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ASSESSING THE RELATIONSHIP BETWEEN PHYSICIAN AVAILABILITY AND VIRAL LOAD SUPPRESSION IN BRITISH COLUMBIA

Ofer Amram,

Spokane Health Education and Research Building Third Floor, P O Box 1495 , Spokane, WA 99210-1495. Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS. Department of Nutrition and Exercise Physiology, Elson S. Floyd College of Medicine, Washington State University

Lu Wang,

Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS

Paul Sereda,

Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS

Jean A. Shoveller,

Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS. Division of AIDS, Department of Medicine, Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada

Rolando Barrios,

Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS. Division of AIDS, Department of Medicine, Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada

Julio S.G. Montaner, and

British Columbia Centre for Excellence in HIV/AIDS. Division of AIDS, Department of Medicine, Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada

Viviane D. Lima

Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS. Division of AIDS, Department of Medicine, Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada

Abstract

Objectives—In 2014, the Joint United Nations Programme HIV/AIDS (UNAIDS) set the target of dramatically reducing the burden of HIV through expansion of access to timely HIV treatment. In order to achieve this target it is necessary to expand access to care along the HIV cascade of

care. This study examines the relationship between viral suppression and the availability of physicians providing HIV treatment in British Columbia, Canada.

Methods—Data from the Drug Treatment Program of the British Columbia (BC) Centre for Excellence in HIV/AIDS was used for this analysis. The floating catchment method was used to assess physician availability. Multivariable Logistic Regression was used to implement a confounder selection technique to independently assess the relationship between physician availability and viral load suppression.

Results—Individuals with more than 25 physicians within a one-hour catchment were more likely to reside in urban areas and almost twice as likely to have a suppressed viral load (adjusted odd ratio: 1.97; 95% CI 1.50 – 2.58).

Conclusions—This study highlights the impact of physicians' availability on viral load levels. Mapping technology was used to identify the locations in which patients were most impacted by the lack of physicians.

Keywords

Physician Availability; Antiretroviral Therapy; Viral Load Suppression; GIS

INTRODUCTION

In 2014, the Joint United Nations Programme HIV/AIDS (UNAIDS) set the target of dramatically reducing the burden of HIV around the world through expansion of access to timely HIV diagnosis and antiretroviral therapy (ART), and the reduction of the number of individuals virologically suppressed (HIV/AIDS and HIV/Aids 2014). Specifically, the target calls for a 90% diagnosis coverage for those who are infected with HIV, for 90% of those diagnosed to undergo ART treatment, and for 90% of those on ART to experience sustained viral suppression. If this ambitious target is reached, it is expected that the AIDS epidemic will be eliminated by 2030. In order to achieve this goal, an effort to expand access to care along the HIV cascade of care, especially in terms of diagnosis and treatment, is needed (HIV/AIDS and HIV/Aids 2014). However, as the availability of HIV treatment varies greatly between countries, achievement of this goal will require each country to focus its effort on the population with the poorest access to care. For example, geographically large countries with substantial rural population counts will need to prioritize access to HIV treatment in rural areas.

Adequate access to health care services is an important factor in determining health and well-being. It is also one of the cornerstones of the publicly funded Canadian health care system (Bulger 2009). Access may be impacted by a variety of different factors, including demographic, psychosocial, clinical and geographical factors (Ricketts 2010). Generally, access to care depends both on the ability of the health care system to deliver care and on the individual and social conditions, characteristics and behaviours that enable access to care (Aday and Andersen 1974; Andersen 1995). As a result, measuring access to care is a somewhat complex process.

There are several different methods of measuring access to care. One of these involves the separation of spatial and non-spatial factors (Aday and Andersen 1974). Geographical/spatial factors play a critical role in determining access. In fact, studies of many different illnesses, including HIV, have demonstrated a direct relationship between spatial access to health services and health outcomes (Hogg et al. 1998; Dheda et al. 2004). The differences in HIV treatment outcomes and service utilization between rural and urban settings are also well known (Cook et al. 2002). However, the impact of physicians' availability on HIV treatment outcomes is understudied and an in-depth analysis of those differences has yet to be conducted.

This manuscript focuses on the province of British Columbia (BC), Canada's most Western province. Although BC occupies an extensive amount of land (close to 950 000 square km), the bulk of its population (60%) resides in the South, along the United States border, within the city of Vancouver and in its satellite municipalities (an area known as Greater Vancouver) (Schuurman, Crooks, and Amram 2010; Grzybowski, Kornelsen, and Schuurman 2009; Brubacher et al. 2016). The city of Vancouver hosts the province's largest population of individuals living with HIV, most of whom reside within the downtown area (Maas et al. 2007). The remainder of the province's population is scattered amongst a number of small and/or medium-sized rural communities located throughout the region, on Vancouver Island and on smaller islands along the Pacific Coast. These communities are connected by a network of roads that run through a series of mountain ranges including the Canadian Rockies, and the Coast and Cassiar mountains. The remoteness and inaccessibility of many of these communities is a principal challenge in effectively delivering care, particularly during the winter season.

In Canada, those who reside in rural areas have a shorter life expectancy and are more likely to suffer from chronic diseases (Sutherns, McPhedran, and Haworth-Brockman 2004; Mitura and Bollman 2003; DesMeules et al. 2006). Shortage of health care services and longer travel time are major contributors to health disparities between urban and rural populations (Ng et al. 1997). For those living with HIV, access can play an even greater role in disparity of outcome when treatment is provided by a specialist (Veinot and Harris 2011).

The objective of this study was to examine the relationship between viral suppression and availability of physicians providing HIV treatment in BC, between 2003 and 2013, in order to identify areas in which poor physician availability may have negatively affected achievement of viral suppression.

METHODS

Data

Data used for this analysis originated from the Drug Treatment Program (DTP) of the BC Centre for Excellence in HIV/AIDS. The DTP is a population-based data registry which monitors and follows individuals, approximately every 3 months, with the aim of tracking their treatment's progress. In the process, the individual's place of residence and their prescribing physician's location are constantly updated. HIV treating physicians are defined as those that administer ART. The study inclusion criteria involved only individuals who

received ART for the first time in BC (i.e. ART naïve) and who were 19 years of age at the time of enrollment.

The University of British Columbia Ethics Review Committee at the St. Paul Hospital site provided ethics approval for this present study (H05-50123). The study complies with the BC's Freedom of Information and Protection of Privacy Act. The study was conducted primarily using anonymized data, and therefore informed consent was not required.

Assessing access – Floating Catchment method—The calculation of the health care providers to population ratio is a traditional method of identifying gaps in access to care. This method is quite simplistic, and uses existing data (e.g. boundary of health authority or municipality) to measure the ratio of service providers to patients within a clearly defined area. In contrast, this study utilized spatial methodology, also known as the Floating Catchment method, in order to more accurately identify underserved areas (Hayes and Amram 2012). In this study we used a modified version of this method as we only used the number of physicians around an individual's place of residence (the catchment), as opposed to overall number of physicians (supply) and population count (demand) within the catchment. This analysis was made possible as a result of advances in spatial-epidemiology and Geographic Information Systems, which enable the incorporation of spatial measures of access into analyses of HIV treatment outcomes.

Outcome and exposure variables—The primary outcome variable used in this analysis was whether an individual achieved viral suppression defined by having two consecutive viral loads <200 copies/mL within 12 months after initiating treatment (yes/no). The number of physicians within an estimated one hour travel time catchment from the individual's place of residence was the main exposure variable. A threshold of one hour was used because it captured a sufficient number of physicians within each individual catchment to run the analysis, and since similar catchments sizes were previously used to assess spatial access to primary care (Hayes and Amram 2012; Maas et al. 2007; Brennan-Ing et al. 2014; Rodriguez-Penney et al. 2013). Several studies have used different catchments to assess spatial access to primary care and catchment sizes that were usually used ranged from 30 to 120 minutes (Maas et al. 2007). However, most of those studies were conducted in much smaller areas. The one study that assessed spatial access to primary care within Canada used a catchment of 120 minutes. This was done specifically because of the disparities in physician availability between rural and urban areas (Schuurman, Berube, and Crooks 2010). A one hour catchment is used within this study in order to account for geographical heterogeneity in population size and density between rural and urban areas while also taking into consideration the minimum number of physicians required by the statistical modelling. The one hour travel time catchments were created using the ArcGIS Network Analyst tool (ESRI 2012). Taking into account both speed limits and turn-by-turn calculations, the Network Analyst tool allows for relatively accurate estimations of travel time (Schuurman, Crooks, and Amram 2010; ESRI 2013). A more detailed explanation of this methodology can be found in previous publications (Hameed et al. 2010; Schuurman, Crooks, and Amram 2010). The DMTI Spatial™ Route Logistics road network data set was used for the travel time catchments' calculation (DMTI 2011). DMTI Spatial™ Route Logistics is suitable for

use with Network Analyst and is widely used by researchers in Canada for this purpose (Schuurman et al. 2015; Deering et al. 2014).

Potential Confounder variables—To ensure accurate assessment of physician availability, only those individuals who provided accurate locational information, i.e., postal code or full address, for both place of residence and physician's location, were used in the analysis. Potential baseline confounding variables included: age (years), gender (male/female), CD4 count (Cells/ μ L), viral load (Log_{10} copies/mL), history of injection drug use (IDU) (no/yes/unknown), having had an AIDS diagnosis prior to starting ART (yes/no) and adherence to treatment. Adherence was defined as the number of days of antiretroviral drugs dispensed divided by the number of days of follow-up (expressed as a percentage) and categorized at 0 – <40 %, 40 – <80 %, 80 – <95 %, 95%. To control for geographic variation within the model, a categorical variable was created to identify rural and urban areas using the definition provided by Statistics Canada (StatsCan 2011), which characterizes differences between urban and rural areas based on the size of population centres and population density. Using this characterization, the study's final categorical variable had four levels: three for urban areas classified as small, medium, and large population centres, and one for rural areas. A more detailed description for this classification can be found on the Statistics Canada website (StatsCan 2011).

Analysis

Exploratory analyses were done to examine the composition of the study's population, depending on whether an individual experienced viral suppression or not. The Wilcoxon Rank Sum test was used for comparing continuous variables and Fisher's exact test was utilized for categorical variables. The Cochran-Mantel-Haenszel test was used for comparisons involving adherence level. All statistical analyses were conducted in SAS 9.4 (© SAS Institute Inc., SAS) (SAS inc 2015). Multivariable logistic regression was used to implement a confounder selection technique that had been previously published by our group, based on the work by Maldonado and Greenland (Maldonado and Greenland 1993; Lima et al. 2007).

Mapping

To identify locations which may be most impacted by the lack of physician availability, the one hour catchments used to calculate the number of physicians around an individual's place of residence were also used for mapping. Each catchment area was then mapped to create areas of poor, intermediate, and good availability of physician. The threshold that constitutes a good number of physicians was based on the distribution of the number of physicians in all the catchments. Finally, the largest population centers (based on Statistics Canada definition) within the areas of poor physician availability were identified, and a one hour catchment was then created around them in order to assess how many individuals would benefit the most from increased services.

RESULTS

The original data set initially included 3,876 individuals. Out of those, 907 (23%) had to be removed because they either lacked accurate information concerning their place of residence, or their physician's location, or their viral load information was unavailable. As a result, only 2,969 (77%) subjects were eventually considered in this study (Table 1). Those excluded from the analysis were more likely to be non-adherent to treatment, be female, to have no history of IDU, to be younger, and to have lower CD4 cell count (all p-values <0.001).

The distribution of the number of physicians indicated that approximately 75% of the individuals in the study had at least 156 physicians within a one hour catchment (Fig. 1). As Figure 1 shows, there is a clear natural break in the distribution of the number of physicians within each one hour catchment. Based on this, a cutoff point of >25 physicians within the one hour catchment (which corresponds to the 25th percentile) was considered to represent high physician availability, while ≤25 was considered to represent low availability.

The relationship between physician availability (the exposure variable) and the model's variables showed that those with >25 physicians within their travel time catchment adhered to treatment more frequently (90% vs. 84%, p-value = 0.0001) and had a higher CD4 cell count (400 vs. 300 Cells/μL, p-value = 0.0001) when compared to those with lower physician availability. A higher percentage of females than males resided in areas with lower physician availability (22% vs. 9%, p-value = 0.0001), and those who had a history of IDU also resided in areas of low physician availability in comparison to individuals without such history (91% vs. 80%, p-value = 0.0001). Differences in age, viral load, and AIDS prior to ART initiation were also significant.

Table 2 shows the comparison between the exposure variable, each of the potential confounders and our definition of viral load suppression. Individuals with >25 physicians within one hour had a substantially higher chance of suppressing their viral loads compared to those with lower physician availability (73% vs. 50%, p-value = <0.0001). Being a male was associated with a higher likelihood of having a suppressed viral load (75% vs. 48%, p-value = <0.0001) as so those with higher level of adherence ([≥95% = 82%] vs. [80 – <95% = 67%] vs. [40 – <80% = 31%] vs. [0 – <40% = 11%], p-value = <0.0001). Individuals who had a history of IDU were less likely to reach suppression levels (50% vs. 79%, p-value = <0.0001), as did those who had AIDS prior to ART initiation (65% vs. 71%, p-value = <0.0001). Those who resided in large population centers were also more likely to be virally suppressed compared to individuals who resided in medium and smaller population centers or in rural areas ([Urban – Large = 73%] vs. [Urban – Medium = 57%] vs. [Urban – Small = 49%] vs. [Rural = 62%], respectively, p-value = <0.0001).

The results for the multivariable logistic regression model indicated that, after accounting for gender, history of IDU, CD4 cell count, adherence to treatment, and rural/urban differences, individuals who had >25 physicians within a one hour catchment had a significantly higher chance of achieving viral suppression in comparison to those outside one hour catchment (adjusted odds ratio 1.97; 95% Confidence Interval 1.50 – 2.58).

Creating a one-hour catchment for each individual across BC, and assessing whether they had >25 physicians within the catchment, resulted in a map showing areas with three levels of physician availability (Fig. 2). The first consists of locations where all individuals have good physician availability (depicted as dark blue catchments on the map), the second one relates to areas of intermediate physician availability where there is a mixture of individuals with good and poor physician availability (depicted as medium blue catchments on the map), and the third one represents only those who have poor physician availability (depicted as light blue catchments). The map shows that areas with the highest levels of physician availability were located within Vancouver and neighboring regions, while areas of mixed availability were typically located in mid-size towns in rural. The figure also highlights the three largest population centers located within areas of poor physician availability, and an accurate count of individuals residing within a one hour travel time of each one of these population centers (yellow catchments on the map).

DISCUSSION

The primary findings of this study highlighted the impact of physician availability on suppression levels resulting from HIV treatment. The results showed that individuals who resided in areas where there were substantially less physicians available to provide HIV treatment had a higher chance of not achieving viral suppression. It also demonstrated how the utilization of accurate granular level data, which includes clinical outcomes and individual and physician locations, can play an important role in identifying specific geographical areas which would greatly benefit from improved physician availability. In addition, the use of spatial analysis techniques allowed for estimation of the number of individuals who might potentially benefit from increased physician levels in those regions.

Several other studies have highlighted the relationship between spatial accessibility and treatment outcomes for HIV patients (Lankowski et al. 2014; Siedner et al. 2013; INGLE et al. 2010). For example, *Taiwo et al.* examined this relationship in Nigeria and found that those residing within 20 km of a physician were significantly more likely to have undetected viral loads at weeks 24 and 48 of treatment, when compared to those outside that distance (Taiwo et al. 2010). Similarly, a study in Philadelphia assessed the relationship between distance to HIV clinic and viral suppression, and found that those residing outside the average distance to the clinic providing HIV treatment were less likely to achieve the desired levels of viral load (Eberhart et al. 2013). Increased distance to HIV treatment was also found to be associated with increased likelihood of mortality and decreased likelihood of engagement in treatment (INGLE et al. 2010). In a study conducted in South Africa, the authors showed that the measurements of both of these outcomes (i.e. higher mortality and lower level of adherence) were significant for individuals who resided more than 8 km away from a treatment facility (INGLE et al. 2010).

Our study was unique in that it not only examined the relationship between physician availability and viral load levels, but also highlighted areas of insufficient service while quantifying the number of individuals impacted by suboptimal levels of physician availability. This study focused on local issues, but is based on methodologies that, once streamlined, could potentially allow researchers to maximize data collection and analysis

procedures in a wide variety of settings. The utilization of spatial methods, like those used in this study, could play an important role in decision-making by enabling local decision makers to pinpoint those areas where increased treatment availability would be most beneficial. It is also important to note that since financial barriers were not a confounding factor, as ART treatment is provided to all individuals free of charge without co-payments and deductibles, the results of this study further highlights the important role geographical remoteness can have access to HIV treatment. Furthermore, as health service availability is a system level barrier (also known as structural barrier) that impedes access to care, it also needs to be addressed by the health care system (Nosyk et al. 2014). Therefore, training additional physicians in rural areas and/or increasing the availability of physicians in the areas specified within this study could increase suppression levels for these populations (Duff et al. 2010; CATIE 2016).

Physician availability, however, is only one dimension of access to care, and this manuscript was solely focused on those populations who have difficulty accessing care as a result of suboptimal spatial allocation of physicians. Access to care is complex to measure. Socio economic status (SES) also plays a key role in accessing ART treatment (Wood et al. 2008; HIV/AIDS and HIV/Aids 2014). It has been shown that the populations least likely to access ART treatment are those composed of individuals who are struggling with addiction, are involved in sex work, or who have psychiatric health issues (Shannon et al. 2005; Krüsi et al. 2010). As a result, these populations are less likely to adhere to treatment and to reach viral suppression (Wood et al. 2008; Wood et al. 2005). In addition, the results of the final model indicated that variables like history of IDU and rural/urban place of residence were confounders in the final multivariable model. This indicates the existence of another important factor that may impact viral suppression within rural areas but was not captured by our model. We believe that this factor may relate to SES as people living in rural British Columbia, and particularly those with a history of IDU, tend to have lower SES than do those in urban areas. Low SES is known to be associated with poor health care outcomes. As matter of fact, a lower SES has been shown to increase the likelihood of not accessing primary care because of distance (Schuurman 2009).

This study has some limitations that should not be ignored. First, when calculating distance to the ART prescribing physician, the study used only the location of the first ART prescribing physician. The second limitation stems from the fact that the estimated travel time calculations did not take into account traffic information. This can further hinder access to care. Gathering this kind of information, however, would have been arduous, especially retrospectively. Also, the fact that we had to drop many individuals from the study because of imprecise location data may cause our results to be somewhat inaccurate. However, as the primary objective of the study was to assess access to physicians using highly accurate location data we had no choice but to drop these individuals from the analysis. Lastly, it should be noted that access to care has several intertwined dimensions, of which spatial access is only one. For example, cultural factors like language, stigma and attitude towards certain diseases (like HIV), as well as the presence of comorbidities like cardio vascular disease, diabetes and hypertension (all of which are prevalent with HIV patients) can all impact an individual's access to care. In addition, travel costs to physician are also not

accounted for in this study. As these variables were not available to us, we were not able to account for them within our analysis.

CONCLUSION

This study highlights the relationship between physician availability and viral suppression within BC. People living with HIV in rural areas of BC are less likely to be virally suppressed and have poorer access to treating physicians. Mapping techniques were used to indicate both where lack of physician availability is most acute and where increased availability would have the greatest impact on those currently undertaking ART treatment in BC. Increased physician availability, as a result of additional training, or an increase in the number of HIV treating physicians within the identified locations, could play a key role in helping BC achieve the 90/90/90 goal, set by UNAIDS, by the year 2020.

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Key Messages

- Individuals residing in areas where there were substantially fewer physicians available to provide HIV treatment had a higher chance of not achieving viral suppression.
- Individuals residing in rural areas have poorer health outcomes when compared to those residing in urban areas
- Discrepancies in HIV treatment outcomes exist despite the fact that HIV treatment costs are borne directly by government

Fig. 1.

Distribution of the number of physicians (y-axis) within a one-hour catchment of those participating in the study.

Notes: Q1: 25th percentile.

Fig. 2.

Different areas of physician availability across BC (poor, intermediate, good) as a result of overlapping individual catchments. Blue lines represent roads in catchments classified according to physician availability within one hour's travel time: light blue lines indicate poor availability (participants have 25 physicians); medium blue lines indicate intermediate availability (some participants have 25 physicians and some have >25); and dark blue lines indicate good availability (participants have >25 physicians). One-hour catchments around population centres located in areas of poor physician availability are depicted in yellow; call-out boxes reflect number of individuals residing in each yellow catchment.

Table 1

Comparison of included and excluded groups of individuals, their main outcomes, and potential confounder variables.

Variables	Group of Individuals		
	Included (N=2969; 71%)	Excluded (N=907; 29%)	P-value
Adherence level, n(%)			
0 – <40 %	170 (66.93%)	84 (33.07%)	<0.0001
40 – <80 %	330 (69.77%)	143 (30.23%)	
80 – <95 %	375 (71.7%)	148 (28.3%)	
95%	2094 (79.74%)	532 (20.26%)	
Gender, n(%)			
Female	542 (69%)	241 (31%)	<0.0001
Male	2427 (78%)	666 (22%)	
Individuals with history of IDU, n(%)			
No	1419 (82%)	307 (18%)	<0.0001
Yes	883 (65%)	477 (35%)	
Unknown	667 (84%)	123 (16%)	
Having an AIDS diagnosis prior to ART initiation, n(%)			
No	2577 (77%)	776 (23%)	0.3453
Yes	392 (75%)	131 (25%)	
Age at ART initiation			
Median	42	41	<0.0001
Q1-Q3	(35–49)	(34–48)	
CD4 cell count (Cells/μL)			
Median	380	300	<0.0001
Q1-Q3	(210–560)	(40 – 500)	

Notes: IDU: history of injection drug use; Q1: 25th percentile; Q3: 75th percentile.

Table 2

Comparison of the potential confounders and main exposure variable in relation to viral suppression.

Variables	Viral Suppression		
	Yes(N=2087)	No(N=882)	P-value
Number of physicians within one hour catchment, n (%)			
25	172 (50%)	172 (50%)	<0.0001
> 25	1915 (73%)	710 (27%)	
Gender, n(%)			
Female	259 (48%)	283 (52%)	<0.0001
Male	1828 (75%)	599 (25%)	
Adherence to treatment, n(%)			
0 – <40 %	19 (11%)	151 (89%)	<0.0001
40 – <80 %	103 (31%)	227 (69%)	
80 – <95 %	253 (67%)	122 (33%)	
95%	1712 (82%)	382 (18%)	
Individuals with a history of IDU, n(%)			
No	1117 (79%)	302 (21%)	<0.0001
Yes	441 (50%)	442 (50%)	
Unknown	529 (80%)	138 (20%)	
Population centers , n(%)			
Urban – Large	1826 (73%)	677 (27%)	<0.0001
Urban – Medium	115 (57%)	86 (43%)	
Urban – small	66 (49%)	70 (51%)	
Rural	80 (62%)	49 (38%)	
Having an AIDS diagnosis prior to ART initiation, n(%)			
No	1831 (71%)	746 (29%)	0.0240
Yes	256 (65%)	136 (35%)	
Age at ART initiation			
Median	43	41	<0.0001
Q1-Q3	(36 – 50)	(34–47)	
CD4 Cell Count (Cells/ μ L)			
Median	420	250	<.00001
Q1-Q3	(280–590)	(0 – 460)	
Viral Load (Log ₁₀ Copies/mL)			
Median	4.85	4.78	0.0058
Q1-Q3	(4.32 – 5.00)	(4.20 – 5.00)	

Note: IDU: history of injection drug use; Q1: 25th percentile; Q3: 75th percentile;