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Process Monitoring of an HIV Treatment as Prevention Program in British Columbia, Canada

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Abstract

Background—In light of accumulated scientific evidence of the secondary preventive benefits of antiretroviral therapy, a growing number of jurisdictions worldwide have formally started to implement HIV Treatment as Prevention (TasP) programs. To date, no gold standard for TasP program monitoring has been described. Here, we describe the design and methods applied to TasP program process monitoring in British Columbia (BC), Canada.

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Conflicts of Interest

The funders had no role in the design, data collection, data analysis, data interpretation, or writing of the report. The remaining authors report no disclosures.

Methods—Monitoring indicators were selected through a collaborative and iterative process by an interdisciplinary team including representatives from all five regional health authorities, the BC Centre for Disease Control (BCCDC), and the BC Centre for Excellence in HIV/AIDS (BC-CfE). An initial set of 36 proposed indicators were considered for inclusion. These were ranked on the basis of eight criteria: data quality, validity, scientific evidence, informative power of the indicator, feasibility, confidentiality, accuracy, and administrative requirement. The consolidated list of indicators was included in the final monitoring report, which was executed using linked population-level data.

Results—A total of 13 monitoring indicators were included in the BC TasP Monitoring Report. Where appropriate, indicators were stratified by subgroups of interest, including HIV risk group and demographic characteristics. Six Monitoring Reports are generated quarterly: one for each of the regional health authorities and a consolidated provincial report.

Conclusions—We have developed a comprehensive TasP process monitoring strategy using evidence-based HIV indicators derived from linked population-level data. Standardized longitudinal monitoring of TasP program initiatives is essential to optimize individual and public health outcomes and to enhance program efficiencies.

Keywords

HIV; treatment as prevention; monitoring; TasP; Canada

INTRODUCTION

The outlook of HIV-infection has improved dramatically since the emergence of highly active antiretroviral therapy (HAART) in 1996^{1,2}. Today, it is estimated that a 20 year old individual diagnosed with HIV infection will have an additional five decades of near normal life expectancy with continued use of HAART³. The proposition of life-long HAART has become a reality in the last decade with the advent of simplified once daily, single tablet regimens, as well as more effective, safer and better tolerated antiretrovirals⁴⁻⁶.

More recently, it has been shown that HAART has a secondary population-level benefit of reducing the risk of HIV transmission⁷. This has been highlighted in mathematical models^{8,9}, cohort, and ecological studies^{7,10-14}. In 2011, this was confirmed in a randomized clinical trial, the HPTN052 trial, where immediate use of HAART was associated with a 96% reduction in heterosexual HIV transmission¹⁵. Importantly, expanded HAART coverage has been shown to be a highly cost-effective and even potentially a cost-averting strategy to prevent HIV/AIDS related morbidity and mortality as well as HIV transmission¹⁶⁻¹⁸.

This has fuelled the enthusiasm for the adoption of ‘Treatment as Prevention (TasP)’ initiatives. UNAIDS has called for the acceleration of the global roll out of ART to curb morbidity and mortality, as well as HIV transmission¹⁹, based on the implementation of the 2013 Consolidated World Health Organization (WHO) Antiretroviral Therapy Guidelines. The 2013 WHO Guidelines recommend that HAART be offered to all HIV infected individuals with CD4 cell counts below 500/mm³, and regardless of CD4 cell count among

selected groups of HIV infected individuals (i.e.: TB co-infected, hepatitis B virus related liver disease, sero-discordant couples, pregnant women, and children below the age of five)⁵. A recent modeling study suggested that the optimal implementation of the WHO guidelines could lead to 3 million averted deaths and 3.5 million averted new infections in low- and middle-income countries within 13 years compared with 2010 WHO guidelines²⁰. As a result, jurisdictions across the world including USA, China, France, Brazil and Panama have formally started to roll-out TasP programs.

While the efficacy of TasP has been clearly established, the real world effectiveness of this strategy will depend on overcoming numerous barriers, which will vary widely between settings. These include financial and structural barriers to accessing HIV testing, care and treatment, patient and provider-level factors and institutional barriers^{21,22}.

Careful longitudinal monitoring of TasP programs will, therefore, be essential to optimize individual and public health outcomes and to enhance program efficiencies. This will need to take into account heterogeneities across regions and among sub-populations, which may require enhanced or novel programmatic support to promote and sustain engagement of HIV-positive individuals on the HIV continuum of care. Indeed, the WHO has listed 'defining methods for monitoring and evaluating TasP programmatic impact' as one of their priority work areas²³. Despite the recognition of the importance of monitoring TasP implementation programs, there is no gold standard for outcomes assessment in this area. Recently, the "HIV cascade of care" has been proposed as a metric in this regard²⁴; however this does not fully capture the complexities and diversity of care engagement in real life²⁵.

The province of British Columbia (BC) has progressively expanded access to antiretroviral therapy consistent with the IAS-USA antiretroviral guidelines for adults since 1996⁴. In 2013, this commitment to universal access to antiretroviral care evolved into a formal province-wide Treatment as Prevention (TasP) initiative funded by the BC Ministry of Health under the name of 'Seek and Treat for Optimal Prevention of HIV/AIDS' (STOP HIV/AIDS). The BC Centre for Excellence in HIV/AIDS (BC-CfE) has been mandated to oversee the monitoring of STOP HIV/AIDS programming in BC. The impact of the expansion of HAART coverage in BC has recently been described²⁶. Here we describe the design and methods applied to TasP process monitoring in BC, developed using evidence-based HIV indicators and linked administrative and surveillance data. Our goal was to develop a province-wide quarterly Monitoring Report that addressed BC STOP HIV/AIDS goals, based on key indicators, using real-time data to inform STOP HIV/AIDS planning with an emphasis on engagement on the stages of the HIV continuum of care.

METHODS

Subjects and Data Sources

A key element of the STOP HIV/AIDS program is the linkage of a series of population-level health administrative registries containing detailed HIV testing, physician billing, hospital admission, and pharmacy dispensation records. These population-based province-wide registries form the empirical basis for all STOP HIV/AIDS monitoring and surveillance efforts, and are updated on a continuous basis.

The registries were used to construct the STOP HIV/AIDS cohort, which captured all individuals identified as HIV-positive within the province from 1996 onward. The methodology to define the STOP HIV/AIDS cohort and a comprehensive description of its content and limitations has been published previously^{27,28}. In brief, data sources included the BC Centre for Disease Control (BCCDC), the BC-CfE and administrative databases from the Ministry of Health. The BCCDC is responsible for HIV surveillance in BC and provides data on HIV testing, diagnosis and AIDS events. The BC-CfE is mandated to distribute all antiretrovirals in BC and captures relevant clinical and laboratory data for all HIV-positive BC residents²⁹. Each of these services (antiretroviral drugs, as well as laboratory and medical monitoring) is fully funded by the BC-Ministry of Health. All provincial HIV genotyping and viral loads are performed at St Paul's Hospital (where the BC-CfE is located); thus, the BC-CfE has 100% antiretroviral prescription and dispensing data capture, 100% viral load capture, approximately 85% CD4 cell count capture, as well as extensive capture of baseline sociodemographic factors (age, sex, exposure category, etc.), patients residence and location of services. Provincial health administrative databases provide comprehensive data capture for in- and out-patient services and prescription drug dispensation, with few exceptions²⁷. Finally, HIV-specific mortality data was obtained through monthly linkages with BC Vital Statistics.

Indicator Development

Several resources were used in designing the monitoring report. For a general context, we used the Morbidity and Mortality Weekly Report Framework for Program Evaluation in Public Health³⁰. This framework was originally developed for evaluating public health programs. We followed this framework by: 1. Engaging stakeholders, 2. Describing the program, 3. Focusing the monitoring design, 4. Gathering credible evidence, 5. Justifying conclusions, and 6. Ensuring use and knowledge transfer.

An interdisciplinary working group was established including different provincial representatives responsible for the delivery of care from each of BC's five regional health authorities, the BCCDC, and the BC-CfE, as well as HIV specialists, epidemiologists, health economists, demographers, clinical researchers, statisticians, mathematicians, clinicians and community members. This working group met regularly to develop a list of HIV TasP monitoring indicators and to provide feedback as the process evolved.

During indicator development, we conducted a literature review of TasP-specific monitoring and HIV surveillance processes. The literature was summarized into table form and an initial list of 36 proposed indicators was considered uniformly against eight criteria using a decision-making table (Table 1) which took into consideration: (1) Indicator data quality; including the ability of the indicator to be captured in as close to real-time as possible; (2) Whether or not the indicator had been validated; (3) Existing scientific evidence of the value of the indicator; (4) The informative power of the indicator; (5) Feasibility in calculating the indicator; (6) Ability of the indicator to retain patient confidentiality; (7) Accuracy of the estimated indicator; and (8) Administrative requirement (i.e.: if an indicator was specifically requested by the BC Ministry of Health for internal administrative purposes). This list of criteria was created by the study team and informed by the second element of the MMWR

framework³⁰, the UNAIDS Operational Guidelines for Selecting Indicators for the HIV Response³¹, and the Institute of Medicine's "Improving Health in the Community: A Role for Performance Monitoring"³². Only indicators that met all "strong recommendation" criteria, or were required by the Ministry of Health, were included in the short-list of monitoring indicators. Indicator definitions and calculation procedures were arrived at based on availability and format of data and/or had been previously defined through published work.

Indicator Selection and Data Display

Early drafts of short-listed indicators were shared with the interdisciplinary working group for review and feedback. Comments from 40 reviewers were tracked and reviewed and their suggestions incorporated into an updated draft. This process was reiterated until consensus was reached regarding the most appropriate indicators and the best method to display the indicators, and their stratification.

RESULTS

Monitoring HIV Indicators

Thirteen HIV indicators were selected for regular reporting and are summarized in Table 2 by type of indicator, significance, definition, corresponding validation/supporting reference and reporting time frame and data lag. Overall, the indicators incorporated: HIV testing, diagnosis, linkage, retention in care, ART initiation and adherence, genotyping and HIV drug resistance as well as key health outcomes including AIDS case reports and HIV-related mortality.

Specifically, we selected the following indicators: HIV testing episodes and rates (including point of care testing); new HIV diagnoses counts; stage of HIV infection at time of diagnosis; the HIV cascade of care³³; HAART uptake as described by new starts in both treatment experienced and naïve persons, CD4 cell count at time of HAART initiation, active and inactive (previously on HAART but stopped picking up HAART prescriptions) HAART users, antiretroviral adherence (measured by refill compliance)³⁴; resistance testing results by resistance category; AIDS cases and rates; and HIV-related mortality. Where appropriate we stratified our indicators by age, gender, HIV transmission risk category (men who have sex with men (MSM), history of injection drug use (IDU), other), regional health authorities and health service delivery area (a sub-set of a regional health authority) to allow the detection of heterogeneity between various sub-groups and regions. Figure 2 shows examples of some of our final monitoring indicators.

In addition, we included the Programmatic Compliance Score (PCS) as a monitoring indicator, as recently described³⁵. In brief, the PCS represents a score resulting from summing the results (yes=1, no=0) of six measures of quality of care based on IAS-USA treatment guidelines: (1) Having <3 CD4 cell count tests in the first year after starting antiretroviral therapy (ART); (2) Having <3 plasma viral load tests in the first year after starting ART; (3) Not having drug resistance testing done prior to starting ART; (4) Starting on a non-recommended ART regimen; (5) Starting therapy with CD4<200 cells/ μ L; and (6)

Not achieving viral suppression within nine months since ART initiation³⁵. PCS is categorized as scores of 0 (best score) to 4 (worst score). Increasing PCS has been shown to be strongly statistically associated with poor health outcomes, including death, disease progression, as well as immunological and virological failure.

Of the 13 indicators, eight have up-to-date quarterly data and four (HIV testing rates, AIDS case reporting, stage of HIV infection at time of diagnosis, and HIV-related mortality) are currently limited to annual reporting. Since the HIV testing rate and HIV-related mortality rate are relatively small when measured quarterly, we present these two indicators annually to allow for trend observation. AIDS case reporting is passive in BC. AIDS cases are only captured biannually and with considerable time lag, therefore this is reported yearly. The same restriction applies to the indicator 'stage of HIV infection at time of diagnosis' since it incorporates 'AIDS' in its definition. HIV-related mortality comes directly from BC Vital Statistics and thus the reporting frequency is dependent on linkages with BC Vital Statistics.

Monitoring Reporting and Frequency

Six monitoring reports are produced quarterly: one for each of the five regional health authorities in BC and one for the province of BC overall. There is approximately a six-week lag from the end of a given calendar quarter and the release of the monitoring reports. All reports are made publicly available online through the BC-CfE website (<http://www.cfenet.ubc.ca/stop-hiv-aids/documents>). Data tables displaying counts used to create plots included in the monitoring reports appear as appendices in each report. In addition, a technical report providing: (1) monitoring indicator definitions; (2) indicator significance including instructions on how to interpret indicators and desired outcomes for each indicator; (3) data sources used in indicator construction; (4) calculation method including numerator, denominator definitions and inclusion and exclusion criteria; (5) limitations and; (6) any additional notes, is available on the BC-CfE website. All proposed changes to either the technical or monitoring reports undergo formal review and approval by the Technical Monitoring Committee. Once agreement is reached on a proposed change, the change is incorporated, tracked and dated. In addition, prior to report dissemination, representatives from each regional health authority are provided their respective monitoring report and are given an opportunity to comment and request further clarification or changes regarding monitoring report outputs. Once all necessary changes are made and representatives from each regional health authority provide consent to release their respective reports, reports are uploaded to the BC-CfE website.

Monitoring Report Knowledge Translation

Observations from the monitoring report are then translated to the HIV care and patient communities which includes clinicians, HIV specialists and patients who are a part of an existing "expert advisory group" by the HIV Continuum Care Collaborative. This group's focus is on quality of care improvement, including HIV patient care and experience, based on methodology described by the Institute for Healthcare Improvement³⁶. Regional health authorities and health service delivery areas, however, are ultimately responsible for the design and implementation of STOP HIV/AIDS strategies and interventions aimed at

improving outcomes measured in the monitoring reports or other outcomes of particular interest in their regions.

DISCUSSION

We described here a coordinated, inclusive, evidence-based process for developing a monitoring framework for a province-wide HIV TasP program in Canada. The indicators selected for inclusion in the report capture the full spectrum of engagement in care, including the HIV cascade of care and the Programmatic Compliance Score. Further, these lend themselves well for multiple stratifications, aimed to better characterize sub-groups (based on sociodemographic characteristics and risk factors, baseline variables, place of residence or site of access to health care services) that may need special attention, or targeted initiatives. Most of the indicators selected are suitable for relatively frequent and semi-automated reporting predominately using simple to interpret graphic displays (see full report at <http://www.cfenet.ubc.ca/stop-hiv-aids/documents>). Our report provides a valuable option for the standardized longitudinal monitoring of TasP initiatives and should assist efforts to harmonize TasP monitoring tools across jurisdictions.

Despite international agreement on both the pivotal role of TasP in curtailing the HIV epidemic and the need for monitoring and evaluation strategies, there are few published recommendations on the implementation of such strategies⁵. A growing number of jurisdictions are currently moving to embrace expanded HAART guidelines based on the 2013 Consolidated WHO Guidelines. Monitoring the impact of these initiatives will be essential to optimize individual and public health outcomes and to enhance efficiencies.

The applicability and feasibility of our specific indicators outside of the BC context depends on data availability, quality and the technical resources to develop and maintain such a monitoring tool. Organizations may need to adapt our indicators to meet their own TasP project goals and to accommodate their own data resources and restrictions. The process for developing a TasP program monitoring tool is, however, more widely applicable. While there is limited published work on the development of TasP-specific monitoring indicators, there are several publications and existing databases, which include HIV monitoring indicators^{37–41}. Our indicator selection process was heavily informed by these published literature.

The most broadly known and well-published method for monitoring and informing TasP implementation to date is the HIV cascade of care. This has proven to be a useful descriptive tool upon which a surveillance system can be focused; however, it can be augmented with more detailed contextual information on health system performance and specific gaps in care^{25,42}. The HIV cascade of care does not provide critical information on indicators such as HIV-related mortality and other health outcomes or process indicators such as stage of HIV infection at diagnosis. Furthermore, HIV cascade of care step outputs are dependent on the criteria and definitions used. Moreover, the HIV cascade of care provides no information regarding the component factors that may influence success or failure at each step of the HIV cascade of care including physician or care system characteristics- a key driver in our decision to include the PCS score as an outcome. Thus, while the HIV cascade of care is

highly informative, additional monitoring indicators are needed to provide a more detailed picture of effects of TasP programming.

During development of our TasP monitoring process and after releasing the first draft of our monitoring report, the WHO released the *Consolidated Guidelines on the use of antiretroviral drugs for treating and preventing HIV Infection* (June 2013)⁵. These include recommendations for monitoring the implementation of the guidelines. Our monitoring report contains indicators that reflect most of those suggested by the WHO. Indicators not incorporated by us, but suggested by the WHO, include those related to tuberculosis and mother-to-child transmission. These are important indicators; however, these are less relevant in our context. TB incidence in BC is low and has decreased significantly over the past decade⁴³, and despite a total of 284 live births between 2003–2013 (an average of 25 to 30 pregnancies per year) among HIV infected women in BC, only two children have been diagnosed with HIV in the last decade and both of their mothers were not in HIV care (Neora Pick (Oak Tree Clinic), personal communication, March 10th, 2014)^{44,45}.

The BC STOP HIV/AIDS monitoring report is made possible by the availability of linked population-level databases used in concert and updated on a continuous basis. Access to these linked databases is the result of a decade-long partnership between the Ministry of Health, regional health authorities, the Provincial Health Services Authority Laboratories, the BCCDC and the BC-CfE. Developing and maintaining such an extensive dataset involves substantial dedicated resources, however, we believe the public health value of such efforts can be profound, as detailed in other jurisdictions and disease areas^{46–48}. The centralized generation of the monitoring report also represents a major strength. Centralization allows for greater efficiency, and harmonization, namely uniform and comparable definitions across all geographical health areas. Finally, this helps to maintain focus and commitment across a wide number of stakeholders, who from time to time may be under pressure to revisit priorities and allocation of resources.

It should also be acknowledged that each indicator has intrinsic limitations. For instance, our HIV cascade of care does not show the ‘infected’ population. Rather, we show the HIV cascade of care as a proportion of the diagnosed population. This improves retention along our cascade of care. Next, ART adherence was based on prescription refill compliance; however, prior studies have demonstrated that refill compliance was associated with other measures of adherence, as well as key clinical outcomes^{49,50}. Also, AIDS reporting is a passive process in BC and it is subject to a degree of delayed- or under-reporting. To account for this, we defined AIDS case reporting using both physician completed AIDS case reporting forms as well as clinically using a CD4 cell count of <200 cells/ μ L. Finally, HIV transmission risk category data was missing for approximately 20% of our monitored population. Better reporting for the risk category would improve our understanding and interpretation of indicator outputs by risk category and identify areas for targeted interventions where they need the most help to improve. These limitations were described in detail in our technical reports and we designed our indicator definitions and calculation methods to account for and minimize the impact of these limitations.

It's important to note that our surveillance report was not intended to serve as a comprehensive account of all HIV-related outcomes and their determinants within the province. Nonetheless, the reports may be expanded or otherwise augmented to provide more specific guidance to province-wide implementation efforts in at least three ways. First, epidemiological data for subsets of the HIV-infected population on the social determinants of HIV-related outcomes, including psychosocial (eg. stigma, social support), structural (eg. housing, treatment access) and institutional factors (eg. patient-physician relationship), have been demonstrated to impact engagement in HIV care and subsequent HIV-related outcomes^{51,52}. Second, information on the utilization of prevention services, such as condom distribution and the utilization of needle exchange, supervised injection facilities, and substance abuse treatment, may complement existing reporting standards and provide a more comprehensive focus for the STOP HIV/AIDS program. Finally, additional stratification for specific high-risk populations, including the incarcerated and those enrolled in opioid substitution treatment can provide information for more specifically targeted community-based intervention to improve HIV/AIDS care.

In summary, we have developed a comprehensive TasP process monitoring strategy using evidence-based HIV indicators and linked administrative and surveillance data. We further incorporated multiple stratifications to better characterize heterogeneity of engagement on the stages of the HIV continuum of care. Standardized longitudinal monitoring of TasP initiatives will be essential to optimize individual and public health outcomes and to enhance efficiencies. Harmonization of monitoring tools, such as those reported here, will greatly facilitate communication and collaboration across jurisdictions.

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Appendix

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Figure 1.
STOP HIV/AIDS Program Indicator: Estimated HIV cascade of care overall and by sex in British Columbia, 2013.

Figure 2.

Selected STOP HIV/AIDS Monitoring Indicator Outputs for British Columbia, Panel A: 2009–2013, Panels B–D: 2012 Q1–2013 Q4.

*PCS=Programmatic Compliance Score; ART=antiretroviral therapy; VL=plasma viral load; DTP=Drug Treatment Program (program run through the BC-CfE which is responsible for the distribution of all antiretrovirals in the province of BC).

Table 1

Indicator Decision-Making

Indicator Criteria	Ideal Indicator Criteria	Strong Recommendation for Indicator	Low Recommendation for Indicator
Quality Data	<ul style="list-style-type: none"> Indicator data sources are reliable, compatible, and accurate. Data used in indicator development can be regularly assessed for quality assurance. Infrastructure is in place to ensure ongoing data quality assurance. Data used in indicator calculation lags by a maximum of 1 year. 	<ul style="list-style-type: none"> Data used in indicator calculation comes from a reliable source, can be made compatible with other HIV databases and is accurate. Also, data undergoes routine quality assurance. Indicator data has a lag time of less than one year, allowing for indicator interpretation which facilitates immediate program planning and change. 	<ul style="list-style-type: none"> Data is infrequently or never reviewed for quality assurance. It is unlikely that data will undergo a quality assurance process in the imminent future. Data for indicator has greater than a one year time lag and there is no foreseen opportunity for improved timeliness in data capture in the near future.
Validation	<ul style="list-style-type: none"> Indicator has been previously validated and published in a peer-reviewed journal. There is an established link between indicator and measured health improvement. Indicator calculation methods have been validated by one of the BC health organizations contributing data to the linked population-level database. 	<ul style="list-style-type: none"> The indicator has been validated as evidenced by one or more published scientifically sound methods. 	<ul style="list-style-type: none"> Indicator has not been validated or published validation methods lack scientific rigour.
Scientific Evidence	<ul style="list-style-type: none"> Scientific evidence supports the use of the indicator. This can be evidenced in several ways: <ul style="list-style-type: none"> The informative power of an indicator has been evidenced by both patient and/or public health outcomes as described in published, peer-reviewed journals. Precedence: Previous or ongoing use or recommendation of an indicator by the scientific HIV community or recognized HIV surveillance organizations 	<ul style="list-style-type: none"> There is clear scientific evidence in the value of the monitoring ability of the indicator and meets some or all of our indicator criteria. 	<ul style="list-style-type: none"> Little to no scientific evidence supports the value of the monitoring indicator. Available evidence is poorly described or lacks scientific rigour.

Indicator Criteria	Ideal Indicator Criteria	Strong Recommendation for Indicator	Low Recommendation for Indicator
	(e.g., WHO, UNAIDS).		
Informative	<ul style="list-style-type: none"> The indicator informs progress or lack thereof of meeting STOP HIV/AIDS program broad goals⁵³: <ol style="list-style-type: none"> 1. Reduce the number of new HIV infections in BC. 2. Improve the quality, effectiveness and reach of HIV prevention services. 3. Improve on early HIV diagnosis. 4. Improve quality and reach of HIV support services for those living with and vulnerable to HIV. 5. Reduce the burden of advanced HIV infection on the health system. The indicator directly informs whether or not BC STOP HIV/AIDS milestone achievements, set out by the MoH, are reaching achievement. <i>For example, by 2016, rates of HIV testing in each HSDA will be at or above 3,500 per 100,000 people, and each HSDA will have increased HIV testing by at least 50 percent.</i> Learned lessons of the indicator will improve STOP HIV/AIDS effectiveness. Learned lessons of the indicator are expected to meet the needs of monitoring report users to inform need for a change in practice. 	<ul style="list-style-type: none"> The indicator informs one or more of the broad goals of the STOP HIV/AIDS program effort. Indicator outputs are likely to provide outputs which inform where meaningful change is required to improve STOP HIV/AIDS program implementation. 	<ul style="list-style-type: none"> The indicator outputs are likely to provide little to no valuable information which will inform STOP HIV/AIDS implementation.
Feasibility	<ul style="list-style-type: none"> Indicator can be measured (i.e. all required data is accessible and available at a reasonable cost to allow for indicator measurement). Indicator can be defined (using available data) in such a way that the indicator provides meaningful outputs that lend towards easy public health interpretation and use of lessons learned. 	<ul style="list-style-type: none"> It is feasible to calculate the indicator using available data sources OR steps to acquire appropriate data are possible to calculate the indicator in the imminent future. 	<ul style="list-style-type: none"> We have limited to no ability to calculate the indicator (with available data sources) and there is no evidence that such a calculation will be feasible in the imminent future.

Indicator Criteria	Ideal Indicator Criteria	Strong Recommendation for Indicator	Low Recommendation for Indicator
	<ul style="list-style-type: none"> Indicator must be amenable to multiple stratifications (where necessary). 		
Confidentiality	<ul style="list-style-type: none"> The indicator does not compromise patient confidentiality. All possible steps are taken to mitigate the opportunity for compromising patient confidentiality. 	<ul style="list-style-type: none"> Indicator will not compromise patient confidentiality. 	<ul style="list-style-type: none"> Indicator may or will likely lead to breaches in patient confidentiality.
Accuracy	<ul style="list-style-type: none"> The indicator conveys technically accurate information using available data resources. Sufficient data is available that the indicator can be calculated with reasonable belief that the indicator output is as close to the true estimate as possible. The indicator can be stratified (when reasonable) to detect heterogeneity within the BC population. 	<ul style="list-style-type: none"> The indicator can be calculated to provide a close to truth estimate of the outcome. The indicator can be stratified. There is complete and representative monitoring data to calculate the indicator. If monitoring data is incomplete, estimated data used to calculate the indicator contributes no greater than 15% of indicator calculation data. 	<ul style="list-style-type: none"> Data quality for this indicator is moderate to poor and results in large estimations of the indicator. The indicator can be stratified for some or no variables of interest.
Administrative Requirement	<ul style="list-style-type: none"> The indicator was specifically requested by STOP HIV/AIDS program funders, the BC Ministry of Health. 	<ul style="list-style-type: none"> The indicator was specifically requested by the BC STOP HIV/AIDS program funders, the BC Ministry of Health. 	Not applicable.

Table 2
British Columbia Seek and Treat for Optimal Prevention (STOP) HIV/AIDS Quarterly Monitoring Report Indicators

Indicator	Reference	Definition	Calculation [‡]	Significance	Stratified by	Reporting time-frame of Indicator and Indicator Data lag
Number of HIV test episodes	5,39-41,54	The volume of HIV tests performed.	Total number of HIV tests grouped by test episodes. A test episode consists of all HIV tests conducted for an individual in a 30-day period.	HIV test episodes ordered is a direct reflection of STOP HIV/AIDS program initiatives related to HIV screening and may lead to increased case-finding, reduced number of individuals unaware of their HIV status, and reduced stigma.	Regional Health Authority (HA), Sex, Prenatal/non-prenatal testing, Age category, Point of care HIV tests, Health Service Delivery Area (HSDA)	Indicator is reported quarterly. Data used to calculate this indicator has no time lag.
Population HIV testing rates	5	Annual population rate of unique HIV test episodes ordered per 100,000 population per year.	Denominator: Population of BC/HA/HSDA. <ul style="list-style-type: none"> Numerator: Number of HIV test episodes ordered. Unit of analysis: rate of HIV test episodes ordered per 100,000 population per year. 	Rate of HIV test episodes ordered is a direct reflection of STOP HIV/AIDS program initiatives related to HIV screening and may equate to increased case-finding and reduced number of individuals unaware of their HIV status.	HA, Sex, Age category, HSDA	Indicator is reported annually. Data used to calculate this indicator has no time lag.
Number of new HIV diagnoses	5,37,38,40,54	Number of new HIV diagnoses.	Individuals identified with a new positive HIV test in BC are included in the calculation of the number of new HIV diagnoses. Individuals with a previous positive HIV test inside or outside BC are excluded.	The number of individuals identified with a new HIV diagnosis may be influenced by initiatives to expand HIV screening, resulting in increased case-finding and an increase in new diagnoses, which may be observed during initial implementation of screening initiatives. In addition, new HIV diagnosis may be influenced by decreases in HIV incidence as a result of expanded ART.	HA, Sex, Age category, Risk category, HSDA	Indicator is reported quarterly. Ethnicity and exposure category is elicited during public health follow up and there is an expected data reporting delay of 3–6 months.

Indicator	Reference	Definition	Calculation [‡]	Significance	Stratified by	Reporting time-frame of Indicator and Indicator Data lag
Stage of HIV infection at diagnosis	38,40,55	Indicates stage of infection at HIV diagnosis, utilizing data from laboratory acuity testing, prior HIV testing history, CD4 cell count information, and AIDS case reports.	<p>Staging classifications of infection at time of HIV diagnosis (based on US CDC HIV surveillance case definitions)</p> <p>Stage 0: Laboratory criteria met for acute HIV infection or previous negative or indeterminate HIV test within 180 days of first confirmed positive HIV test.</p> <p>Stage 1: Stage 0 not met, and no AIDS case report within 12 months of diagnosis, and CD4 cell count ≥ 500 cells/mm³</p> <p>Stage 2a: Stage 0 not met, and no AIDS case report within 12 months of diagnosis, and CD4 cell count 350–499 cells/mm³</p> <p>Stage 2b: Stage 0 not met, and no AIDS case report within 12 months of diagnosis, and CD4 cell count 200–349 cells/mm³</p> <p>Stage 3: Stage 0 not met, and (AIDS case report within 12 months of diagnosis, or CD4 cell count <200 cells/mm³)</p> <p>Stage unknown: Stage 0 not met, and no AIDS case report within 12 months of diagnosis, and no information available on CD4 cell count.</p>	Individuals diagnosed late are at increased risk of HIV-related morbidity and mortality and will, inevitably, initiate ART late ²¹ . Furthermore, a persistent undiagnosed HIV infection may contribute to ongoing HIV transmission.	HA, Sex, Age, Risk category.	Reported annually. This indicator relies on public health follow-up and submission of AIDS case report form, which affects the timeliness of the reporting. Thus, there is an expected reporting delay of up to 12 months.
HIV Cascade of Care	5,24,33,37,56	The HIV cascade of care (cascade) is a histogram of engagement along the HIV care continuum. We show 5 stages of the cascade: 1. Linked to HIV care (shown as a proportion of the diagnosed population); 2. Retained in HIV care (shown as a proportion of the linked population); 3. On ART (shown as a proportion of those retained in HIV care); 4. Adherent to ART (shown as a proportion of those on ART);	<p>Details on stage definitions can be read in Nosyk et al.³³. Data for cascade creation comes from a linked database consisting of: 1) BC-CfE database (CD4 cell count, pVL, ART use and adherence). 2) Administrative database (hospital admissions and physician visits) and 3) BCCDC database: HIV testing data. BC-CfE data has no data lag. Non-BCCfE data lags by 1 year and represents between 0–12% of individuals in each stage of the cascade. Thus, we calculate a quarterly cascade using BC-CfE data and estimate the proportion of patients we are missing using linked administrative data[‡]. How the data is estimated to acquire a current estimate of the cascade can be read in the STOP HIV/AIDS Monitoring Technical report.</p>	The success of TasP programs are reliant on linking the HIV-positive population with HIV care, initiating persons on ART and ensuring excellent adherence to ART so that viral load suppression can be achieved. The HIV cascade of care model highlights leakage points along the model.	HA, Sex, Age category, MSM status (yes/no/unknown), MSM status and Age category, IDU status (yes/no/unknown), HSDA.	Reported quarterly. Data used to calculate this indicator has no time lag.

Indicator	Reference	Definition	Calculation [‡]	Significance	Stratified by	Reporting time-frame of Indicator and Indicator Data lag
Programmatic compliance score:	5,8,40,57**	The PCS assesses the impact of non-compliance to HIV treatment guidelines on mortality and clinical outcomes.	<p>PCS: A score composed of adding the values for six performance indicators (yes=1, no=0):</p> <ol style="list-style-type: none"> 1 Having <3 CD4 cell count tests in the first year after starting ART. 2 Having <3 pVL tests in the 1st year after initiating ART. 3 Not having drug resistance testing done prior to starting ART; 4 Initiating a non-recommended ART regimen; 5 Initiating ART therapy with CD4<200 cells/μL; 6 Not achieving viral suppression within 9 months of ART initiation. <p>Scores are categorized as 0, 1, 2, 3 and 4 (where a PCS=0 is the best score and a PCS of 4 or more is the worst score). The six performance indicators are based on the appropriate International AIDS Society USA guideline recommendations for a given year. We show outputs for all six performance indicators as well as composite PCS scores.</p>	Compliance with HIV treatment guidelines relies on physician's following the guidelines but also a patient's cooperation with a treating physician's recommendations. The PCS is a composite measure of physician and patient-related indicators.	HA	Reported quarterly. Data used to calculate this indicator has no time lag.
New ART Starts	5,37,41	This indicator provides counts of the number of persons initiating ART.	<p>The number of new active ART participants is the sum of all persons on ART for at least one day in a given quarter, as indicated by recorded prescription length. This number is calculated for those who are "first starts" and "experienced starts".</p> <ul style="list-style-type: none"> • <i>First starts:</i> first ART prescription in BC among ART naïve • <i>Experienced starts:</i> Persons who either: i) were previously on treatment, but not in the previous quarter, or ii) prescribed their first regimen ever in the BC-CIE HIV/AIDS Drug Treatment Program (DTP) but was not ART naïve. 	TasP is reliant on use of ART. This indicator measures the number of new ART starts.	HA, First ART starts and Experienced ART starts	Reported quarterly. Data used to calculate this indicator has no time lag.

Indicator	Reference	Definition	Calculation [‡]	Significance	Stratified by	Reporting time-frame of Indicator and Indicator Data lag
CD4 cell count at ART initiation for ART Naïve Individuals	15	CD4 cell count at ART initiation.	Data is presented as: i) The absolute median CD4 cell count at ART initiation and ii) The proportion of ART naïve individuals initiating ART with CD4 cell counts of: <49 cells/mm ³ , 50–199 cells/mm ³ , 200–349 cells/mm ³ , 350–499 cells/mm ³ or >500 cells/mm ³ .	TasP success relies on early ART initiation. This indicator measures the proportion of ART naïve individuals initiating timely ART.	HA	Reported quarterly. Data used to calculate this indicator has no time lag.
Active and Inactive Individuals who have ever been on ART	37,41	The number of individuals actively filling ART prescriptions.	The number of persons enrolled in the DTP stratified by being active or inactive: <i>Active DTP participant</i> : had ART dispensed at least once in a given quarter. <i>Inactive DTP participant</i> : No ART dispensed in a given quarter; however, were previously on treatment.	Treatment interruptions reduce the potential benefits of ART.	Distribution of persons on ART by HA, Sex, Age, IDU and MSM.	Reported quarterly. Data used to calculate this indicator has no time lag.
ART Adherence	5,49,50,57	Distribution of individuals by adherence level, based on pharmacy refill compliance.	Adherence to ART measured at 12 months from antiretroviral initiation. Adherence is estimated by dividing the number of days on ART by the number of days in a 12 month period. Prescription refill adherence is categorized as one of four levels <40%, 40% to <80%, 80% to <95% and 95%.	Imperfect ART adherence compromises ART benefits and allows for ART resistant mutation development.	HA	Reported quarterly. Data used to calculate this indicator has no time lag.
Resistance Testing	5,57	This indicator shows cumulative resistance testing results over time.	<ul style="list-style-type: none"> Annual denominator: number of patients who had at least 1 pVL in a given quarter. BC-CHE DTP participants are categorized as either suppressed, wild type, never genotyped, or resistances to 1, 2 or 3 HIV treatment classes. Drug resistance status is categorized by drug class from all available genotype data. <ul style="list-style-type: none"> In cases of multiple genotypes per patient per quarter, the genotype with the greatest resistance (worst case, most classes) is used. Patients remain in a resistance category until their next test. In order to fall into the "suppressed" category, all of a patient's pVL measurements collected in that quarter must fall below the lower assay cutoff (<50 copies/mL). 	Resistance testing prior to ART initiation is recommended in the BC HIV ART primary care guidelines. Monitoring trends in the types and frequency of ART resistance over time inform effects of ART expansion.	HA	Reported quarterly. Data used to calculate this indicator has no time lag.
AIDS Case Rate and Reports	5	AIDS case reports are	AIDS case reporting is passive in BC. As such, AIDS cases are investigated using three definitions: 1. The	Improvements in ART and the expansion of	HA	Reported annually.

Indicator	Reference	Definition	Calculation [‡]	Significance	Stratified by	Reporting time-frame of Indicator and Indicator Data lag
		shown as an absolute number of AIDS cases per 100,000 through AIDS case report shown as an absolute number of AIDS cases per 100,000 of AIDS cases shown as an absolute number of AIDS cases per 100,000 of AIDS cases shown as an absolute number of AIDS cases per 100,000 of AIDS cases		ART province-wide should result in very low numbers of recorded AIDS cases across BC.		AIDS case reporting from the BC-CFE has no lag time. However, AIDS case reporting from the BCCDC lags by one year.
HIV-Related Mortality	5	Number and rate (per 100 000) of HIV-related mortality.	<p>i. Calculation for the HIV-related death rate in the general population (rate per 100,000 persons):</p> <p>Numerator: number of HIV-related deaths. Denominator: General population (BC or HA). We then multiply by 100 000 to obtain the HIV-related mortality rate in the general population for 100 000 persons.</p> <p>ii. Calculation for the HIV-related death rate in the HIV-positive population (rate per 100 persons):</p> <p>Numerator: Number of HIV-related deaths. Denominator: HIV-positive population (for BC or HA) and multiplied by 100 to obtain the HIV-related mortality rate in the HIV-positive population for 100 persons. HIV-related mortality data is obtained online from the BC Vital Statistics Annual Report. Vital statistics classify deaths due to HIV disease as ICD-10 codes B20–B24.</p>	Evidence indicates that individuals who initiate HIV treatment with recommended ART in a timely fashion may live near normal lifespans ³ . Excess mortality among HIV-positive persons is, therefore, an important measure of HIV care with a goal of minimizing HIV-related mortality in BC.	HA	Reported annually. HIV-related mortality is made available through the BC Vital Statistics Annual Report. Data lags by 1–2 years.

[‡] See the BC-CFE STOP HIV/AIDS Monitoring Technical report for further details <http://cfenet.ubc.ca/publications/centre-documents/stop-hiv-aids-monitoring-reports>.

Age category= <30, 30–39, 40–49 and 50 years; Men who have sex with men (MSM); History of injection drug use (IDU); Risk category: MSM, IDU, Heterosexual, no identified risk/other); HA=regional health authority (there are five HAs in BC); HSDA=Health Service Delivery Area (these are sub-regions of HAs; there are 16 HSDAs in BC.); ART=antiretroviral therapy; pVL= plasma viral load; BC-CFE= British Columbia Centre for Excellence in HIV/AIDS; BCCDC=British Columbia Centre for Disease Control; DTP=Drug Treatment Program (program run through the BC-CFE which is responsible for the distribution of all ARVs in the province of BC).

^{**} References which support PCS include components of PCS such as initiating ART therapy with CD4<200 cells/μL.