, 0.53)[c]
Non-high school graduation rate (%)	
≤ 20	1.00 (Ref)
20-40	0.95 (0.83, 1.08)
> 40	1.17 (1.03, 1.33)[c]
Prevalence of low income - quantile	
0	1.00 (Ref)
1	0.86 (0.77, 0.97)[c]
2	1.04 (0.91, 1.20)
3	1.16 (1.06, 1.28)[c]

Labor force Participation rate (%)	
< 63	1.00 (Ref)
63-65	1.45 (1.30, 1.61)[c]
> 65	1.33 (1.19, 1.49)[c]
Hospital Size (beds)	
< 200	1.00 (Ref)
200-399	1.02 (0.89, 1.16)
≥ 400	1.28 (1.15, 1.43)[c]
Hospital teaching Status	
Non-teaching	1.00 (Ref)
Teaching	1.19 (1.10, 1.29)[c]
Year of hospitalization	
2001-2004	1.00 (Ref)
2005-2009	0.97 (0.88, 1.06)
2010-2013	0.81 (0.74, 0.89)[c]
Enabling factors	
Length of stay(days)	
0	1.00 (Ref)
1-3	2.85 (2.54, 3.19)[c]
4-5	3.11 (2.71, 3.56)[c]
6-8	3.63 (3.16, 4.18)[c]
≥ 9	4.35 (3.88, 4.86)[c]
Alternative level of care days	
0	1.00 (Ref)
≥ 1	1.26 (1.01, 1.59)[c]
Acuity of admission - The urgency of admission	
Not Urgent	0.21 (0.19, 0.24)[c]
Urgent	1.00 (Ref)
Number of prior admissions in last 12 months	
0	1.00 (Ref)
1-2	1.63 (1.51, 1.75)[c]
≥ 3	2.79 (2.48, 3.14)[c]
Number of emergency department visits in last 6 months	
0	1.00 (Ref)
1-3	2.17 (1.99, 2.35)[c]
≥ 4	4.09 (3.14, 5.33)[c]

Admitted via emergency department	
No	1.00 (Ref)
Yes	3.39 (3.10, 3.71)[c]
Leaving against medical advice	
No	1.00 (Ref)
Yes	3.94 (3.59, 4.33)[c]
level of cares	
Acute Care	1.00 (Ref)
Day Surgery	0.18 (0.16, 0.20)[c]
Free-standing Rehabilitation	0.74 (0.37, 1.50)
Responsible payer for hospitalization	
Canadian/Other country resident self-pay	0.91 (0.36, 2.31)
Federal/province/territory government	1.00 (Ref)
Type of hospitalization	
Medical	1.00 (Ref)
Surgical	0.40 (0.36, 0.44)[c]
Transferred within hospital	
No	0.43 (0.15, 1.28)
Yes	1.00 (Ref)
Transferred between hospitals	
No	1.00 (Ref)
Yes	1.71 (1.43, 2.05)[c]
Surgical index admission	
Non-surgical index admissions	1.00 (Ref)
HIV complications including HIV infections/Other infections/Fever or Wound/Leukemia/Chemotherapy[d]	1.86 (1.14, 3.04)[c]
Respiratory/Heart/Pulmonary complications	0.53 (0.32, 0.86)[c]
Gastrointestinal complications	0.31 (0.24, 0.41)[c]
Other Complications	0.38 (0.35, 0.43)[c]
Hospital Location	
Rural	1.00 (Ref)
Urban	1.08 (0.95, 1.21)
Need factors	
CD4 Counts (cells/µL)	
≤ 50	1.00 (Ref)
51-200	1.20 (1.07, 1.34)[c]
201-400	0.71 (0.64, 0.80)[c]
> 400	0.57 (0.51, 0.63)[c]

[a] Confidence Interval. [b] Reference level. [c] statistically significant ($p \leq 0.05$). [d] Other infections include Urinary tract infection, septic / site, and other infections.

A broad range of variables were associated with the risk of all-cause readmission (Table 4.7). All of the predisposing factors considered, including gender, age at admission, diagnostic category, non-high school graduation rate, prevalence of low income, labour force participation rate, hospital size and teaching status, and year of hospitalization, were all associated with the risk of all-cause readmission in univariable analysis.

Of all enabling factors, LOS, ALC days, acuity of admission, number of previous admissions within the last 12 months, number of ED visits in last 6 months, admitted via ED, leaving AMA, level of care, type of admission, transfer between hospitals, and surgical index admissions were associated with outcome. Analyzing the ORs of the significant enabling factors of LOS, the number of previous admissions, and the number of ED visits confirmed the existence of a positive association with the outcome. For LOS, for instance, a progressive increase in the risk of readmission by increasing LOS was identified. The only need factor of the study, CD4 cell count, also had an association with the outcome.

4.8. Goodness of fit

Tests of goodness of fit for independent variables were implemented using logistic regression models and comparing QIC[132]. Table 4.8 shows the results of goodness of fit for the explanatory variables individually. Similar to the univariable regression results, a broad range of the explanatory variables were statistically significant. However, entering the responsible payer for hospitalization; transfer within hospital; and location of hospital, urban/rural, in the models one at a time, did not improve the models. These three non-significant variables also produced the highest AIC/QIC in regression with the outcome.

Table 4.8. Goodness of fit – Explanatory variables

	Proc Logistic		Proc Genmod[a]		
Parameter	**Chi-square[b]**	***P-value***	**AIC[c]**	**QIC[d]**	**QICu[e]**
Acuity of admission	1584.62	<.0001	23495	21241	21240
Level of care	1510.94	<.0001	23571	21288	21287
Admitted via ED	1294.92	<.0001	23785	21526	21525
Length of stay	1181.01	<.0001	23905	21563	21562
Leaving against medical advice	982.98	<.0001	24097	21714	21713
Number of ED	925.28	<.0001	24156	21992	21991
Number of prior admissions	873.87	<.0001	24208	22040	22039
Diagnostic category	774.55	<.0001	24329	21980	21977
Type of admission	643.16	<.0001	24437	22088	22087
Surgery category	333.11	<.0001	24766	21494	21493
CD4 count	247.72	<.0001	24836	22401	22399
Age at admission	138.75	<.0001	24945	22536	22534
Labor force participation rate	63.37	<.0001	25018	22587	22585
Hospital size	46.26	<.0001	25035	22604	22603
Gender	42.23	<.0001	25037	22623	22622
Prevalence of low income	40.01	<.0001	25043	22607	22606
Transferred between hospitals	28.25	<.0001	25051	22612	22611
Non-high school graduation rate	29.82	<.0001	25052	22611	22610
Hospital teaching status	20.48	<.0001	25059	22624	22622
Alternative level of care days	7.78	0.0053	25072	22640	22639
Transferred within hospital	2.56	0.1093	25077	22648	22647
Responsible payer	0.06	0.8077	25079	22649	22648
Hospital location (urban/rural)	0.18	0.6748	25079	22649	22647

[a] Proc Genmod using GEE. [b] Chi-Square likelihood ratio. [c] Akaike information criterion. [d] Quasi-likelihood under independence model criterion. [e] a simplified version of QIC.

4.9. Multicollinearity

Before starting to create multivariable logistic regression models, multicollinearity was assessed. Based on the correlation coefficient criterion ($\rho > 0.6$), the pair variables with a correlation coefficient greater than 0.6 were identified and one of the pair variable was removed.

Therefore, type of admission, acuity of admission, number of ED visits, non-high school graduation rate, and level of care were excluded in further analyses.

4.10. Multivariable analysis

To identify the final predictive model of all-cause readmission, in addition to significant covariates from the univariable models, all enabling and need factors were considered. However, two enabling factors including responsible payer for admissions and transfer within hospital, which were not significant, were excluded in further analyses because both had very low frequencies in one of their categories. Highly correlated factors were not considered in further analyses too. Table 4.9 shows the details of the modeling and the QIC and QICu resulting from each model. Interestingly, entering step-by-step independent factors improved the models' ability to predict the outcome regarding both the QIC and QICu. Adding hospital teaching status, alternative level of care days, prevalence of low income, labor force participation rate, hospital location, and year of hospitalization variables did not improve the fit of the model (Table 4.9). However, these variables were kept in the model. In fact, after excluding collinear variables, the selection of variables was according to Andersen model theory. As mentioned before, the model indicates mutable variables as potentially changeable and is to be considered in policies for decreasing health service utilization.

Table 4.9. Selection of final model

Model	Variable	QIC[a]	QICu[b]
1	Gender	22,623	22,622
2	Gender + age	22,532	22,529
3	Gender + age + Diagnostic category	21,960	21,955
4	Gender + age + Diagnostic category + hospital size	21,949	21,943
5	Model 4 + hospital teaching status	21,951	21,945
6	Model 5 + length of stay	21,402	21,397
7	Model 6 + alternative level of care days	21,403	21,397
8	Model 7 + admitted via emergency department	21,208	21,202
9	Model 8 + leaving against medical advice	20,648	20,643
10	Model 9 + surgical index admission	20,081	20,075
11	Model 10 + # of prior admissions	19,723	19,719
12	Model 11 + transferred between hospitals	19,722	19,718
13	Model 12 + prevalence of low income	19,722	19,718
14	Model 13 + hospital location	19,725	19,720
15	Model 14 + labor force participation rate	19,725	19,720
16	Model 15 + CD4 counts	19,697	19,692
17	Model 16 + year of hospitalization	19,698	19,693

[a] Quasi-likelihood under independence model criterion. [b] a simplified version of QIC.

The results of multivariable logistic regression are shown in Table 4.10. The results showed that among predisposing factors only the diagnostic category covariate was statistically significant. Significant covariates among the enabling factors were LOS, number of previous admissions within the last 12 months, admitted via ED, leaving AMA, transfer between hospitals, and surgical index admissions. Within this group, the location of the hospital was not significant. The CD4 count also significantly improved the model. As the QIC of the final model was the smallest one among all considered models, it is suggested that the model was a good fit for the data. Recoding of levels that are not different from the references was not checked because of two reasons. One reason is theoretical: the different levels may be qualitatively different from the reference. Another reason is statistical: there are other possible pairwise comparisons which may be significantly different from one other while they are not different from the reference.

Table 4.10. Multivariable analysis of risk factors of all-cause readmission

Parameter	Odds ratio (95% CI[a])	P-value
Predisposing Factors		
Gender		
Male	1.00 (Ref[b])	
Female	0.96 (0.88, 1.05)	.4119
Age at admission (years)		
< 30	1.00 (Ref)	
30-39	1.01 (0.87, 1.17)	.8926
40-49	1.00 (0.86, 1.16)	.9994
≥ 50	1.01 (0.87, 1.18)	.8730
Diagnostic category		
Non-AIDS defining infection	1.00 (Ref)	
Gastrointestinal/Liver	0.92 (0.74, 1.14)	.4626
AIDS Defining Illness	1.12 (0.92, 1.37)	.2545
Psychiatric	1.15 (0.94, 1.42)	.1739
Injury/Poisoning	0.84 (0.67, 1.05)	.1276
Pulmonary	0.81 (0.65, 1.01)	.0659
Symptomatic	1.11 (0.89, 1.40)	.3586
Endocrine/Metabolic/Immune, Neurologic, Hematologic, Obstetric/Gynecologic	1.32 (1.04, 1.67)[c]	.0216
Cardiovascular	1.01 (0.79, 1.30)	.9073
Renal/Genitourinary	0.75 (0.57, 0.99)[c]	.0423
Orthopedic	0.97 (0.75, 1.25)	.7984
Dermatologic	0.90 (0.70, 1.14)	.3851
Oncologic	1.46 (1.10, 1.95)[c]	.0096
Unclassified/Congenital/Perinatal	0.76 (0.58, 0.98)[c]	.0353
Prevalence of low income - Quantile		
0	1.00 (Ref)	
1	0.94 (0.83, 1.07)	.3314
2	1.03 (0.87, 1.21)	.7447
3	0.94 (0.70, 1.25)	.6564
Labor force Participation rate (%)		
< 63	1.00 (Ref)	
63-65	1.11 (0.88, 1.40)	.3882
> 65	1.12 (0.98, 1.29)	.0938

Hospital Size (beds)		
< 200	1.00 (Ref)	
200-399	1.01 (0.87, 1.18)	.8645
≥ 400	0.98 (0.82, 1.16)	.8011
Hospital teaching Status		
Non-teaching	1.00 (Ref)	
Teaching	1.01 (0.89, 1.14)	.8932
Year of hospitalization		
2001-2004	1.00 (Ref)	
2005-2009	0.93 (0.86, 1.02)	.1251
2010-2013	0.99 (0.89, 1.09)	.7840
Enabling factors		
Length of stay(days)		
0	1.00 (Ref)	
1-3	1.45 (1.25, 1.70)[c]	< .0001
4-5	1.63 (1.37, 1.95)[c]	< .0001
6-8	1.94 (1.63, 2.32)[c]	< .0001
≥ 9	2.27 (1.93, 2.66)[c]	< .0001
Alternative level of care days		
0	1.00 (Ref)	
≥ 1	0.81 (0.66, 1.00)[c]	.0554
Number of prior admissions in last 12 months		
0	1.00 (Ref)	
1-2	1.47 1.36, 1.59)[c]	< .0001
≥ 3	2.49 (2.21, 2.81)[c]	< .0001
Admitted via emergency department		
No	1.00 (Ref)	
Yes	1.65 (1.44, 1.89)[c]	< .0001
Leaving against medical advice		
No	1.00 (Ref)	
Yes	3.02 (2.74, 3.33)[c]	< .0001
Transferred between hospitals		
No	1.00 (Ref)	
Yes	1.20 (1.00, 1.46)[c]	< .0001

Surgical index admission		
Non-surgical index admissions	1.00 (Ref)	
HIV complications including HIV infections/Other infections/Fever or Wound/Leukemia/Chemotherapy[d]	1.63 (1.02, 2.63)[c]	.0433
Respiratory/Heart/Pulmonary complications	0.69 (0.40, 1.20)	.1873
Gastrointestinal complications	0.60 (0.44, 0.82)[c]	.0011
Other Complications	0.73 (0.64, 0.83)[c]	< .0001
Hospital Location		
Rural	1.00 (Ref)	
Urban	1.02 (0.88, 1.18)	.7945
Need factors		
CD4 Count(cells/µL)		
≤ 50	1.00 (Ref)	
51-200	1.07 (0.95, 1.19)	.2704
201-400	0.84 (0.75, 0.93)[c]	.0010
> 400	0.78 (0.70, 0.78)[c]	< .0001

[a] Confidence Interval. [b] Reference level. [c] statistically significant ($p < 0.05$). [d] Other infections include Urinary tract infection, septic/site, and other infections.

The results of the multivariable analyses revealed that staying longer at the hospital, leaving AMA, transferring between hospitals, or having higher rates of inpatient and ED utilization were associated with a higher odds of readmission within 30 days of discharge.

In addition, PLWHA who were hospitalized due to an oncological (adjusted Odds Ratio: 1.45, 95% Confidence Interval: 1.10-1.95) or endocrine, metabolic, immune, neurological, hematological, obstetrical, or gynecological disease (1.32 (1.04, 1.67)) had a higher odds of readmission within 30 days of release. However, PLWHA initially diagnosed with a renal or genitourinary disease were corresponded with lower odds of readmission within 30 days after discharge (0.75 (0.57, 0.99)). Moreover, PLWHA who left the hospital AMA were at higher odds of being readmitted within 30 days of release (3.02 (2.74, 3.33)). The odds of being readmitted among PLWHA initially admitted for a surgery with any type of infection were 1.6 times higher than the odds of readmission in PLWHA who were initially admitted for medical care (1.6 (1.02, 2.63)). Finally, a higher odds of readmission was associated with lower CD4 counts. Compared to the odds of readmission among people with a CD4 count ≤ 50 cells/µL, PLWHA with higher

CD4 cell counts (201-400 or > 400) had a significantly lower odds of readmission within 30 days (0.84 (0.75, 0.93)); and (0.78 (0.70, 0.78)).

Chapter 5. Discussion, Conclusions, and Recommendations

5.1. Discussion

Unplanned hospital readmissions represent a burden to the healthcare system and may be result from either low quality of care or a number of factors unrelated to the quality of hospital care such as severity of illness, co-morbidities, or social supports. Readmission rates have been reduced in many countries[142] through financial incentives. In the United States and Denmark, for example, financial incentive programs have been implemented[142,143]. Public reporting has also been used by the United States, England, and Denmark to motivate hospitals to decrease readmissions[143]. The United States also applies a reduction in market basket (payment rates for hospitals which is updated annually by the CMS) update for hospitals not participating in public reporting. Another example is England, which uses financial incentives such as block grants to hospitals to decrease readmissions. Readmission rates in Canada have not changed in recent years[142]. In Canada, one in 12 hospitalized patients are readmitted to the hospital within 30 days of discharge[3], which costs approximately $1.8 billion (excluding physician fees for services) per year for the Canadian healthcare system. In BC, more than three-quarters of the hospitals had a readmission rate higher than the expected readmission rate for heart attacks, heart failure and pneumonia with a cost of $13 million over the 3-year period of 2010 to 2013[142].

Hospital readmissions may be influenced by several factors[4,5,25]. In this study, the potential factors associated with readmissions were studied through Andersen's behavioral model. The model frames factors that lead to the use of health services in three categories: predisposing, enabling, and need factors. For this study, predisposing factors included age at admission, gender, diagnostic category, prevalence of low income, labour force participation rate, hospital size and teaching status, and the year of hospitalization. These factors are considered to have low mutability or low capability of being altered if intervened upon. Enabling

factors included LOS, ALC days, number of prior admissions in last 12 months, admitted via emergency department, leaving AMA, transferred between hospitals, surgical index admission, and hospital location. Enabling factors are highly mutable. The study included one need factor, CD4 count, which can also be altered to change health services use. Identifying the factors associated with readmissions and capable of being changed in order to change healthcare use could improve the quality of care of PLWHA and would help to save money for the Canadian healthcare system.

The primary purpose of this study was to describe the patterns of readmission among the PLWHA in BC. The study also examined the risk factors of 30-day all-cause readmissions using logistic regression models. The study used data of the DAD, which contains administrative, clinical, and demographic information on hospital discharge between 2001 and 2014. HIV-related laboratory test results and demographic information of the patients were extracted from the BCCfE drug treatment program and laboratory disease registry databases. Data required for hospital- and community-level characteristics were adopted from the CIHI and BCStats.

5.2. Key findings

Our study has several important findings. The 30-day all-cause readmission rate among PLWHA in BC was 14.3%, 95% CI [14.0%, 14.6%]. The outcome rate exceeds the 30-day all-cause readmission rate of 8.5% among patients admitted to acute inpatient care in Canada according to the findings from a CIHI study[3]. The rate also exceeds the 30-day readmission rate for mental illness in Canada (11.8%) and in BC (13.8%) as well as the 30-day acute myocardial infarction (AMI) readmission rate in Canada (11.0%) and in BC (12.4%) according to the health system performance report by the CIHI[35]. This could be because PLWHA are more vulnerable to the complications of the care they receive during their stay at the hospital. Findings of a study conducted in six hospitals in Toronto, Canada, to identify unplanned readmissions among high-risk patients for readmission[73] showed a readmission rate of 12.6% within 30 days of discharge, slightly lower than the readmission rate in our study. This may be because of differences in the study population and definitions. In the study in six hospitals in Toronto, only medical patients

were considered and patients whose index admission was due to psychiatric, obstetrics, or gynecologic issues were excluded. There are few studies on readmission among PLWHA in Canada. A study by Palepu et al.[94] found that of all PLWHA with pneumonia admitted to St. Paul's Hospital between 1997 and 2000, 19% were readmitted within 14 days of discharge. The difference between the rates of readmission of the given study and the present study may be due to the more common use of ART in recent years in BC. In a comparison study of a matched cohort of PLWHA admitted to a specialized HIV/AIDS ward at St. Paul's Hospital, Vancouver, BC, between 1997 and 2002, Nosyk et al.[55] found that PLWHA who were on ART had a lower risk of readmission than the patients who were not on ART.

Compared with the related studies of PLWHA, our rate of 14.3% readmissions is much lower than the 19.3% from a U.S. multisite cohort study[4] and the 25.3% from a recent study of PLWHA at a large hospital in Dallas County, Texas[5]. The differences in the rates could not be related to the differences in health status. This is because in the current study PLWHA with a CD4 ≤ 50 had more index admissions than the population of the two other studies (37.0% vs. 18.0%[4] & 31.0%[5]). One contributing factor may be due to the different rate of being on ART. Other reasons could be differences in the population, healthcare system, and the underlying age structure in the study cohorts.

Factors independently associated with readmission included diagnostic category, LOS, number of prior admissions in last 12 months, admitted via ED, leaving AMA, transferred between hospitals, surgical index admission, and CD4 count. Among predisposing factors, only diagnostic category was associated with readmission. The diagnostic categories of oncologic, endocrine/metabolic/immune, neurologic, hematologic, obstetric/gynecologic diagnoses were found to be associated with a higher risk of readmission, which agrees with the findings of an earlier study[4]. The study which was carried out by Berry et al.[4] also found that AIDS-defining illness and cardiovascular, gastrointestinal/liver, renal/genitourinary disorders were significantly associated with a higher risk of readmission, whereas in our study, these reasons for admission showed no association with readmission. Among all reasons for hospitalization, AIDS-defining illness was associated with a higher risk of readmission; two other studies suggested[5,25]. These differences may be due to the wide use of ART among PLWHA in BC, Canada. In one of the studies[5], more than half of the patients had no history of ART. The results of the current study

provide support for the examination of hospital readmission rates in PLWHA, and justifies further study.

Comparing to predisposing factors, there were more risk factors among the enabling factors which showed an association with readmission rates. In this study, longer LOS was associated with a higher risk of readmission. This result is consistent with the results of a study by Berry et al.[4]. Berry et al. in a prospective multicenter observational cohort study noted that longer LOS was associated with higher risk of readmission among PLWHA. A retrospective case control of 276 family medicine inpatient by Garrison et al.[105] also found the same relationship between LOS and hospital readmission. PLWHA are at a higher risk of readmission if they have a prolonged stay at hospital, because a longer hospital LOS increases the risk of being exposed to hospital-related complications such as infections[3] which consequently increases the risk of readmission. However, early discharge may lead to incomplete required care and threaten the patients' safety due to the complexity and scope of the related issues[11]. Based on our findings, about half of the PLWHA had a CD4 count lower than 200, which indicates a poor health status of the patients. Therefore, strategies can include a proper discharge planning, particularly for PLWHA with low CD4 counts who stay in hospital for longer periods.to make sure the patients are ready to be discharged. It is critical to prioritize the patients' safety in considering any of the strategies to reduce hospital readmissions.

The number of prior index admissions and admitted via the ED were found to be associated with a higher odds of readmission. The findings related to healthcare utilization from our study are consistent with the findings from other studies by CIHI[3], Nijhawan et al.[5], and Feller et al.[25]. A study by Singh et al. using Texas Medicare claims data also showed a variation in risk of readmission by ED facility and ED providers care[144]. The study found patients with an emergency visit at larger facilities and for-profit facilities have higher readmission rates. In addition, studies showed PLWHA are admitted through the EDs more often than non-HIV people[108]. Therefore, considering interventions in ED facility systems of care and ED provider practices could be expected to reduce readmissions among PLWHA.

Our finding on discharge AMA confirms earlier research showing that the PLWHA who were discharged earlier than their physicians recommended were more often readmitted than

the patients who were discharged on a routine basis[5,25]. Some studies examined patient self-discharge and found that discharge AMA is a preventable problem which can be reduced by adequate and appropriate behavioral management and by improving access to appropriate care[25,145]. Additionally, the risk of leaving AMA is high in PLWHA due to the high prevalence of injection drug use[112]. An alternative social assistance disbursement may be a potential solution to decrease discharge AMA rate[146]. Studies have shown that monthly social assistance payments increase the risk of drug use[147], drug-related harm[148], and demand for health utilization including drug-related admissions as well as discharges AMA[112]. A randomized controlled trial study by Richardson et al.[146], currently in progress, aims to evaluate the impact of changing the time and frequency of social assistance disbursement on drug-related harm and health service utilization among people who use illicit drugs. Reducing discharges AMA may result in both improving the health status of the patients and reducing the unnecessary readmissions.

To the best of my knowledge, this is the first study to examine the effect of transfer between hospitals on readmissions among PLWHA. However, the effect of hospital transfers on post-discharge outcomes among other population has already been studied. A U.S. study of comparison of readmission rate in patients with AMI directly admitted to hospital versus transferred from another hospital showed that patients with AMI who are transferred are more likely to be readmitted than directly admitted patients[149]. In this study, the odds of being readmitted among PLWHA who were transferred between hospitals were 1.2 times higher than the odds of readmission in those discharged from the same hospital to which they were initially admitted. The finding in this study illuminate the independent association between a lower CD4 count, need factor of the study, and readmission rate. These relationships were also identified in other studies by Berry et al.[4], Nijhawan et al.[5], Nosyk et al.[55], and Palepu et al.[94]. PLWHA with low CD4 counts are at higher risk to exposure to infectious and non-infectious diseases. Based on the aforementioned association, using HIV treatment (ART) can be expected to reduce readmissions. The current study further supports previous research examining the importance of ART among PLWHA[6,55].

A number of variables in our study were found to have no effect on readmissions when adjusted for other variables. The current study suggests that readmission is not influenced by a

patient's age or gender (predisposing factors). This is consistent with findings in previous HIV-based studies[5,25,74]. The other predisposing factors including community-related factors and hospital related characteristics also showed no effect on readmissions. This study showed that the prevalence of low income and labour force participation rate had no association with readmission. Some studies found that lower socioeconomic status (such as lower income or lower education level) were associated with higher readmission rates[3,5,25]. The difference may be related to the fact that in the current study, unlike other studies, the hospitals' neighbourhood characteristics were considered rather than patients' neighbourhood characteristics. Similar to the results of a study by Goodney et al.[150], our study showed that there was no association between hospital characteristics including size and teaching status and the risk of readmission. In a study by the CIHI[3], the independent association between size of hospital and risk of readmission was examined. The results are consistent with our findings. There was seen no association between the year of hospitalization, the last predisposing factor of the study, and the risk of readmission which confirms findings of a previous study by Berry et al.[4].

After analysing the results, post hoc power analyses were conducted. A high statistical power of 1 (probably because of a large sample size in the present study) showed that readmission rate is reliable. In addition, the statistical power for the overall model in explanation of readmission was 1. It means the model was able to detect the effects of statistically significant independent variables on hospital readmissions. Also, it indicated that the sample size of study was sufficient to detect significant effects of independent variables. Nothing can be said about non-significant results because the statistical power which is the probability of correctly rejecting the null hypothesis is relevant to the false null. Non-significant results do not identify if the null hypothesis is true or false. However, it is unlikely that the non-significant findings of this study are due to lack of statistical power.

In conclusion, this study found a high rate of 30-day all-cause readmission among PLWHA in BC. This readmission rate can be used by HIV healthcare providers for their practices. Policymakers can use this high rate when considering policies that can produce reductions in readmissions among PLWHA. Findings of our study provide a better understanding of the factors associated with readmissions which is an important step to improve the quality of care of PLWHA. The association of readmissions with enabling factors including

LOS, admitted via ED, leaving AMA, number of previous admissions, and transferred between hospitals as well as the need factor of CD4 count suggests that reducing readmission rate is possible by reconsidering these modifiable factors through policy and clinical practice in Canada.

5.3. Study limitations and directions for future research

There are several limitations to this study which need to be considered carefully.

Generalizability: The data used in the study is from one province, BC, with a universal healthcare system, where the government is the only insurer. Administration of care in Canada is done on a provincial basis. Provinces may charge a health premium on their residents to help pay for publicly funded healthcare services; however, non-payment of a premium does not limit access to medically necessary health services (e.g. BC). Another point that needs to be considered is that BC is the one province that offers ART free of charge. Therefore, comparing the readmission rates between regions should be done with caution. Further studies may benefit from capturing and analyzing readmission characteristics of the patients on ART and other regions of the country.

Measurement error: This study is limited to administrative data with possibly some measurement limitations such as system coding bias for diagnostic categories and missing data. However, CIHI has increased the accuracy and quality of the information through centralized data processing of the DAD records. There were also few missing values for the variables of the study.

Identifying PPRs was another limitation of this study. Identification of PPRs typically requires it to be done through a manual review or an automatic classification. The first method requires the assistance of a professional physicians' team. The second method is typically accomplished through specialized software packages, using a set of pre-defined diagnosis codes (based on ICD-9/10) as the reasons for readmission. Examples included 3M PPR grouping software and SQLape (Striving for Quality Level and analyzing of patient expenses).

However, the automatic classifications could not be applied for this study because the Canadian health services system uses a modified version of ICD-9/10 for coding diagnoses. There has been also no published study on PPR among PLWHA in Canada to our knowledge. Further studies are needed to explore what proportion of readmissions among PLWHA are preventable through manual and/or automated methods.

This study used Pearson's r to check the multicollinearity among the explanatory variables. However, applying other types of correlation coefficients such as Spearman's rank correlation coefficients might address the multicollinearity problem more effectively in a future study.

Potential unmeasured confounding: of the many variables that affect readmission among PLWHA, this study took only some factors into consideration. For example, chronic disease score might have an effect on readmission but it was not considered for this study. Factors such as patient's socioeconomic status[5,25], mental health[5,25], substance abuse[5,25], viral load[4,5], comorbidities[5,25], and ART[5,55] have been found to be related to readmission. There might be some changes on the inferences made in the study by considering these variables. First, the estimated regression coefficients may be changed which means the strength of the association between other risk factors and the risk of readmission would be changed. Second, adding the confounders might change the statistically significant status of other risk factors in the model. The impact of missing potential confounders of ART and risk behavior variables on hospital readmission is also notable. ART has been increasingly applied in BC in recent years and that might be a reason for a decreasing trend of readmission rates. Risk behavior variables such as using drugs also influence readmission. Among HIV positive people, injection drug users have difficulties in accessing or accepting HIV/AIDS treatment. Without adjusting for ART and other behavior variables, unexplained variability of the models is probably large and weak effects may not be seen. Further studies are needed to investigate the effects of these factors on readmissions among PLWHA. Another limitation of the study is the lack of required data to identify PLWHA with specific risk factors for readmission through the LACE index. Identifying this group assists healthcare providers and policymakers to develop the required policies in order to decrease the readmission rate. Future studies are needed to identify those PLWHA who are at high risk of readmission.

The effect of interaction terms in the modeling was not considered in this study. The reason is that there was no hypothesis to test the effect of one risk factor on the predicted response depending on the value of the other risk factor(s). However, adding interactions may explain additional variability in the observed values beyond that which is explained by risk factors. Further studies are needed to determine the impact of such interactions on readmission among PLWHA. Using the Andersen model as the study framework also has its limitations. First, it is required to choose an adequate number of variables in each category of the model[151,152]. Otherwise, little variance of health utilization can be explained by the model[151,152]. Another limit is that the model does not specify any rule to classify certain variables in one of its three distinctive categories. For example, socioeconomic characteristics of neighbourhood may be categorized either as predisposing or enabling factors in the model. This is because socioeconomic status of neighbourhood is associated with individual and community income[42].

5.4. Recommendations

Risk of readmission among PLWHA was found to be associated with several enabling and need factors of the study. Among enabling factors, longer LOS was found to be associated with a higher risk of readmission. PLWHA typically have a higher length of hospital stay than non-HIV patients[28,108]. The nature of HIV and AIDS is complex and it affects how long PLWHA stay in the hospital. Additionally, the general health status of the patients influences their LOS. This study showed that about half of the index admissions occurred in PLWHA with low CD4, which means the existence of a more adverse condition of the patients[108]. As a result, they needed to stay at hospital for longer periods[138]. Therefore, HIV healthcare providers and policymakers need to develop appropriate strategies such as a better discharge planning for PLWHA, and especially for those with low CD4 counts. They need to make sure the patients are discharged when they are in a stable condition and are ready to be discharged.

People living with HIV/AIDS (PLWHA) who leave hospital AMA had a higher risk of readmission compared to PLWHA who do not. This finding suggests that policymakers and stakeholders need to target PLWHA who leave AMA and to devise strategies to encourage this group of patients to do a routine discharge. Strategies such as changing monthly association

payments need to be implemented to decrease the risk of discharge AMA which leads to fewer readmissions[146,147,148]. Implementing such strategies also reduces the hospitalizations and ED visits for PLWHA[147,148]. To reduce risk of readmission regarding risk factor of admission via ED, healthcare providers and policymakers also need to focus on ED facility systems of care and ED provider practices. Additionally, because transferring patients between hospitals was shown to be a risk factor of readmission, appropriate strategies such as appropriate communications between the origin and the destination settings and appropriate discharge planning are needed to be developed by healthcare providers and policymakers.

Lower CD4 count, the need factor of the study, was found to have an association with hospital readmission. One way to reduce the risk of readmission regarding this factor is to improve the health status of PLWHA. This may be achieved by scaling up access to the current treatment for HIV/AIDS in the country. It is recommended that healthcare providers and policymakers should make decisions to ensure more PLWHA are on ART. In addition, educational activities throughout the hospital stay as well as social supports may also encourage PLWHA to choose ART.

A high readmission rate for PLWHA needs to be addressed by the policymakers and healthcare providers. It is recommended that appropriate strategies be considered to motivate hospitals to reduce their readmission rates. Financial policies such as Medicare's incentive program that is currently being implemented in the United States hospitals are claimed to be not as effective for the Canadian healthcare system[142]. A three-year study in 2012 on 18 B.C. hospitals readmission rate for heart attacks, heart failure, and pneumonia showed that applying the incentive program did not decrease readmission rates. Other options such as an obligation for hospitals to publicly report their readmission rate may be more effective in reducing preventable readmissions. Developing a quality plan by hospitals, similar to the one in the Trillium Health Centre in Mississauga[13], may also be beneficial for hospitals in reducing readmission rates.

5.5. Conclusion

Hospital readmission is a leading topic of healthcare policy and practice as they are common and costly. Readmission rate has been increasingly used as a metric of quality of hospital care across the world. This study found a 14.3% (95% Confidence Interval [14.0%, 14.6%]) readmission rate among PLWHA in BC which is higher than the one for the general population in Canada. Although having HIV/AIDS may explain higher readmission rates, there is still a chance to reduce readmissions among PLWHA. Health providers and policymakers may also use this rate as a basis of comparison to assess quality of care of PLWHA.

The results of this study identified many variables were associated with risk of readmission. Among predisposing factors, diagnostic category was a significant factor for explaining readmissions. Admissions in which the patient had diagnoses in endocrine/metabolic/immune, neurological, hematologic, obstetric/gynecologic; and oncological diseases were significantly more likely to be followed within 30 days by a readmission than the admissions with non-AIDS defining infection. Given that the presence of these diagnoses may be a signal for readmission, this information may be useful for healthcare providers to add more support during inpatient care practices.

Our findings suggest that enabling and need factors are associated with hospital readmission within 30 days of discharge. Of enabling factors, LOS, number of prior admissions, admitted via ED, leaving AMA, and transferred between hospitals could explain the variation in the risk of readmission. Relation between LOS, number of prior admission, and admitted via ED and readmission suggests a more efficient care is required to prevent 30-day readmission. Health providers may target PLWHA with longer LOS, more number of prior admissions, and admitted via ED to develop the strategies to prevent readmissions.

People living with HIV/AIDS (PLWHA) who leave hospital against medical advice were more likely to be readmitted within 30 days of discharge than PLWHA who leave hospital on a regular schedule. Healthcare providers and policymakers need to target this population for their strategies and practices. Strategies such as an effective communication between healthcare providers and PLWHA who leave AMA, and more emphasis on providing true patient-centered

care are needed to reduce the number of PLWHA who leave hospital against medical advice. Association between readmission and transferring patients between hospitals identifies a challenge in care continuity and care coordination. Identifying the reasons why patients are transferred can help healthcare providers and decision-makers to overcome this challenge.

The need factor of the study, CD4 count, was also associated with a risk of readmission. Readmission within 30 days of discharge was more likely when PLWHA had lower CD4 counts. As low CD4 counts can be partially explained by low rate of HIV treatments, policymakers and healthcare providers need to develop the strategies such as developing ART to overcome the problem.

Enabling and need factors are highly capable of being altered to change healthcare services utilization. Given the association between enabling and need factors and risk of readmission, there is a high potential opportunity to reduce risk of readmission among PLWHA. Policymakers and health providers need to focus on these factors to develop and implement the effective policies and practices to reduce readmissions among PLWHA.

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Appendix A. Tables

Table A1. Identifying diagnosis at admission ICD-10-CA codes – Nijhawan et al. (2012)

Description	ICD-10-CA
HIV/AIDS	B20, B24, Z206, Z21, R75, O987
Pneumonia, pleurisy	A20.2, A21.2, A22.1, A31, A42, A43, A48.1, A78, B01.2+, B05.2+, B25.0+, B58.3, B59, B67.1,J12, J12.0,J12.1,J12.2, J12.8, J12.9, J13, J14, J15, J15.0, J15.1, J15.2, J15.3-J15.9, J16, J16.0, J16.8, J17, J17.0-J17.3, J17.8, J18, J18.0-J18.2, J18.8, J18.9, J85, J85.0, J85.1, P23, P23.0-P23.6, P23.8 'A15.6 , 'A16.5, J86, J86.0, J86.9, J90, J91, J92, J92.0, J92.9, J93, J93.0, J93.1, J93.8, J93.9, J94, J94.0, J94.1, J94.2, J94.8, J94.9, J98.1, J98.2, J98.3, R09.1
Other infectious diseases, Including Urinary Tract Infection (UTI)	A00-B99 (except the previous section codes, and A80-A89), N10, N11, N11.0, N11.1, N11.8, N11.9, N15, N15.1, N15.8, N15.9, N16, N16.0-N16.5, N16.8, N29.1, N30, N30.0-N30.4, N30.8, N30.9, N33.0, N34, N34.0-N34.3, N35.1, N37, N37.0, N37.8, N39.0, P39.3
Cellulitis, local skin infection	B00-B09
Central nervous system infection	A80-A89
Peptic ulcer, hemorrhage, and other specified gastrointestinal disorders	K00-K93
Renal failure	N17-N19
Poisonings and allergic reactions	T36-T50, T51-T65, T97
Oncology/ Chemotherapy	C00-C48, Z51.0, Z51.1,Z51.2, Z29.2
Congestive heart failure	I50, I50.0, I50.1, I50.9
Other causes combined	Other codes

Table A2. Identifying diagnosis at admission ICD-10-CA codes – Berry et al. (2013)

Description	ICD-10-CA
Non-AIDS defining infection	A00-B99 except (B20,B24)
Cardiovascular	I00-I99
AIDS Defining Illness	B20, B24, Z206, Z21, R75
Gastrointestinal/Liver	K00-K93
Psychiatric	F00-F99
Renal/Genitourinary	N00-N99
Pulmonary	J00-J99
Endocrine/Metabolic/Immune	E00-E90
Injury/Poisoning	S00-T98
Oncologic	C00-C97(except), D00-D48
Neurologic	G00-G99
Hematologic	D50-D89
Orthopedic	M00-M99
Symptomatic	R00-R99(except R75)
Obstetric/Gynecologic	O00-O99
Dermatologic	L00-L99
Unclassified/Congenital/Perinatal	P00-P96, Q00-Q99, H00-H95

Table A3. Identifying diagnosis at admission ICD-10-CA codes – Berry et al. (2015)

Description	ICD-10-CA
AIDS-defining illness	B20, B24, Z206, Z21, R75
Non-AIDS defining infection	A00-B99 except (B20,B24)
Oncological	C00-C97(except), D00-D48
Endocrine/metabolic/ nutritional/immune	E00-E90
Hematological	D50-D89
Psychiatric	F00-F99
Neurological	G00-G99
Cardiovascular	I00-I99
Pulmonary	J00-J99
Gastrointestinal/liver	K00-K93
Renal/genitourinary	N00-N99
Obstetric/gynecological	O00-O99
Dermatological	L00-L99
Musculoskeletal	M00-M99
Injury/poisoning	S00-T98
Symptomatic	R00-R99(except R75)
Unclassified	P00-P96, Q00-Q99, H00-H95

Table A4. Identifying diagnosis at admission ICD-10-CA codes - Palepu et al. (2003)

Description	ICD-10-CA
AIDS-defining illness	B20, B24, Z206, Z21, R75
Others	Other codes

Table A5. Number and percentage of missing values

Variable	Number of missing values	Percentage of missing values
Responsible for payer[†]	1	0.00002[a]
Hospital teaching status*	12	0.1[b]
Hospital size**	12	0.1[b]
Labor force participation rate***	4	0.04 [c]
Prevalence of low income***	4	0.04 [c]
non-high school graduation rate***	4	0.04[c]

[a] Total number: 40348 (observations), [b] Total number: 105 (hospitals), c Total number:89 (LHA),
[†] This is a mandatory field of DAD by CIHI which is not allowed to be blank. However, for cadaveric donors and stillbirths, the responsible for payer filed is left blank.* These hospitals were considered as closed hospitals and the size was considered as zero, ** These hospitals were considered as closed hospitals and the teaching status was considered as non-teaching, ***The data for the variable was imputed by the data from the nearest LHA neighbourhood.

Table A6. Identifying Surgical hospitalization reasons

Description	CMG code
HIV Infections	655- 658
Other infections	32, 97, 133, 141, 316, 318, 322, 324, 328, 333, 477, 478, 592, 660
Fever or Wound	662, 776
Leukemia/Chemotherapy	613, 624-626, 638, 639,
Respiratory	115, 117-120, 130, 132, 134, 137, 145, 146, 148, 149, 589, 591
Heart	160, 175, 176, 195, 196, 203, 204
Pulmonary complications	139, 200
Gastrointestinal complications	220, 225, 226, 230-232, 236, 237, 254, 255, 258, 570
other complications	Others

Table A7. SQLape method – Diagnosis and procedure codes to identify preventable readmissions

Step 1. Foreseen readmissions	Inclusions*	Step 2. Exclusions*
Material removal or replacement	0122, 0129, 0207, 0243, 0295, 0394, 0398, 0493, 1192, 146, 1671, 1672, 3764, 3777, 3785-3789, 3797-3799, 3943, 4494, 5195, 5598, 5694, 5798, 6496, 6694, 6996, 7697, 786, 800, 8393, 8594, 8596, 9788 as readmission procedure	Unplanned readmission or surgery complications (see step 6 below) for ungrouped cases, reason of readmission=complication (OFS variable 4.7.V03/V13/V23/V33=2) for grouped cases.
Temporary stoma closure	3172, 3472, 4283, 4462, 4650-4652, 4872, 5192, 5582, 5683, 5782, 5842 as readmission procedure	Idem
Postoperative aftercare	Z42-Z48 as readmission diagnosis	Idem
Programmed surgical readmission after a surgical or obstetrical stay	main readmission diagnosis of the same system as at least one diagnosis of the previous stay	Idem or reopening of surgical site: 0070-0073, 0080-0084, 0123, 0242, 0302, 0397, 0475, 0602, 1152, 1266, 1267, 1283, 156, 1662-1664, 1666, 1921, 1929, 196, 2062, 2092, 2184, 2763, 3163, 3174, 3403, 3595, 3775, 3779, 3942, 3949, 445, 4496, 4640, 4641, 4643, 4693, 4694, 4975, 5194, 5412, 5461, 5492, 5652, 5662, 5672, 5722, 8153, 8155, 8159, 8197, 843, 8466, 8467, 8468, 8469, 8481, 8483, 8485, 8593, 8675 as readmission procedure.
Programmed surgical readmission after a non-surgical/non-obstetrical stay	main readmission diagnosis of the same system as at least one diagnosis of the previous stay	None

Step 1. Foreseen readmissions	Inclusions*	Step 2. Exclusions*
Programmed non-surgical intervention after a non-surgical/non-obstetrical stay	Main readmission diagnosis of the same system as at least one diagnosis of the previous stay and intervention performed during the two first days of readmission. Non-surgical interventions: 0058, 0059, 0068, 0069, 011, 0120, 0332, 0339, 041, 051, 0611-0613, 070, 0711-0717, 0751, 0771, 0791, 0811, 0911, 0912, 1021, 1121, 1122, 1222, 1411, 1501, 1623, 1812, 2032, 2122, 2211, 2212, 2411, 2412, 2501, 2502, 2612, 2721, 2722, 2723, 2724, 2811, 2912, 3143, 3144, 3145, 3324-3328, 3393, 3421-3428, 3721-3725, 3727-3729, 3821, 3823-3826, 3829, 4011, 4019, 411, 4131-4133, 4139, 4221, 4224, 4225, 4411, 4412, 4414, 4415, 4511, 4514, 4515, 4516, 4521, 4525-4527, 4821, 4824, 4825, 4826, 4922, 4923, 5011-014, 5112-5115, 5151, 5211, 5212, 5214, 5421-5425, 5524, 5632, 5633, 5634, 5733, 5734, 5823, 5824, 5921, 6011-6015, 6111, 6211, 6212, 6301, 6411, 6511-6514, 6611, 6711, 6712, 6813-6816, 7023, 7024, 7111, 7611, 774, 803, 8198, 8321, 8329, 8511, 8512, 8611, 884, 8851-8857, 8859.	Drug, radiation and insemination complications
Step 3. Deliveries and transplants		
Labour and deliveries	Obstetrical conditions as readmission diagnosis	
Organ transplants	0794, 335, 336, 3751, 4194, 4697, 505, 528, 556 as readmission procedure	
Leucopherese, bone marrow grafts	410, 9972-9974 as readmission procedure	
Step 4. Chemo- and radiotherapy	Z510-Z512 as readmission diagnosis 922 or 9925 as readmission procedure D70 as readmission diagnosis (agranulocytosis) after chemotherapy	
Step 5. Follow-up		
Treatment follow-up	Z08, Z09 as readmission diagnosis	
Rehabilitation	Z50 as readmission main diagnosis	
Procedure not carried out	Z53 as any programmed readmission diagnosis	
Step 6. Complications		
Iatrogenic complications	Following complications as readmission main diagnosis: - surgical complications - health care complications - obstetrical complications - possible surgical complications or complication as reason of readmission	

Step 6. Complications	**Inclusions***
Other health care complications:	E86, I460, I461, I469, K316, K382, K603, K604, K632, K661, K823, K832, K833, K922, N321, N322, N82, O678, O679, O95, O960, O961, O969, O970, O971, O979, R048, R049, R570-R572, R578, R579, R58, R960, R961, R98, R99, T793.
Preventable disease (deep vein thrombosis, pulmonary embolism, decubitus ulcer)	I260, I269, I801-I809, I820-I829, L89 as readmission main diagnosis.
Step 7. New medical condition	**Inclusions***
The readmission damaged system (determined by the main diagnosis) is not equal to any damaged system of the index hospitalisation (determined by all diagnoses of the previous stay).	List of systems: blood, circulatory, cutaneous, digestive, endocrine, ENT, female, hepatic, locomotion, nervous, new-born, mental, ocular, respiratory, urinary.
Step 8. Trauma and diseases difficult to cure	**Inclusions***
Trauma	K131, L550-L552, L559, M125, M242-M244, M483, M626, M660-M665, M843, M992, S00-S99, T00-T35, T691, Z57, Z584, Z585 as unplanned readmission main diagnosis
Diseases difficult to cure: Idiopathic thrombocytopenic purpura, myelodysplastic syndrome, multiple sclerosis, cirrhosis of liver, urinary calculus, acute bronchiolitis of nurseling, non-surgical intestinal adhesion	D693, G35, J21 (< 2 years old), K700, K703, K717, K746, N20, N21, N220, N228, N23, R18, as readmission main diagnosis D46, D570 as any readmission diagnosis with 9904 as readmission procedure (packed cell transfusion) D694-D696 as any readmission diagnosis with 9905 as readmission procedure (platelet transfusion) K565 or K660 main diagnostic codes for index non-surgical hospitalisation and the same main diagnostic codes for readmission (intestinal obstructions/adhesions relapses)

***Diagnostic and procedure codes**	The SQLape® tools are updated every year with latest valid international nomenclatures: ICD-10 (WHO version) for diagnoses and ICD-9-CM (US version). Subdivisions are not given in the documentation if they do not have an impact on the algorithms or have no effect on SQLape® diagnostic or operation groups. For instance, the procedure code 513 (three digits) correspond to 5131, 5132, 5133, 5134, 5135, 5136, 5137, 5139 ICD-9-CM procedure codes.	
New case definition, since 2012	In Switzerland, a new definition of the case was introduced in 2012. If a patient is readmitted within 18 days in the same hospital for the same major diagnostic category (MDC), corresponding cases are merged. The Swiss medical records provides the dates of interruptions, as well as the dates of procedures and the reason of the readmissions. To ensure the continuity of the temporal comparisons, actual stays are re-built to identify each hospital stay separately, with corresponding procedures with their dates; however, diagnoses are allocated to every stay. Grouped cases caused by a complication are considered as potentially avoidable. The user can identify those cases with their stay identifier followed by its rank (e.g. 19222110_1, 19222110_2, 19222110_3 if there were two interruptions). The cases grouped because of complications are considered potentially preventable. The other cases are processed normally by the algorithm. The new case definition was simulated on the basis of 2010 data (January to November). The percentage of errors was 2.7% (false positives and false negatives), which is fortunately relatively low and ensures continuity of results. This good result is due to several reasons: - planned readmissions (stage 1) remain identifiable since the operations are properly attached to each of the stays (material removal or replacement, temporary stoma closure, scheduled surgery, obstetrics stay); - complications of readmission (steps 2 and 6) are recognizable by reason of readmission (new OFS variable); - readmissions for transplantation, leukopherese, bone marrow transplant, radiation therapy or chemotherapy (stages 3 and 4) are correctly assigned to each stay through their procedure dates;	

New case definition, since 2012	- readmissions for a new condition (step 7) are generally not affected by the consolidation of cases (various MDC); - trauma and diseases difficult to cure are still identifiable (step 8); - readmissions occurring after 18 days are not concerned by the new definition of case; - readmissions by retransfer (excluded from the eligible population) can be identified by the reason for readmission (new OFS variable).

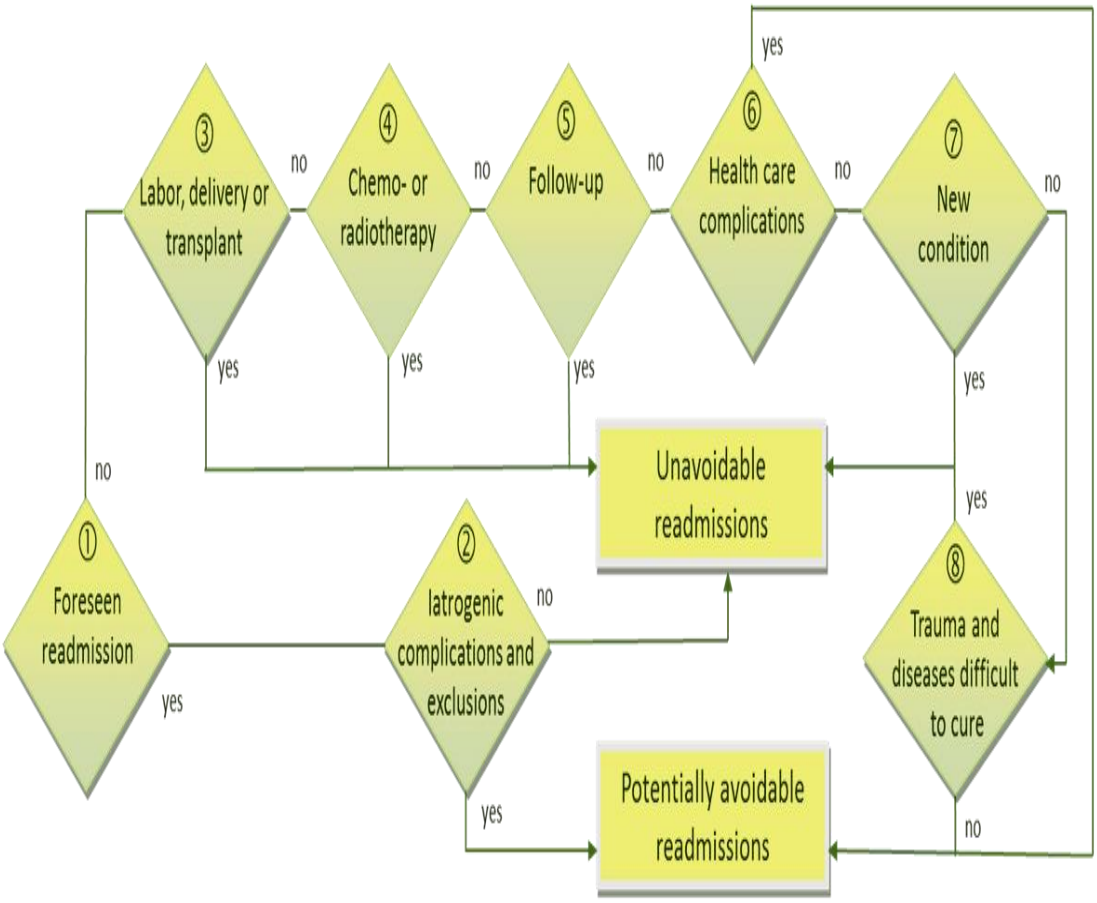
Source: © SQLapes.à.r.l. and Yves Eggli, 2014. Last update: 29.04.2016. Available from: http://www.sqlape.com/AR_ALGORITHM.htm.

Table A8. Literature Search Strategy

Title	Description
Required information	Hospital readmission within 30 days of discharge among people living with HIV/AIDS and associated factors.
Search keywords & phrases	Hospitalization, Readmission, 30-day readmission, Readmission within 30 days, HIV, AIDS, quality of care, British Columbia, BC, Canada, preventable readmission, Canadian healthcare system.
Operators	Boolean operators: AND, OR, search operators: asterisks and quotation marks.
Databases	PubMed database, Google Scholar, Research gate, and websites of BCCFE, WHO, Health Canada, Ministry of Health: British Colombia.
How the key words were combined	Several combinations of keywords were created using “AND”, “OR”, quotation marks (“”), and asterisks (*).
Selecting sources of information of articles	Relevant articles (Published journal Articles and unpublished research) by titles, and abstract were selected. References of review articles, Scientific reports, and conference presentations also were included in search.

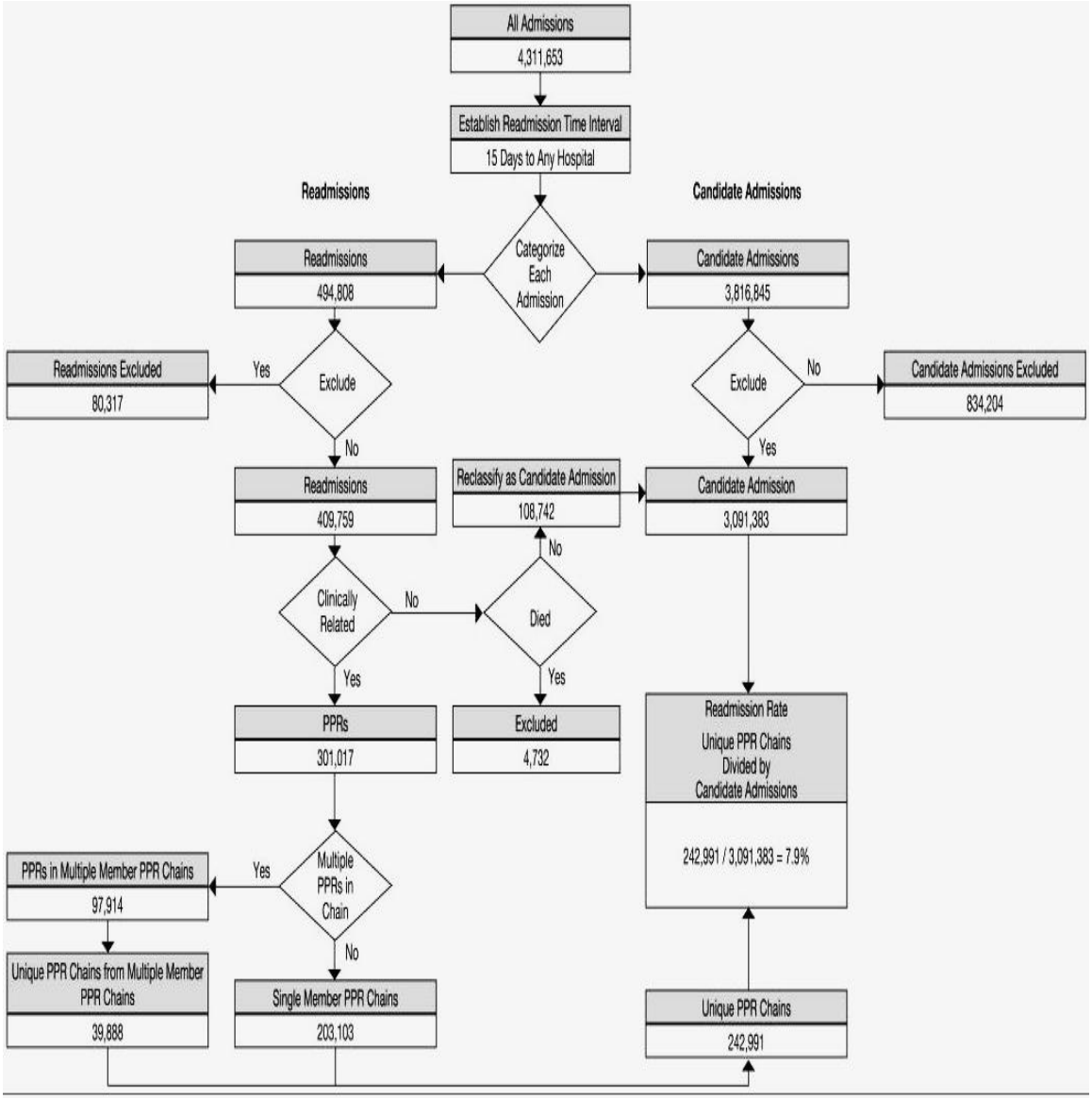
Appendix B. Figures

Figure B1. Potentially Preventable Readmission algorithm –SQLape®



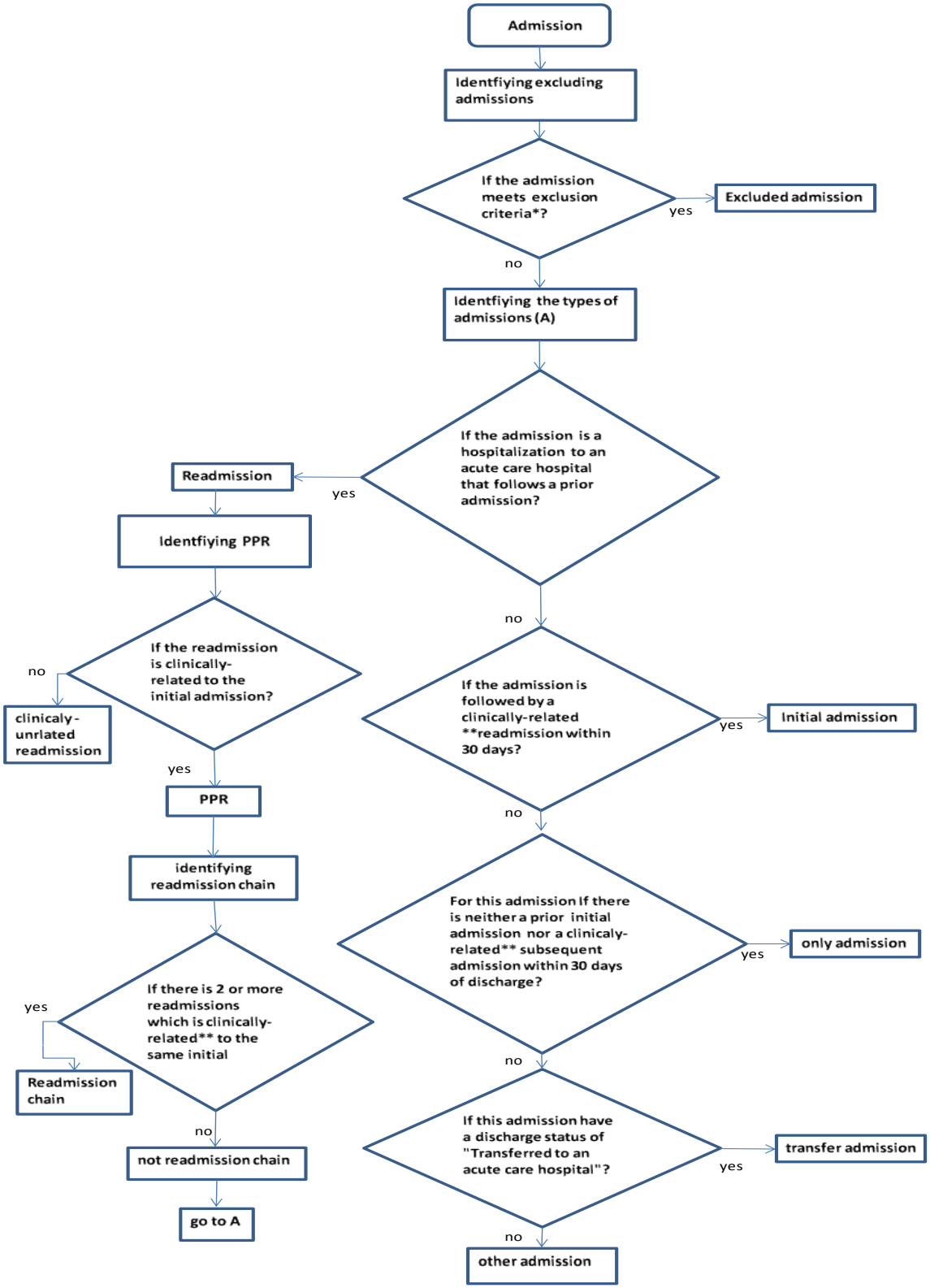
Source: SQLape. Tools for Quality Management, Readmissions. Available from: http://www.sqlape.com/AR_ALGORITHM.htm. [Accessed Aug. 2015].

Figure B2. Potentially preventable readmissions algorithm - Goldfield et al. (2008)



Source: Goldfield NI, McCullough EC, Hughes JS, Tang AM, Eastman B, Rawlins LK, Averill RF. Identifying potentially preventable readmissions. Health Care Financing Review. 2008 Sep; 30(1):75-91.

Figure B3. Identifying PPR and classifying admissions, 3M^{TM} method (next page)


Admission
Identfiying excluding admissions
If the admission meets exclusion criteria*?
yes
Excluded admission
no
Identfiying the types of admissions (A)
If the admission is a hospitalization to an acute care hospital that follows a prior admission?
yes
Readmission
Identfiying PPR
If the readmission is clinically-related to the initial admission?
no
clinicaly-unrlated readmission
yes
PPR
identifying readmission chain
If there is 2 or more readmissions which is clinically-related** to the same initial
yes
Readmission chain
no
not readmission chain
go to A
no
If the admission is followed by a clinically-related **readmission within 30 days?
yes
Initial admission
no
For this admission If there is neither a prior initial admission nor a clinicaly-related** subsequent admission within 30 days of discharge?
yes
only admission
no
If this admission have a discharge status of "Transferred to an acute care hospital"?
yes
transfer admission
no
other admission

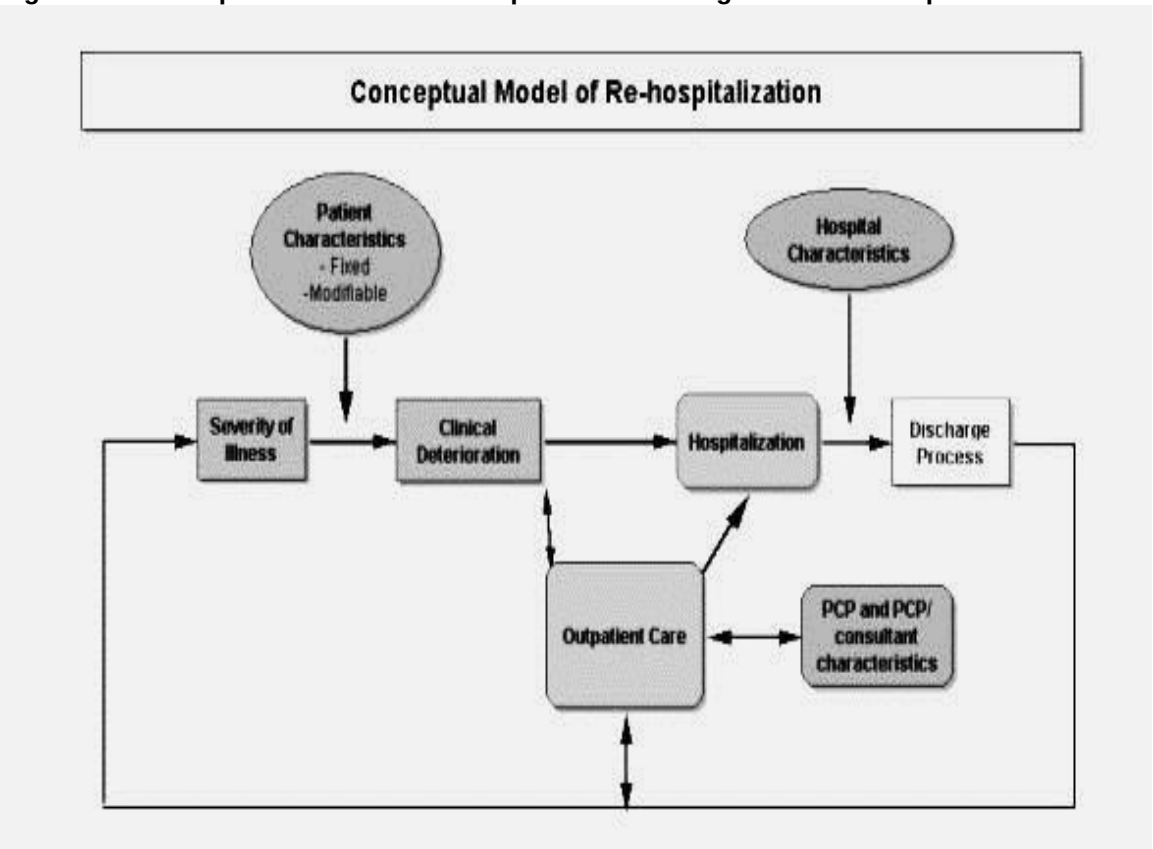
* Exclusion criteria: admissions for 1) Major Metastatic malignancies or other malignancy, 2)trauma, 3)burn, 4)neonatal (newborn), 5)obstetrical, 6) discharge status of “left against medical advice”, 7)admissions to non-acute care facility, an acute care hospital for rehabilitation aftercare or convalescence and 8)same day transfer to acute care hospital for non-acute care.

**A readmission is clinically-related to the initial admission if:

1) The reason (diagnosis code) for medical readmission is for :
   - The reason is a continuation/recurrence of or closely related to the reason for initial admission
   - An acute decompensation of a chronic problem which could have been resulted from inadequate quality of care during the initial admission or inadequate outpatient follow-up care and it was not the reason of the initial admission
   - An acute medical problem which could have been resulted from inadequate care in the initial admission
2) The reason (surgical procedure code) of surgical readmission is for :
   - The reason is a continuation/recurrence of the reason for initial admission
   - The complication which could have been resulted from care rendered during the initial admission
   - The reason resulted from a lack of post admission follow up such as lack of follow-up arrangements with a primary care physician.

Source: 3M™ Health Information Systems. 3M™ potentially Preventable Readmissions Grouping Software. 3M Company. USA. 2015; 2p. Available from: http://multimedia.3m.com/mws/media/849903O/3m-ppr-grouping-software-fact-sheet.pdf. [Accessed Sep. 2015].

Figure B4. Conceptual model of the components affecting rates of re-hospitalization



Source: Anthony D, Chetty VK, McKenna K, DePaoli MR, Jack B. Re-engineering the Hospital Discharge: An Example of a Multifaceted Process Evaluation. Advances in Patient Safety: From Research to Implementation. 2005 Feb; 2: 379 – 394