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Economic Report

AN ECONOMIC EVALUATION OF EXPANDING PHYSIOTHERAPY COVERAGE FOR PERSONS LIVING WITH HIV

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realize FOSTERING POSITIVE CHANGE FOR PEOPLE LIVING WITH HIV AND OTHER EPISODIC DISABILITIES

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Abbreviations

AE	Adverse Event
CD4	Cluster of Differentiation 4
CUA	Cost Utility Analysis
EC	Episodes of Care
FTE	Full time equivalent
HIV	Human Immunodeficiency Virus
ICUR	Incremental Cost-Utility Ratio
LE	Life Expectancy
OHIP	Ontario Health Insurance Plan
NCD	Non-communicable Disease
PLWHIV	People living with HIV
PT	Physiotherapy
QALY	Quality Adjusted Life Year
WTP	Willingness to Pay

Executive Summary

Background

This business case investigates the cost-utility of provincial-government-funded physiotherapy services for persons living with HIV. Improved access to community-based Physiotherapy (PT) services would be of particular benefit to this population given the high risk of comorbidity and complexity of social determinants associated with HIV and ageing. These risks include a higher prevalence of many non-communicable diseases, and comorbidities such as heart disease, stroke, pain, and osteoporosis. Growing clinical evidence has shown PT to be beneficial for improving quality of life and reducing hospital length of stay for patients after an acute episode of ill health. Physiotherapy has also been shown to be valuable as a preventative treatment for adverse events like falls.

Objective

The objective of this report is to estimate the cost associated with the onset and exacerbation of non-communicable diseases among people living with HIV (PLWHIV) in Ontario. The authors first assess the value of funding PT services for this patient population. Based on this cost, we estimate the cost savings associated with preventing and proactively managing non-communicable diseases and adverse events in this population. Finally, we assess the overall cost-utility of funding PT services for this population. We measure cost-effectiveness by comparing the expected associated cost or cost savings under a PT intervention relative to standard care, along with gains or losses to quality of life. We measure patient quality of life through life expectancy weighted by a quality of life utility index.

Economic Evaluation

To assess the costs and quality-adjusted life years gained we built a multi-state model that simulates a non-communicable disease trajectory for an ageing person living with HIV. To minimize complexity in the model, we look to a population of PLWHIV who are over the age of 50, have stable housing and who do not use injection drugs. We estimate the onset of six common non-communicable diseases including hypertension, peripheral neuropathy and pain, diabetes, osteoporosis and non-acute stroke. We also estimate three key adverse events: myocardial infarction, adverse stroke and hip fracture. We incorporate costs associated with living with HIV, along with expenses related to care and relevant adverse events. A treatment arm is built to include these same factors as well as the costs and benefits to disease and mortality associated with access to PT services.

We simulate 10,000 individuals through this multi-state model to estimate the average expected cost and quality-adjusted life years (QALYs). The simulation runs over both the control arm, consisting of standard care and the PT intervention arm. A comparison of average expected costs and QALYs for each arm provides information about the likely additional cost or

cost savings associated with the PT interventions per additional unit gain in quality of life. We report all dollar values in 2018 Canadian dollars.

Results

Cost-utility is assessed over both lower and higher intensity PT interventions for PLWHIV, based on best-practice guidelines. We evaluate the effects of a PT intervention first from a health payer perspective, where only health system costs are taken into consideration. The impact of PT expansion is then assessed from a societal perspective, which brings into account job loss associated with the onset of a chronic condition or an adverse event. Results show that, under all scenarios, publicly-funded PT services for this population would be considered cost-effective. The least cost-effective scenario, from the health payer perspective, involved the provision of higher intensity PT services. Even in this case, the intervention cost is $6,561 per QALY gain. This incremental cost per utility ratio would, by any general willingness to pay threshold, be considered highly cost-effective. One scenario, when cost-effectiveness is assessed from a societal perspective, results in both a QALY gain and cost savings to the system compared to no PT expansion, regardless of PT level. This cost saving is due to downstream cost savings resulting from the prevention of chronic conditions and adverse events, as well as mitigation of health system usage following an adverse event. When we reassess costs to the clinic level all strategies, outside of higher intensity PT services from a health payer perspective, become both cost savings and result in QALY gains.

Limitations

We assess the robustness of these results and uncertainty over input parameters using multiple sensitivity and scenario analyses. These include testing of assumed cost-structure for PT coverage, testing assumptions related to the mortality rate and the assumed risk of hip fractures when a person is living with HIV and ageing. Other assumptions tested include the time horizon of analysis: the base case measures cost out to 2050; we examine lifetime costs out to a maximum age of 100 years. Sensitivity analysis around the proportion of the population employed is also tested. Baseline results hold under these differing assumptions.

Conclusion

A physiotherapy intervention for PLWHIV is considered to be cost-effective over every assessed scenario. Depending on the assumed level of PT service intensity and costing perspective, some scenarios would result in both cost-savings and increases to QALYs for this population. These results indicate that the cost of PT services for this population is likely to be offset by the prevention of certain non-communicable diseases and the reduced burden on the acute health care system. It would thus be considered good value for money to invest in these services for this population.

Background

With advances in life-saving antiretroviral medication, HIV has evolved into a chronic health condition for those with access to treatment. A chronic condition is one that persists in the long-term and may follow one of several trajectories. HIV is described as being 'episodic' in nature due to the unpredictable pattern of illness/disability and wellness experienced by those with the disease. These fluctuations create several challenges for people living with HIV (PLWHIV), including uncertainty about the future, and varying difficulty performing daily activities.[1] In addition to the difficulties associated with the episodic nature of HIV, comorbidities or non-communicable diseases (NCDs) are common as a result of the presence of the virus and long-term drug therapy.[2] Common comorbid conditions include cardiovascular disease, stroke, peripheral neuropathy, osteoporosis and mental illness. Though primary preventative care is essential in the management of these NCDs, some socioeconomic barriers, such as income and housing insecurity, can limit access to this care.[1] With limited access to preventative interventions in this community, care is frequently accessed in reaction to an acute exacerbation or significant functional decline.[2] As a result, an increasing proportion of hospitalizations in this population can be attributed to comorbidities.[2] This reactive approach to managing complex chronic disease impacts quality of life for individuals, and imposes a financial burden on the healthcare system. [2,3]

Specialized inter-professional primary care clinics that include physiotherapy (PT) services have been effective in promoting access to care, and greater adherence to medication among PLWHIV, which, in turn, can serve to reduce downstream use of costlier health services.[4] One study found that PLWHIV who are receiving HIV inter-professional care are less often hospitalized than those who are undiagnosed or untreated.[2] Physiotherapy and exercise regimens have been shown to positively impact CD4 counts in PLWHIV, which in turn affect both cost of HIV care and mortality.[5–7] For the general population, but pertinent to the population of PLWHIV who are at increased risk of certain NCDs, integration of PT has been shown to improve mental health,[8] reduce pain associated with peripheral neuropathy,[9] and reduce falls leading to hip fracture.[10] Physiotherapy has also shown some benefit in lowering non-acute costs related to osteoporosis.[11] Physiotherapy also has been found to have an impact on mortality, and recovery from specific adverse events like myocardial infarction,[12,13] and stroke.[14–16]

Given these substantial benefits, integrating regular consultation with a rehabilitation specialist into existing inter-professional primary care could increase value for PLWHIV through supported self-management and routine re-assessment.[3] As it stands, however, several barriers limit access to rehabilitation for PLWHIV within the current care delivery system. First, inter-professional primary care teams are not available to all PLWHIV across the broad geography of Ontario or Canada. Second, with only 26% of PLWHIV estimated to have access to private insurance benefits that would cover costs associated with private PT services, cost remains prohibitive to access for many.[17] A portion of this population (e.g. those who receive income assistance or who are over the age of 65) may be eligible for publicly-funded clinics in some

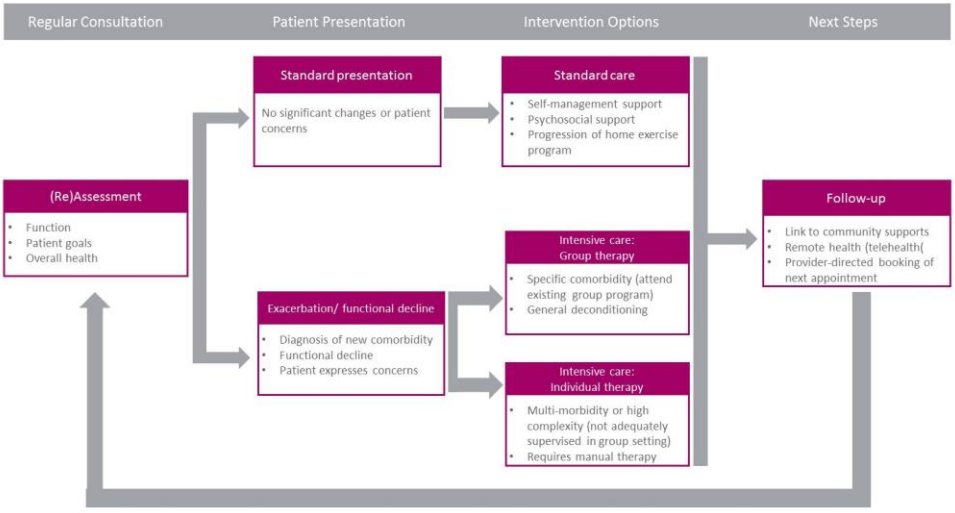
jurisdictions (e.g. Ontario Health Insurance Plan (OHIP) funded PT clinics),however, significant constraints on the number of patients that can be served through this avenue make access exceedingly difficult.[18,19] Currently, patients experiencing acute events may be eligible for some publicly funded PT directly following their contact with the health care system. However, it has been shown for people living with chronic health conditions, including HIV, the role of PT is greater than rehabilitation following an acute event; PT has a role in the maintenance of function and prevention of future decline.[20]

Taking these current system constraints into consideration, this business case seeks to estimate the cost associated with fully funded coverage of PT services for PLWHIV. We assess this in the province of Ontario, drawing specifically on the characteristics of PLWHIV in Ontario and the unique aspects of the Ontario healthcare system. With this, we also assess the potential down-stream cost savings associated with the implementation of best-practice PT, either within an inter-disciplinary team or accessed independently without cost to the patient.[21] In the next section, we outline best practice for PT, as reported in the literature, to estimate PT intensity and cost of services. Using these estimates, we then undertake a cost-utility analysis to evaluate the short- and long-term cost per unit of quality-adjusted life year gained of best-practice PT services for this population. We follow the economic evaluation with two individual case studies. A summary of our findings concludes the report.

Assessing Required PT Intensity and Cost

The Agency for Clinical Innovation's chronic condition management framework recommends several core components that are integral to care for people living with chronic health conditions. Some of these components include regular consultations, screening for exacerbation or functional decline, intervention and follow-up.[22] Figure 1 provides an adapted graphical representation of best practice care.

Figure 1: Adapted from the Agency for Clinical Innovation Chronic Condition Management Framework



Regular Consultative Care

Due to the chronic, episodic nature of HIV, ideal care for PLWHIV includes a physiotherapist as an integral member of their primary care team.[21] PLWHIV would attend regular consultation appointments with the physiotherapist every 6 to 9 months, in conjunction with other medical or allied health appointments, whenever possible. These consultation appointments would consist of a full assessment or maintenance screening to assess functional changes and/or unmet needs of the patient. Depending on patient needs, consultative services can be delivered by different members of the inter-professional team. Examples of consultative care include:

- Education on energy conservation and workplace ergonomics;
- Psychosocial support; and,
- Review/progression of the patient's home exercise program.

Should regular consultative care or screening reveal no development of new comorbidities, no functional decline and no patient concerns, interventions to maintain function will continue in conjunction with regular consultation and screening.

Interventions with Progression or Exacerbation

If consultation or screening reveals an exacerbation or functional decline, patients will then be referred for a block of active rehabilitation. Referrals to any other relevant health professionals will be made at this time, as necessary. Active care may consist of individual or group therapy.

Individual Therapy

Individual therapy typically consists of a block of one-on-one sessions with a physiotherapist. This form of therapy is indicated if the patient presents with a PT need that would be better managed in an individual setting, for example their treatment requires manual therapy skills, or direct, uninterrupted supervision by the professional. A block of individual therapy typically consists of 1 to 2 sessions per week for a period of 8 weeks. If the patient is not able to attend outpatient rehabilitation appointments, homecare therapy options should be considered. At the conclusion of a block of individual PT services, the supervising therapist, in consultation with the patient, determines if the patient's goals have been met.

Group Therapy

Group therapy may be indicated in cases of general deconditioning to address concerns such as overall fitness or falls prevention. Alternatively, group therapy can be utilized to address specific conditions such as total joint arthroplasty, cardiac rehabilitation and pulmonary rehabilitation. The duration of an intervention will depend on the group model, and patient goals. At the conclusion of the group program, the supervising therapist, in consultation with the patient, determines whether the patient's goals have been met.

Group rehabilitation programs are already in place at some community care centres and rehabilitation hospitals. The physiotherapist performing regular screening and assessment can refer patients to these programs, based on the program's referral and inclusion criteria, and the person's comorbidities and functional goals. For example, a person living with both HIV and heart disease presenting with decreased exercise tolerance may benefit from a cardiac rehabilitation program.

Follow-up Care

After completion of the appropriate active care, the primary health care team should connect with the patient to review next steps. The primary care health team initiates the process of booking and confirming the next consultation appointment in 6 to 9 months and patients are to be connected to any relevant community supports. Alternatively, if a patient's care goals have not been met, they can explore further PT options with their physiotherapist.

Disease-specific Treatment Plans and Costing

Comorbid conditions common in PLWHIV include stroke, peripheral neuropathy, osteoporosis, diabetes, and pain. We outline a best practice care plan for each of these conditions, in conjunction with specialist care, based on published guidelines and clinical opinion in Table 2. As most physiotherapy interventions are recommended on a range of care (see Table 2), we estimate the cost of care based on both low intensity and high intensity recommendations. To calculate the approximate cost of these interventions, we looked to both hourly PT rates charged at a sample of private clinics for individual and group sessions, as well as pro-rated hourly wages for physiotherapists hired to work within an interdisciplinary primary care team (Table 1).

Table 1: Estimated Annual Cost for Physiotherapy

Specific Co-morbidity	**Intervention Intensity (Total number of sessions)**	
Individual Therapy	**Low Intensity**	**High Intensity**
Stroke	$2,180	$3,620
Myocardial Infarction	$2,180	$3,620
Peripheral neuropathy	$845	$1,610
Hip fracture	$2,750	$4,070
Group Session Therapy	**Low Intensity**	**High Intensity**
Osteoarthritis, osteopenia	$368	$629
Diabetes	$497	$754
Hypertension	$425	$785

Mental Health	$425	$785
All values include costs of initial consults and subsequent care. Four group session a year assumed.		

A search of PT treatment costs in facilities across Ontario found that a 1-hour assessment and treatment consultation were $110, on average. An hour treatment block ranged from $120 to $150. This aligns with a PT guideline for accidents which stated that fees should be between $95 and $120 per hour or that 15 min sessions should cost between $23.75 to $30.[23] The average cost employed in this analysis is $60 for individual therapy. Estimating a value for group therapy costs was difficult given that many group therapy sessions are directed at seniors and thus covered by OHIP. To ascertain a cost for PLWHIV who do not qualify for OHIP-funded programs a search for group therapy costs across Ontario yielded an estimate of $145 for a session totalling 36 hours over 24 weeks.[24] This cost was used to produce a cost for other group sessions, weighted by their duration and number of recommended sessions. Cost for each treatment course as prescribed in Table 1 are detailed in Table 2.

Table 2: Recommended Course of Treatment for Individual NCDs

Co-morbidity	**Plan best practice or recommendation**	**Number of Prescribed Weekly Sessions**		**Week N**	**Total Number of Sessions**		**Notes and Sources**
		Low	**High**		**Low**	**High**	
Individual Therapy							
Stroke	One-on-one sessions with a rehabilitation clinician in an out-patient setting after discharge from the hospital	3	5	8	24	40	Blocks should be minimum of 45 minutes per day up to 3 hours per day.[25]
Peripheral neuropathy	Individual sessions including hands-on therapy, stretching, desensitization, self-management education.	0.5	1.0	52	26	52.0	2 to 4 times a month. Duration may be 12 to 18 months.[26]
Pain	Tailored progressive exercise, manual therapy, therapeutic taping, and patient education	1	-	8	8	-	Once weekly visits for average 8 weeks.[27]
Hip fracture	Group-based therapy or community rehabilitation with a focus on functional strengthening. May also consist of post-acute in-home therapy based on patient severity.	2	3	24	48	72	Duration 6 to 12 months depending on patient needs.[28]

Group Session-Based Therapy							
Osteoarthritis, osteopenia	Group sessions. Multiple component programs targeting: strength, balance, gait, functional tasks, flexibility and endurance.	2	4	8	16	32	Minimum 2 hours/week. No specific maximum assumed.[29]
Diabetes	Group sessions recommended to work towards increased levels of physical activity as blood glucose can be partially managed with a supervised exercise therapy program. This may reduce insulin dependence.	3	5	8	24	40	Interventions should be minimum of 8 weeks. Intensity of 3-5 sessions/week.[30–32]
Pain	Individual sessions for treatment of pain may be adapted as a group therapy session. Focus of session would be on education, progression of home exercises, postural re-education, balance, and manual therapy.	-	1	8	-	8	No differences in outcomes between individual and group therapy for pain.[33]

Population-Level Cost-utility Analysis

To assess the cost-utility of government-funded PT for PLWHIV, we perform an economic evaluation. First, we estimate expected cost and life expectancy (LE) associated with living with HIV, acute health events and chronic conditions. We then estimate cost and LE for PLWHIV if they had access to publicly-funded PT services consistent with best practice clinical guidelines. Life years are weighted by utility to determine QALYs. The incremental cost-QALY ratio (ICUR) is calculated using the cost difference between the treatment and control groups per the QALY difference. This ratio determines cost-effectiveness. There is a small but positive literature showing the benefits of PT services for PLWHIV in general, as well as for specific co-morbid chronic health conditions that tend to increase with age in this population. Benefits of PT are measured through cost savings to the healthcare system, either through prevention of adverse health events or disease exacerbation, leading to decreased acute care usage. Other benefits include improvements to LE and improvements in quality of life as measured through quality-adjusted life years (QALYs); life years weighted by some measure of utility. Utility ranges from 0 to 1, representing a spectrum from death to perfect health.

Population

The population of interest consists of individuals living with HIV who are over the age of 50. Individuals are assumed to have been on active antiretroviral treatment (ART) for more than one year. Based on ART status, we assume a CD4 count of 430.[34] Individuals are assumed to not to be currently living with AIDS based on current trends among ART-treated populations. AIDS-related events are also not explicitly modeled under the assumption that PLWHIV on ART have a low likelihood of AIDS-related events. We assess cost-utility over a population of PLWHIV that are predominantly male as 80.5% of the current population of PLWHIV in Ontario is male.[17] To reduce the complexity of the model, individuals are assumed not to use injection drugs and to be stably housed and stably employed.[1]

Methods

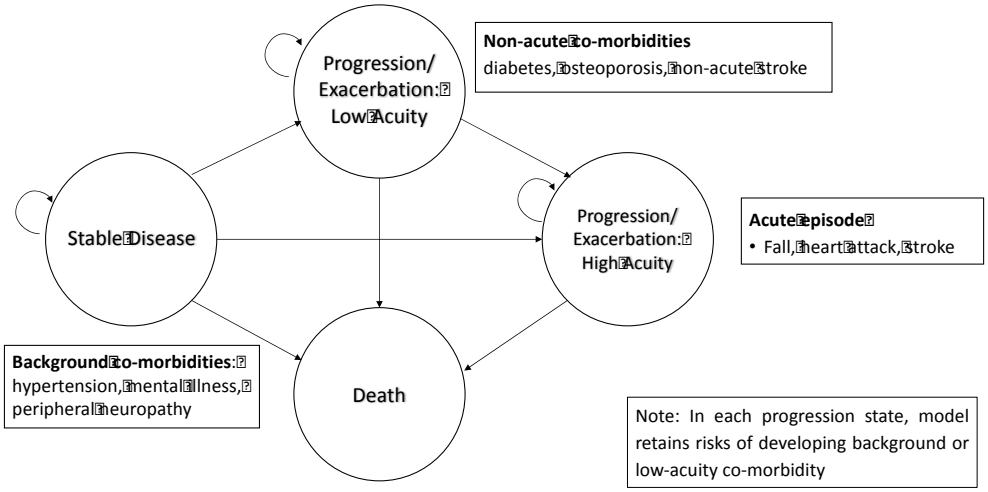
To estimate the cost-utility of PT services for this population of PLWHIV we utilize a multi-state simulation model. A multi-state simulation model builds a map of disease and treatment trajectory over potential disease exacerbation states, and death. An important component of multi-state simulation models is that they allow for competing risks of death. This is highly important in the context of HIV as PLWHIV are at risk of dying from HIV but also co-morbid chronic health conditions that are exacerbated due to HIV. A multi-state simulation model accounts for all possible scenarios.

This model includes four main health states: stable disease, low acuity exacerbation, high acuity exacerbation, and death. A schematic of the four-state simulation model is found in **Figure 2**. Patients can move directly from stable disease to low acuity or high acuity disease states, or

[1] The base case scenario is the ideal we should be striving for, though it is not the current reality.

death. Once they have moved from stable disease to one of the other states they cannot return to stable disease, or, for the high-acuity state, cannot return to low-acuity. This is because low or high acuity states indicate presence of a disease or adverse event that will continue to impact health care usage and health state over time. Costs and utilities both improve somewhat with time spent in each state to map out stabilization of disorders or post-acute recovery. Having no returns to stable disease, however, may result in a higher estimated cost and thus less favourable cost-utility estimates.

Figure 2: Diagram of Health States in Economic Evaluation Model



Onset of low acuity exacerbation is determined by incidence of common comorbidities for PLWHIV such as diabetes, osteoporosis or non-acute stroke. Patients in a stable state or low-acuity exacerbation may move to high acuity with an adverse event such as myocardial infarction, ischemic stroke or a fall resulting in hospitalization. In each state, including the stable state, patients are at risk for developing hypertension, mental health disorders and peripheral neuropathy. The cost and utility of these NCDs are incorporated into each state based on their risk.

Incorporating predicted transitions between different states, 10,000 individual patients are simulated, starting at age 50 in 2018 and moving through the year 2050, to map out a full disease trajectory. This equates to 32 years and corresponds to the approximate average life expectancy of 82 years for Canadians. Costs associated with each stage and utility weights by health state are incorporated into the simulation to arrive at an estimated total cost and QALY for each individual.

Model Input Parameters

To estimate disease and treatment trajectories, economic models usually rely on individual level data such as patient health records to make predictions. Due to limited data availability within the scope of this project, we rely on publicly available data and literature-derived values for estimating transitions to disease onset and death. To estimate the impact of PT on people aging with HIV we draw predominantly from O'Brien's (2014) *Evidence-informed recommendations for rehabilitation with older adults living with HIV.*[35]

Mortality

At every health state (stable, low acuity exacerbation, and high acuity exacerbation), individuals are at risk of death due to all-cause mortality. PLWHIV have an increased risk of death due to HIV status. People with non-communicable diseases also have additional risk of death; those with multi-comorbidities even more so. To model movement from any health state to death, we use 2011 Canadian age- and sex-specific all-cause mortality rates. These rates are then adjusted for relative risk of death due to HIV status (Table 3). Those in a stable state of HIV disease have a relative risk of death of 1.14, making them 14% more likely to die at a given point in time than a person without HIV. Those with multiple comorbidities in a high acuity state have a relative risk of death of 10.79.[36]

To measure excess burden of death in the low-acuity health state for PLWHIV there was no perfect match available in the published literature. We use instead a relative risk of death from an HIV population without multi-comorbidities but with HIV-related risk factors. HIV-related risk factors are defined as having at least one of: a detectable viral load (>49 copies/ml), CD4 <200 cells/ul or AIDS-defining disease.[36] The relative risk of death for this cohort is 4.27. A midway point between the matched stable state and high acuity exacerbation state would be a relative risk of death of 5.97. We use 4.27 as our baseline value and test this assumption in sensitivity analysis by employing the midway point relative risk. We also test assumptions about whether relative risk in these categories are additive, being that a person in low acuity would have a baseline relative risk of 1.14 and a further additional relative risk of 4.27, rather than separable relative risks. Our base case analysis assumes additive risk as, again, mortality rates derived from the literature do not perfectly correspond to low and high acuity co-morbidities.

Table 3: Model Input Parameters

Mortality Adjustments	**Relative Risk** (CI)	**Source**
HIV+ stable state	1.14 (0.58-2.33)	[36]
Low Acuity Exacerbation	4.27 (2.57-7.08)	
High Acuity Exacerbation	10.79 (6.29-18.52)	

Benefits of Physiotherapy on Mortality Risk

For our PT intervention simulation, we assume a mortality benefit of PT on patients as PT treatment and exercise interventions have been found to increase CD4 counts, which in turn reduces the risk of mortality.[5] For example, a change in CD4 count of 71 moves a baseline patient from an assumed CD4 count of 430 to 501. Relative risk of death for a person with a greater than 500 CD4 compared to one with a count less than 500 is 0.90.[6] This is based on a patient who has been on ART treatment for over 5 years.

Development of NCDs

Development of NCDs is based on incidence rates by age and sex, adjusted for HIV status. At the start of the simulation, individuals are assigned to either stable, low-acuity or high-acuity states based on prevalence of these conditions for a person aged 50 years in Canada and adjusted for HIV prevalence. This is based on known higher rates of NCDs in PLWHIV. As patients age in the model, development of NCDs and placement into either low or high acuity health states are determined through incidence rates adjusted for HIV status (Appendix Table 1). Presence of certain co-morbidities will have a bearing on subsequent susceptibility to other morbidities; this co-morbidity cascade is incorporated through risk adjustments on estimated probabilities. Literature-derived values for relative risk of hip fractures in the HIV population varied greatly from 1.27 to 6.16. Both values are tested in sensitivity analysis.

Table 4: Prevalence rates per 100,000 for chronic disease in Canada for those 50-64 years old, by sex

	Males	Females	HIV Adjustment
Acute myocardial infarction	3.5	0.97	1.12
Stroke	2.39	2.01	1.53
Hip Fracture	0.11	0.05	1.27, 6.16
Osteoporosis/osteopenia	3.41	13.14	3.70
Peripheral Neuropathy/Pain	42.00	42.00	-
Diabetes	14.67	11.36	1.19
Hypertension	32.34	29.08	0.95
Hospitalized stroke events	2.39	2.01	1.53
Mental illness	13.90	19.37	1.84

Source: PHAC Canadian Chronic Disease Surveillance System (CCDSS) 2015. Mental illness prevalence rates are approximated through use of health services for mental illness. Because PHAC only reports annual rates of hip fractures and no cumulative prevalence, starting prevalence for Hip Fractures is approximated as being equal to the cumulative annual hip fracture from the previous 10 years for those aged 40 to 49 years old. Prevalence rates for peripheral neuropathy by sex are derived from a study on PLWHIV and thus do not require HIV status adjustment.[37] Adjustments for HIV are derived from Kendall et al., 2014, except for hip fracture and osteoporosis.[17] Hip fracture rate adjustments for PLWHIV are derived from two different sources.[38,39] Osteoporosis/osteopenia prevalence adjustments are derived from a meta-analysis.[40]

Physiotherapy NCD Prevention Benefits

Previous research has shown improvements in strength from exercise and PT would result in a decreased number of falls, improved cardiovascular function, reduced depression, improved mood and improved quality of life.[35] It is however difficult to quantify the impact of these results on improved outcomes. One study found that PT interventions reduce the overall number of falls and the number of injurious falls by 35%.[10] This reduction is incorporated into adverse events related to hip fracture, osteoporosis and peripheral neuropathy in the model. There is also large literature showing the impact of exercise on mood disorders. A meta-analysis found exercise improved depressive symptoms by 50%.[8] A study specific to anxiety found exercise interventions to improve anxiety symptoms by 24%.[41] There is also considerable evidence regarding the social inclusion benefits of good mental health. This is assumed to be accounted for in the estimated impact of a 50% reduction in mental health symptoms for those participating in PT interventions.

Costing

In the stable state, the cost of care for a person living with HIV is estimated to be $15,604 per year, based on a CD4 count of 430.[2] Costs of additional NCDs are applied on top of this amount based on the presence of each individual NCD (Table 5). NCD costs include regular care costs as measured through ambulatory and outpatient care. They also include costs associated with acute care, applied with a probability of adverse event for that specific disease in stable state (Probability AE in Table 5) or low acuity state. In the high acuity state, the cost of adverse events is applied in the first cycle and regular care plus risk of other adverse events are applied in subsequent cycles. Non-adverse events or non-ambulatory events were not costed as these would be addressed during routine HIV care visits.

Table 5: Annual NCD Costing for Common Comorbidities associated with HIV

	Probability AE	**Acute Care**			**Non-acute Care**	
Age Group		50-59	60-79	80+	50-69	70+
Mental Health	0.20	$4,453	$5,043	$5,584	$423	$431
Diabetes	0.14	$4,501	$5,491	$5,408	$312	$332
Peripheral Neuropathy	0.05	$11,702	$12,414	$9,411	$228	$239
Osteoarthritis	-	$5,715	$5,215	$4,953	$203	$425
Stroke	-	$10,481	$11,139	$10,494	$572	$599

[2] This is a Canadian cost of care by CD4 count from 2006 inflated using the Canadian Consumer Price Index to 2018. Other studies estimate a higher cost of care but assume a lower CD4 count.[7,42]

Hip replacement or repair	-	$13,143	$11,786	$12,157	-	-
Acute Myocardial Infarction	-	$8,000	$8,117	$8,350	$337	$400

Source: Acute care costs estimated using CIHI Patient Cost Estimator. Non-acute care costs estimated from Ontario Case Costing Initiative (OCCI) ambulatory and outpatient care costing. The hip replacement and repair case mix grouping align with other literature showing the average cost of a fall is $11,408. Average cost of a fall leading to fracture is $39,507, occurring in 31% of elderly falls.[35] CIHI Patient Cost Estimator does not report values for acute Myocardial Infarction. Instead, we derive costs from the OCCI 2016/2017 for Acute Myocardial Infarction, using only typical cases and acute care costs to match definitions used in CIHI Patient Cost Estimator for other disorders. Mental health costs derived from mood or affective disorder case mix grouping. There is no p value for any adverse event because likelihood of adverse event is dependent on the incidence rate itself. The adverse event rate for osteoarthritis is based on the hip fracture rate.

Physiotherapy Impacts on Health Care Costs Benefits

In each health state it is assumed that PT care results in a decreased cost. This is indirectly based on increases in CD4 counts. Patients with CD4 counts greater than 500 have lower non-ARV drug, outpatient care and inpatient care costs. This results in an annual cost reduction of $1,152.[42] This is based on an assumed baseline CD4 count of 430,[34] and an estimated increase in CD4 count by 71.[5] This would increase CD4 count to 501. This places the patient within a treatment cost grouping of $1204 per month versus $1300 per month for the <500 CD4 count group.[7] This results in a reduction of annual HIV costs from $15,605 to $14,453. Another costing benefit for PT related to adverse events is a reduction in hospital length of stay for acute events. Based on a Cochrane review, PT reduces hospital length of stay for acute events by an average of 1.08 days.[43] To incorporate this into the analysis, we calculate the average cost per day for adverse events according to the CIHI patient cost estimator and multiply this by an average length of stay reduction of 1.08 days. For stroke, however, there is evidence that PT has an even greater impact on length of stay, with an estimated 14% reduction in inpatient stay.[16] For non-adverse event costing, incorporation of PT services reduced health care costs associated with outpatient attendance, general practitioner visits, inpatient and day hospital visits by an average of 17% for those in group therapy for osteoporosis.[11] Finally, PT interventions were found to reduce pain in patients with peripheral neuropathy by 14%.[9] It is assumed that this impacts the cost of chronic care.

Table 6: Adverse Event Treatment Cost Reduction Resulting from Increased PT Coverage for Common NCDs associated with HIV

	Adverse Event Treatment Cost Reduction		
Age Group	**50-59**	**60-79**	**80+**
Diabetes	$1,389	$1,119	$1,007
Stroke	$1,467	$1,559	$1,469
Peripheral Neuropathy	$1,264	$1,230	$1,196
Osteoarthritis	$1,122	$1,006	$892

Hip replacement or repair	$5,257	$3,744	$3,126
Acute Myocardial Infarction	$3,126	$3,126	$3,126
Mental Health	$1,202	$1,362	$1,508
Acute care costs estimated using CIHI Patient Cost Estimator calculated per day and multiplied by the 1.08-day reduction in hospital length of stay.			

Societal Costing: Loss of Work

Taking a societal perspective into consideration importantly includes the potential for loss of work due to HIV or NCDs. Estimated loss of work due to NCDs ranged from 4% for those with osteoporosis, on average,[44] to an estimated 42% for patients who had not returned to work within 2 years following a stroke.[15] The annual cost of lost work is $70,336, the average Canadian annual salary from Statistics Canada 2017. To calculate the dollar value associated with lost work, we take this annual average wage multiplied by the estimated job loss in each scenario (Table 7). Increased return to work when incorporating enhanced PT services has been found for stroke populations, this is incorporated in analysis.[14–16] Based on current demographics, 47% of PLWHIV over 50 years of age are securely employed,[45] however, this level of disengagement from the workforce is unacceptable and is a symptom of the many barriers to work facing PLWHIV and other disabilities. Instead, we assume at baseline that everyone is working until the age of 65 since, ideally, with the right accommodations and supports in place, this would be feasible. This assumption is tested in sensitivity analysis.

Table 7: Assumed Loss of Work by Co-morbid Condition

Condition	Job Loss	Note	Source
Stroke	0.42	At 2 years' post-stroke. 10% are estimated to have no job loss and 30% return by 3 months.	14,15
Stroke General	0.10		assumed
Hip Fracture	0.30		46
Myocardial Infarction	0.11		47
Diabetes	0.38	For uncomplicated diabetes. Diabetic adverse event results in a 0.475% likelihood of not working.	48
Pain or arthritis	0.15		47
Osteoporosis	0.04		44
Mental Health	0.70	For severe cases only (1 in 5).	49
Hypertension	-		

Quality Adjusted Life-years

In economic evaluation, estimated life years act as a measure of an intervention's effectiveness in terms of potential mortality benefits. The quality of these additional years is also an important outcome to account for, thus, quality of life associated with any additional years of life gained are measured through quality adjusted life years (QALYs). These are life years weighted by health-related quality of life or utility weights. Utility weights range from a maximum value of 1, meaning perfect health to 0, meaning death. Utilities are derived from multiple literature sources. In this analysis each health state is assigned a baseline utility, for example, a value of 0.78 is used in the case of the stable state.[50] This difference from 1 indicates a lower quality of life for a person living with HIV compared to those in perfect health. Within each state, there are further utility decreases resulting from the presence of specific NCDs.

Disutility inputs and sources can be found in Table 8. For those in the PT intervention group, there is some literature to suggest that PT improves utility and thus results in a lessened disutility associated with specific NCDs. PT benefits were not found for every NCD.

There was also limited evidence as to the disutility due to peripheral neuropathy. It has been suggested that a disutility decrement of 0.07, which corresponds to having pain may be too small to account for the disability experienced by people experiencing moderate to severe peripheral neuropathy. There was, however, no definitive literature which provided evidence on the precise value. This may well result in an overestimation of the quality of life in those suffering from peripheral neuropathy which is a very painful condition.

Physiotherapy Utility Benefits

The quality of life benefits from PT translate to a reduced disutility associated with each NCD in the short and long term. Any first value in Table 8 is associated with first year utility loss from having the condition while the second value is associated with the long-term disutility.

Table 8: Utility weight values by health state, disutility from NCDs, by treatment and control groups

Health State & Associated NCDs	**Disutility from NCD (First Year, LT)**		**Sources**
	No PT	**With PT**	
Stable State Baseline	0.78		[50]
Hypertension	0.053	0.017	[51,52]
Mental Health	0.07	-	[12]

Peripheral neuropathy[3]	0.07	-	[51]
Low Acuity Baseline	0.59		
Diabetes	0.106	0.076, 0.069	[51,53]
Osteoarthritis	0.27	0.21	[51,54]
Adverse Event Baseline	0.55		
Stroke	0.23, 0.18	0.18,0.14	[16,51]
Myocardial Infarction	0.43, 0.34	0.25, 0.23	[12,51]
Hip fracture	0.355, 0.165	0.165	[54]

Sensitivity Analysis

To incorporate uncertainty into the analysis, a number of scenarios are investigated. Firstly, we incorporate both the health payer perspective and societal costing perspective into every analysis. We also compare the results of implementing both high- and low- intensity PT interventions. We also test assumptions in our base case analysis related to hip fracture rate, mortality rate, time horizon utilized in analysis, and the proportion of PLWHIV employed in our societal costing analysis. We finally look at different costing scenarios that assess PT cost based on an average hourly rate for a physiotherapist integrated into a primary care setting as compared to PT fees paid to access a private clinic. Finally, we analyze cost estimates taking into account private insurance and OHIP coverage.

Cost Effectiveness Analysis Results

Base Case Results

Costs incurred and quality-adjusted life years gained were estimated for Ontario residents ageing with HIV (age 50+) who received an expanded PT services intervention and those under current care (Table 9). For those receiving the current standard of PT care with their HIV care, life expectancy past age 50 was estimated to be 25.754 years. Upon discounted and incorporation of utility adjustment, this equates to 15.991 additional QALYs. The estimated total cost to the health care system for current care is $343,635. When societal costs are included in the calculations, this cost rises to $344,455.

When PT treatment was incorporated, the estimated life expectancy out to 2050 increases 1.320 years to 27.074 years. When these results are discounted and weighted by utility, this equates to an increase in QALYs of 1.457 to 17.448. The overall estimated health system cost per person ranges from $345,234 to $353,194, depending on PT intensity. Compared to current care, this is an incremental cost of $1,599 per person in a lower intensity PT scenario and an

[3] We use pain as a measure of utility with peripheral neuropathy. We test a high value of -0.24[61] which results in a slightly lower average QALY for both treatment and control groups. This does not affect the overall results nor the incremental change in QALY between the two strategies.

additional cost of $9,559 in the higher intensity PT scenario. When societal costing is incorporated, the overall value ranges from $349,722 to $357,682. This is a cost savings in the lower intensity PT scenario.

Table 9: Estimated QALYs and average total costs of current coverage compared to expanded coverage strategies over a range of PT intensity, health payer and societal costing perspective

Expected Values	**Current Coverage**	**Expanded PT Coverage**		**Difference**	
Life Expectancy	25.754	27.074		1.320	
QALY	15.991	17.448		1.457	
Costing Perspective		**Low**	**High**	**Low**	**High**
Health Payer	$343,635	$345,234	$353,194	$1,599	$9,559
Societal	$355,455	$349,722	$357,682	-$5,733	$2,227
			ICUR	Low	High
			Health Payer Cost	$1,097	$6,561
			Societal Cost	*Dominant*	$1,528

Reported values discounted at a rate of 1.5% as per cost-utility guidelines (CADTH, 2017). Scenarios that are cost savings and result in a QALY gain results in a negative ICUR. Negative ICURs are not typically reported due to interpretability issues.

Cost-utility

The incremental cost per incremental QALY for the three scenarios resulted in a cost of $1,097 to $6,561 per QALY gain. Interventions are considered to be cost-effective with ICURs that range from $50,000 to $100,000 per QALY gain, making this scenario highly cost-effective.[55] The incremental cost per incremental QALY for the three scenarios resulted in a cost of $1,097 to $6,561 per QALY gain. Interventions are considered to be cost-effective with ICURs that range from $50,000 to $100,000 per QALY gain, making this scenario highly cost-effective.55 The overall higher cost predicted is due to incurred costs over a greater number of expected life years. For instance, based on estimated life expectancy, this higher intensity PT strategy (health payer perspective) had an average annual cost of $13,046 (Table 10). Comparable current care had a per expected life year cost of $13,343. Thus, this strategy costs almost $300 less per year and results in gains to QALYs. The lower intensity PT intervention (societal perspective) was both cost saving and resulted in an increase in QALYs over the comparator strategy. This strategy is considered a dominant approach to current coverage.

Table 10: Estimated Cost per life year under Current Care and Expanded Coverage, low or high intensity physiotherapy, Health Payer and Societal Costing Perspective

Perspective	**Current Coverage**	**Expanded Coverage**		**Difference**	
		Low	**High**	**Low**	**High**
Health Payer	$13,343	$12,752	$13,046	-$591	-$297
Societal	$13,802	$12,917	$13,211	-$885	-$591

Reported costs are discounted at a rate of 1.5% as per cost-utility guidelines (CADTH, 2017). Baseline assumptions include a maximum age of 82 and additive mortality risk adjustment.

Estimated total lifetime discounted PT costs are $9,599 to $17,709, depending on PT intensity (Table 11). Deducting the cost of PT from the overall incremental cost of the intervention scenario provides an estimate of the downstream system savings. On average, PT services in the intervention cost $13,654 per individual. This results in an average system savings of $8,075 from a health payer perspective and $15,407 from a societal perspective. These figures produce a per year PT cost of $504 and a per year system savings of $298 to $565, depending on the costing perspective taken.

Table 11: Estimated physiotherapy cost and health system savings across all scenarios

PT Cost	**Total Lifetime**			**Per Expected Life Year**		
	Low	**High**	**Average**	**Low**	**High**	**Average**
Intervention Cost	$9,599	$17,709	$13,654	$355	$654	$504
Utilization Cost Impact	**Total Lifetime**			**Per Expected Life Year**		
Health Payer	-$8,075			-$298		
Societal	-$15,407			-$565		

Per expected life year estimates sing an estimated life expectancy with PT past age 50 of 27.07 years.

Sensitivity Analysis

We perform sensitivity analyses to capture the robustness of our results subject to uncertainty around critical parameters. These include mortality rate assumptions, the relative risk of certain NCDs, calculation of societal costing perspective. Changes to these parameters do not change in the interpretation of our results (see Tables 2 to 5, supplementary materials). Key results around hourly wage costing and incorporation of income assistance and private insurance are detailed below.

Hourly wage costing

An alternative costing strategy involves assessing cost at the clinic level. Private clinic individual session costs were assumed to be $60 per each half hour. A clinic level costing scenario would apply to the incorporation of physiotherapists for this population into established primary care settings as opposed reimbursing the full cost of care at a private clinic. The median wage for a PT in Ontario is $36.80 per hour (Range: $35.00 to $39.08). If we cost PT at the hourly wage rate of the physiotherapist, the total cost for the modelled PT intervention drops by half to a range of $5,264 to $10,289 (Table 12). In the lower intensity scenario, this results in overall cost savings due to PT treatment of $2,648. Higher intensity PT results in an incremental cost of $2,283 per QALY gained. All results are calculated using the more conservative health payer perspective costing scenarios.

Table 12: Clinic Level Costing from Health Payer Perspective		
Strategies	**Low**	**High**
Current Coverage	$343,635	
Expanded Coverage	$340,987	$345,918
Difference	**-$2,648**	**$2,283**
Intervention Cost	$5,264	$10,289
ICUR	-	$1,567
Using an incremental QALY of 1.72 to calculate ICUR. Note that societal perspective costing both result in a cost savings from a clinic level costing perspective.		

Incorporating Income Assistance and Private Insurance

The Ontario government does currently have some programs to help cover costs associated with physiotherapy among persons who receive income assistance or those over the age of 65. This funding allows patients to seek PT services through OHIP-funded clinics. It is estimated that 36% of the HIV+ population is currently on provincial social assistance and has access to some PT services covered through OHIP funded clinics.[17] Furthermore, 27% of PLWHIV in Ontario is estimated to have private or group insurance.[17] Through private insurance, persons living in Ontario can receive approximately 80% of their PT benefits covered with some co-pay or subject to a maximum, which is $250 on average.[56] Incorporating this into the costing projections decreases PT costs payable by the health payer and decreases the incremental cost per person of the PT interventions (Table 13). In the case of expanded PT coverage for persons without private insurance or current OHIP coverage, the lower intensity PT intervention would be cost saving to the system. The higher cost intervention would have an ICUR of $4,885 per QALY gain.

Table 13: Projected PT Cost and Incremental Cost when Incorporating Private Insurance and Public Assistance for HIV Population, per person				
	PT Cost		**Incremental Cost**	
	Low	**High**	**Low**	**High**
Baseline Results	$9,599	$17,709	$1,599	$9,559
Less Private Insurance	$9,081	$16,753	$1,081	$8,603
Less OHIP-covered	$8,070	$16,180	$70	$8,030
Less Private Insurance, OHIP	$7,552	$15,224	-$448	$7,074
Utilizing base case analysis of public payer perspective and high hip fracture rate. Costs with private insurance calculated using a weighted average where 27% of HIV+ individuals have private or group insurance that covers 80% of care costs.				

OHIP Coverage

There are currently 7,196 HIV patients in Ontario over the age of 50. Based on these estimates, there are 2,183 HIV patients over the age of 50 and under the age of 65 eligible for OHIP funded PT clinics and 1,131 over the age of 65 who are eligible.[17,57] This is 3,314 OHIP eligible patients in total. This is 3,314 OHIP-eligible patients in total. Based on a funding rate of $312 per EC for OHIP-funded clinics, the Ministry of Health and Long-term Care currently spends $1.033 million on OHIP-funded physiotherapy for this population.[58,59]

Table 14: Estimated Current OHIP Coverage		
	PT Service Intensity	
	Low	**High**
Total PT Hours	474,046	926,569
Annual Hours	17,509	34,224
FTE PTs	10	20
Individual Patient Cost	$202	$395
Total Program Cost	$670,120	$1,309,815
HIV Population on Social Assistance		3,314
OHIP Funded Rate		$312
Estimated Current OHIP Funding		$1,033,968

The wait times for these clinics, especially for people living with chronic health conditions, are frequently more than a year.[60] The funding of PT services for PLWHIV would result in a re-allocation of potentially high-use patients to private clinics, or clinics specialized to meet HIV-specific needs. This may help alleviate the current wait times issue in the OHIP-funded clinic system. Using estimated projected low-intensity PT hours, coverage of PT services for PLWHIV would free up 17,509 PT hours at OHIP-funded clinics per year (Table 14). Using hourly wage costing in our simulation results in an average estimated PT cost per year from $202 to $395 for low and high intensity, respectively. The average of these is slightly less than the OHIP funded rate, at $299 per person per year. Our results indicate that OHIP-funded PT services already being covered for the minority population of eligible PLWHIV is considered good value for money. Increasing coverage to the broader community of ageing PLWHIV would be regarded as similarly cost-effective. Furthermore, reallocating patients to primary care settings would not incur more costs for patients already covered.

Estimated Demand Increase

Using the estimated results from the clinic-level costing, the required number of full time equivalent (FTE) physiotherapists can be calculated. The program is estimated to cost $202 to $395 per person per year. Over an estimated population size of 7,196[57], this program requires 22 to 42 additional FTE physiotherapists to treat this population in Ontario. With an average

annual salary of $66,976, it would cost between $1.46 to $2.84 million per year to fund these positions.

Table 15: Projected Demand Increase				
	Individual Level		**Group Level**	
	Low	**High**	**Low**	**High**
Lifetime PT Hours	143	280	1,029,341	2,011,947
Annual Hours	5	10	38,020	74,313
FTE PTs Required	0.003	0.006	22	42
Annual Program Cost	$202	$395	$1,455,094	$2,844,123
			HIV Population (N)	7,196
			PT Annual Hours	1750
			PT Annual Salary	$66,976
Current estimated population is the number of Ontario patients over the age of 50 with diagnosed HIV+. PT annual hours and salary based on 35-hour workweek and 50 weeks worked a year. PT hours calculated as the total PT cost (Table 16) divided by the assumed average hourly rate and further divided by the 32-year treatment period.				

Budget Impact Analysis

When taking overall expected cost out to 2050 for the full HIV+ population, implementation of PT will result in an average cumulative cost savings of $6.847 million at the system level from a health payer perspective (Table 16). This is $335,005 annually, on average.

Table 16: Population Level Costing				
	Cost to 2050		**Per year**	
Strategy	**Low**	**High**	**Low**	**High**
Program Cost	$69,074,404	$127,433,964	$2,551,338	$4,706,911
OHIP Funding Cohort	-$17,444,896	-$34,097,746	-$1,033,968	-$1,033,968
Current Private Coverage	-$14,920,071	-$27,525,736	-$551,089	-$1,016,693
Estimated Net Cost	**$36,709,437**	**$65,810,482**	**$966,281**	**$2,656,250**
System Benefits	**Low**	**High**	**Low**	**High**
Health Payer	-$57,568,000	-$58,647,400	-$2,126,336	-$2,166,205
Societal	-$110,329,072	-$111,408,472	-$4,075,123	-$4,114,992
Overall Cost/Savings	**Low**	**High**	**Low**	**High**
Health Payer	-$20,858,563	$7,163,082	-$1,160,055	$490,045
Societal	-$73,619,635	-$45,597,990	-$3,108,843	-$1,458,742
Costs are discounted at a rate of 1.5%. A population size of 7,196 and an OHIP eligible cohort of 3,314.				

Costing Case studies

To demonstrate potential costs associated with integrating PT services for PLWHIV at the individual level, we use data drawn from interviews with two representatives conducted by ***Realize***. The following case studies provide background information on the individual care needs and cost projections for each individual patient based on a physiotherapist care assessment and projected cost and cost savings as per the population-based model described above. We use societal costing projections and assume high PT intensity for each scenario as the most realistic costing prediction for individual cases.

Case Study 1

This patient is a 67-year-old person living with HIV in Ontario. They reported limited social support and increased social isolation due to physical limitations. They also report pain and fear of falling. This patient is at retirement age but was unable to work full-time prior to reaching age 65 due to episodic changes in pain and function. Because of this, they receive income support from a number of programs, including Old Age Security, the Guaranteed Income Supplement, and the Canada Pension Plan. Their comorbidities include a stroke with left side impairment, peripheral neuropathy, arthritis/osteoarthritis, osteopenia, and a previous hip fracture resulting in persistent pain that contributes to limited mobility and necessitates use of a cane and walker. Mobility issues are reported to impact activities of daily living and instrumental activities of daily living. This patient is also in remission from prostate cancer. The patient reports drug and emotional fatigue along with fear, anxiety and uncertainty.

To cost this case, we look first to the immediate issues presented by the patient. In Table 17 a sample care plan was designed by a physiotherapist. This includes an initial assessment of functional concerns at a cost of $110. After this consult, a falls prevention program is recommended for this patient. In this case, the falls prevention intervention is a hip fracture specific program that runs three times a week for 24 weeks at an estimated cost of $290. Any follow-up care from group therapy is costed at the same rate as a regular visit. For subsequent costs and outcomes, we look to the population-based model for the average costs and QALYs for a 67-year old male who is in a high-acuity state due to the lasting effects of a stroke. From this we derive the annual cost with and without treatment.

In the first year of care, this patient will participate in one or two group therapy sessions along with an initial consult for an average cost of $605. Measuring the estimated PT costs in subsequent years, based on the population-based model, renders an average cost of $655. Costs will be higher in the first year of care or after the onset of NCD due to consultation appointments. Lifetime total health costs including PT are estimated to be $6,598 less under extended PT coverage than under current care for this patient.

Table 17: Estimated Total Cost in Case Study 1	
Hypothetical Care in First Year	**Cost**
Flagged need care: 1 consult + 1 group session + follow-up	$460
Flagged care: 1 consult + 2 group sessions + follow-up	$750
Average	$605
Estimated avg PT costs per year from model	**$655**
Estimated annual health cost current coverage	$14,234
Estimated annual cost extended PT coverage	$13,491
Annual Cost Differential	**-$742**
Lifetime Cost Differential	**-$6,598**
Total estimated costs based on a male who reaches a high acuity state by the age of 67. Negative cost differentials represent a cost savings.	

Case Study 2

The second case study involves a 50-year-old female living with HIV. She has a strong social support network from a local immigrant community. Her HIV status is undisclosed to family and community. She is employed part-time and was previously receiving disability insurance. Current co-morbidities include Type II diabetes, hip and back pain, depression and chronic fatigue. Fluctuating pain impacts activities of daily living and work. Pain is managed predominantly through emergency room visits and medication. While the patient has no present mobility issues, she is cautious and walks slowly due to pain and is fearful of walking on uneven or slippery surfaces.

For this woman's care, we again assess functional limitations through an initial consult. This patient would like to participate in PT for hip and back pain. The cost for individual therapy is $675 or $290 for group sessions which could be offered either instead of, or in addition to, individual sessions. Follow-up care commences after individual or group sessions are completed. We select the higher intensity PT cost for this analysis.

For the second case study, we estimate a first-year average cost of care of $813. Subsequent year average costs are estimated to be $647. The average annual cost per year for all health system and job loss costs are estimated to be $415 less under the PT intervention as compared to the current standard of care. Over the lifespan, this translates to an additional cost to the system of $1490 due to the fact that the subset of females selected in this model starting in low-acuity exacerbation at age 50 have a life expectancy 1.5 years longer than those not in the PT intervention group. Thus, the total cost encompassing yearly cost savings but also accounting for 1.13 years' additional cost leads to a slightly higher overall 32-year cost.

Table 18: Case Study Two Estimated Costs

Hypothetical First Year Care	**Cost**
Flagged need care: Consult + 1 Individual Block + Maintenance	$845
Flagged care: Consult + Individual + Group session + Maintenance	$1,135
Flagged care: Consult + Group sessions only +Maintenance	$460
Average cost	**$813**
Estimated PT costs per year	**$647**
Estimated annual health cost current coverage	$14,268
Estimated annual cost extended coverage	$13,852
Annual Cost Differential	-$415
Lifetime Cost Differential	$5,835

Expected costs based on a female in low-acuity exacerbation state at age 50. Estimated PT costs in first year excludes regular care as diabetic woman likely to be enrolled in group sessions. Cost effectiveness reported only for the high cost scenario resulting in a positive incremental cost and positive incremental QALYs. For the low-cost case incremental cost effectiveness ratio not reported but it is deemed to be a dominant strategy.

Results Summary

In assessing the costs and benefits associated with expanded PT coverage, the results indicate that this intervention would be considered cost-effective in comparison to commonly reimbursed drug products or services. From the perspective of the health payer and assuming higher intensity and thus more costly PT services, the PT intervention would cost $6,561 per QALY gained out to 2050. This ICUR result would be considered highly cost-effective. All other scenarios are either a lower cost per QALY gain or result in both cost savings and QALY gains, indicating that they are objectively preferable to the current standard.

When looking over the entire projected lifespan of PLWHIV, PT is estimated to add 1.6 additional QALYs through prevention or delay of certain NCDs and mortality improvements (Appendix Table 5). Looking only from the health payer perspective, the cost per year for treatment under current care is $13,343. The cost under the high-intensity PT intervention is $13,046. Thus, each year lived, an individual receiving the PT intervention costs the system approximately $300 less using the most conservative estimate. Cumulatively, this is a cost savings of $8,075 over the person's life span.

When we cost based on the average hourly wage of physiotherapists instead of by private clinic fee, which would represent the integration of additional PT services into existing primary care teams, estimated PT costs are $5,264 to $10,289 per person out to 2050. These are highly cost-effective interventions with incremental cost savings of $2,648 in the lower intensity scenario and an additional cost per QALY gain of $1,567 in the higher intensity scenario. The cost of PT services to the public payer further decreases and subsequent health system savings increase when we consider the potential for private insurance as the first payer for some portion of the PLWHIV population. When we further incorporate that nearly 46% of the population under study is currently covered by OHIP in some way, either through age or income assistance, the incremental cost of this program to the public payer decreases further.

In assessing the approximate demand increase from funding more PT services for this population group, we estimate an additional 32 (22 to 42) FTE physiotherapists would be required to meet this need. This FTE requirement totals to a cost of $2.15 million per year based on the average salary of physiotherapists in Ontario. Using the cost of private care, less private insurance and current OHIP funding, this is $1.8 million ($0.97 to $2.66 million) annually. At the population level, this renders average annual savings to the system of $2.15 million ($2.13 to $2.17 million) over the study period. This savings is again due to the prevention of NCDs, improved mortality and quicker post-acute recovery for these patients. Over the entirety of the study period, this is a budget impact of $59 million in average savings out to 2050.

At an individual case level, there appear to be demonstrable benefits of integrating PT in terms of either overall cost savings (Case 1) or annual cost savings and improved life expectancy (Case 2).

Limitations

In designing this cost-utility analysis, there were some limitations. Firstly, given the scope of this project, individual-level data on HIV patients were not readily available. To address this, we used literature-derived values for transitions to different co-morbid conditions and death, adjusted for HIV status. These results give a simplified view of a complicated illness and co-morbidity trajectory. One necessary simplifying assumption was that if a patient experienced a low or high acuity exacerbation, then there was no potential to return to a stable disease state. We made this assumption because all incorporated disorders are chronic, and once diagnosed, will always be present. This disease may, however, be stable. We include stabilization through improved long-term costs and utilities, provided there is no further exacerbation. Incorporation of a return to a stable health state would likely lower costs in both treatment and control arms. Cost decreases would, however, be more pronounced in the treatment arm as a patient receiving proactive care is assumed to be more likely to return to a stable state. A lower treatment arm cost compared to the control arm would result in greater estimated cost savings, as well as QALY gains, and thus a larger estimate of cost-savings per QALY gain. Our model thus demonstrates a more conservative cost-effectiveness estimate. Access to individual-level data would provide more precise estimates of these patient trajectories.

A second limitation concerns the dearth of published literature on PT benefits and costs in general and specific to the PLWHIV population. While certain morbidities, such as stroke or hip fracture, had more extensive literature from which to draw, limited information was available for other conditions of interest. One such example is peripheral neuropathy among PLWHIV. Given a lack of research on utility-weighted values and costs for this disorder, our estimates relied on pain as an approximation. This use of pain disorders as an approximate measure may result in an undervaluing of both the cost and the disutility associated with peripheral neuropathy. To address the uncertainty resulting from minimal data and literature sources, we incorporated a significant number of sensitivity-analyses to ensure the robustness of our results.

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Appendix

Additional Input Data Tables

Appendix Table 1: Incidence Rates for Key Chronic Diseases in Canada, by age and sex

	Females			Males			HIV RR
Age Group, Years	50-64	65-79	80+	50-64	65-79	80+	-
Acute myocardial infarction	119	352	1,019	341	691	1,400	1.12
Stroke	218	647	1,913	295	855	2,074	1.53
Hip Fracture	36	201	1,312	31	118	667	6.16
Osteoporosis/osteopenia	1020	2031	2,626	248	611	1,075	3.70
Peripheral Neuropathy/Pain	1690	2806	3,248	1190	2010	2,439	-
Diabetes	952	1331	1,144	1309	1881	1,504	1.19
Hypertension	2137	4251	6,416	2809	5118	6,555	0.95
Hospitalized stroke events	75	249	860	125	362	892	1.53
Mental Illness	305	202	527	1176	307	58	1.84

Source: PHAC Canadian Chronic Disease Surveillance System (CCDSS) 2015. See notes and sources in Table 2.

Sensitivity Analysis Results

Hip Fracture Rate

The reduction in system costs due to PT interventions are dependent on a decrease in in-patient care as a result of a reduced likelihood of adverse events, and prevention or improvement of NCDs including mental health, diabetes, cardiac health and hip fractures resulting from falls. Reduction of hip fractures, in particular, is a significant driver of these savings. To test our assumptions on hip fracture rates, we lower relative risk of hip fracture 1.27, significantly lower than the base care RR of 6.6 (Table 2). Lower hip fracture rates do not change the base case interpretation of PT expansion being cost-effective.

Appendix Table 2: Sensitivity Analysis: HIV-hip fracture relative risk

		Health Payer		Societal	
Strategies	**QALYs**	**Low**	**High**	**Low**	**High**
Current Coverage	16.348	$345,007		$355,888	
Expanded Coverage	17.541	$345,724	$353,709	$350,032	$358,016
Cost Difference	1.193	$717	$8,701	-$5,856	$2,128
ICUR		$601	$7,293	*Dominant*	$1,784

Reported costs and QALYs are discounted at a rate of 1.5% as per cost-utility guidelines (CADTH, 2017). Hip fracture relative risk adjusted to 1.27 RR from 6.6.

Expansion of PT coverage under lower hip fracture rates results higher overall costs across all scenarios. Although individuals have a higher life expectancy with lower hip fracture rates, they are then at risk of other NCDs or adverse events, which are costlier in later life. This scenario tests out assumptions concerning current hip fracture risk for the HIV population and also gives insight into the impact of generally-improved rates of hip fracture on the cost-utility of this intervention. If hip fracture rates decreased outside of this intervention, say through a universal falls prevention program for older adults, PT coverage for the population of people ageing with HIV would still be cost-saving or cost-effective. This result is due to the other benefits of PT coverage -- prevention of adverse events or improvements in quality of life or recovery following an incident.

Mortality Rate Assumptions

In estimating the mortality risk adjustment associated with being HIV+ and having one or more co-morbidities, there were no published figures that were a perfect match to the constructed health states of stable, low and high acuity exacerbation. Because of this, we assumed that relative mortality risk was additive. If we concluded that mortality corresponds directly to the mortality rate found in each health state (Table 2), the cost-effectiveness results would improve from those reported under our base case. This result is due to the longer life expectancy of individuals and correspondingly higher QALYs. The ICUR for the higher intensity PT intervention from the health payer perspective decreases to a cost of $5,754 per QALY gained.

Appendix Table 3: Sensitivity Analysis: non-additive mortality risk adjustment

		Health Payer		**Societal**	
Strategies	**QALYs**	**Low**	**High**	**Low**	**High**
Current Coverage	16.88	$357,548		$369,066	
Expanded Coverage	18.092	$356,286	$364,522	$360,865	$369,101
Cost Difference	1.212	**-$1,262**	**$6,974**	**-$8,201**	**$35**
ICUR		-$1,041	$5,754	-$6,767	$29
Physiotherapy Costs		$9,927	$18,326	$9,927	$18,326
Downstream Cost Savings		$11,189		$11,189	

Reported costs and QALYs are discounted at a rate of 1.5% as per cost-utility guidelines (CADTH, 2017).

Societal Costing Employment Assumptions

The baseline analysis does not take retirement age into consideration. This is because, while 65 is the common age of retirement, not everyone will retire at this age. Additionally, some societal costing projections consider annual average wages in death due to the societal cost of a person dying. Wage loss due to acute event may also be considered a societal cost born by

friends and/or family who must take on care duties personally or a direct economic cost of hiring additional aide in the home. To test the assumption of including wage loss for the duration that a person is alive in the model we run three additional scenarios. The first considers lost wages due to job loss only until the age of 65, using the common age of retirement as a cut off. This scenario assumes 100% employment before the age of 65. The second scenario again uses an Ontario-specific employment rate for persons living with HIV of 47% for those under the age of 65. The third scenario combines both adjustments.

These scenarios result in a lower overall societal cost in both the current care arm and the expanded PT coverage arm. Since job loss impacts the current care arm more, the difference in cost decreases, resulting in lower cost savings in the lower intensity PT arm. In the higher intensity PT arm the difference in cost difference increases. As each scenario still renders a QALY gain of 1.46, the results ICURs remain cost-effective compared convention WTP thresholds (Table 4).

Appendix Table 4: Sensitivity Analysis: Retirement Age and Employment

	Current Care	**Expanded PT Coverage**		**Difference**	
		Lower Intensity	**Higher Intensity**	**Lower Intensity**	**Higher Intensity**
Base Case	$355,455	$349,722	$357,682	-$5,733	$2,227
A) Retirement age 65	$350,027	$347,517	$355,501	-$2,510	$5,474
B) 47% employment	$350,121	$347,749	$354551	-$2,372	$5,612
C) Both	$347,366	$ 346,567	$354,517	-$799	$7,185
ICUR					
	Base case			Dominant	$1,528
	A) Retirement age 65			Dominant	$4,588
	B) 47% employment			Dominant	$4,704
	C) Both			Dominant	$6,023

Uses societal perspective only.

Time Horizon Assumptions

Our base case analysis assumes a lifetime horizon to age 82. This is based on a desire to estimate a shorter-term cost estimate and estimate out only to the average life expectancy of Canadians. When we increase this time horizon to a maximum of 100 years, QALYs increase to 18.84 and 20.43 for current coverage and extended PT coverage, respectively. Costs also rise for both intervention strategies due to the additional years of PT treatment delivered. From the health payer perspective current care costs rise to $413,034 per person on average. Compared

to current coverage this is $8,874 more on average. In terms of cost-utility, all scenarios remain cost effective, with the most conservative costing scenario (health payer perspective, higher intensity PT) increasing to a cost of $8,545 per QALY gain. This is within common cost-utility willingness-to-pay thresholds.

Appendix Table 5: Sensitivity Analysis: Time Horizon

		Health Payer		Societal	
Strategies	**QALYs**	**Low**	**High**	**Low**	**High**
Current Coverage	18.84	$404,160		$418,620	
Expanded Coverage	20.433	$408,303	$417,764	$414,502	$423,964
Cost Difference	1.592	$4,144	$13,604	-$4,118	$5,344
ICUR		$2,603	$8,545	*Dominant*	$3,357
PT Costs		$11,357	$20,950	$11,357	$20,950

Reported costs and QALYs are discounted at a rate of 1.5% as per cost-utility guidelines (CADTH, 2017). Life expectancy under current care was estimated to be 32.46 years. Life expectancy under expanded care was estimated at 34.211.

With expanded PT intervention, simulated individuals live an additional 34 years versus 32 years under the current standard. The cost per year for treatment under current care from the health payer perspective is $12,730. The cost under the PT intervention goes from $11,941 to $12,227. When looking over the entire lifetime, the model still predicts that each additional year lived by an individual receiving the PT intervention (both low and high intensity) costs the system less, on average, than a person not receiving PT per QALY.

Case Study Cost Inputs

Appendix Table 6: Case Study 1 Cost Inputs

Description	**Physiotherapy Component**	**Recommendation**	**Cost**
Initial consultative assessment	Assessing functional concerns or red flags along with reviewing home exercise program.	Initial consult upon initiation of PT plan or with new co-morbidity.	$110
Maintenance Care	Occurs regularly if no flags identified in previous consults.	Maintenance assessment occurs every 6 to 9 months	$60

Identified functional concern	In this specific example, the patient has a risk of falls and has peripheral neuropathy. Reduced confidence and balance, resulting in impaired independence with ADLs/IADLs was also identified as a risk factor.	Recommended falls prevention group program	$290
Follow-up Care	PT Reassessment to determine if the needs of the patient have been appropriately met through active therapy, or if additional active therapy is required.	Occurs once after active group therapy.	$60
Group session calculated based on hip fracture group session recommendations: 3 sessions over 24 weeks (48 total hours) using a rate of $145 for 36 hours.			

Appendix Table 7: Case Study Two Cost Inputs

Description	**Physiotherapy Component**	**Recommendation**	**Cost**
Initial consultative assessment	Assessing functional concerns or red flags along with reviewing home exercise program.	Initial consult upon initiation of PT plan or with new co-morbidity.	$110
Maintenance Care	Occurs regularly if no flags identified in previous consults.	Maintenance assessment occurs every 6 to 9 months	$60
Identified functional concern	In this example, the PT identified hip and back pain resulting in impaired participation in occupational and caregiving responsibilities.	PT recommends block of individual sessions for therapeutic exercise prescription/progression, joint mobilization, soft tissue release, etc. and/or group program for general strengthening	Individual: $675 Group: $290
Follow-up Care	PT Reassessment to determine if the needs of the patient have been appropriately met through active therapy, or if additional active therapy is required.	Occurs once after active group therapy.	$60