Comparison of late HIV diagnosis as a marker of care for Aboriginal versus non-Aboriginal people living with HIV in Ontario

Denise Jaworsky MD¹, LaVerne Monette LLB^{2*}, Janet Raboud PhD^{3,4}, Doe O'Brien-Teengs HBA MA^{2,5}, Christina Diong MSc³, Sandra Blitz MSc³, Sean B Rourke PhD^{6,7,8}, Mona R Loutfy MD MPH^{1,9}; and the OHTN Cohort Study Team

D Jaworsky, LV Monette, J Raboud, et al; and the OHTN Cohort Study Team. Comparison of late HIV diagnosis as a marker of care for Aboriginal versus non-Aboriginal people living with HIV in Ontario. *Can J Infect Dis Med Microbiol* 2012;23(4):e96-e102.

BACKGROUND: Studies have found that Aboriginal people living with HIV/AIDS (APHAs) are more likely than non-APHAs to receive suboptimal HIV care, yet achieve similar clinical outcomes with proper care.

OBJECTIVE: To compare the proportions of individuals diagnosed late with HIV between APHAs and non-APHAs within the Ontario HIV Treatment Network Cohort Study (OCS).

METHODS: The analysis included OCS participants who completed the baseline visit by November 2009. Two definitions of the outcome of late HIV diagnosis were used: the proportion of participants with an AIDS-defining illness (ADI) before or within three months of HIV diagnosis; and the proportion of participants with a CD4⁺ count <200 cells/mL at diagnosis. Logistic regression analysis was used to assess the association between Aboriginal ethnicity and late HIV diagnosis.

RESULTS: APHAs were more likely to be female and have lower income, education and employment. No statistically significant differences were noted in the proportions receiving a late HIV diagnosis defined by ADI (Aboriginal 5.2% versus non-Aboriginal 6.3%; $P=0.40$). Multivariate logistic regression analysis revealed a significant association between Aboriginal ethnicity and late HIV diagnosis defined by CD4⁺ count after adjusting for age and HIV risk factor (OR 1.55; $P=0.04$).

DISCUSSION: APHAs were more likely to have a CD4⁺ count <200 cells/mL at diagnosis but had similar clinical outcomes from late diagnosis when defined by ADI. However, differences may be underestimated due to recruitment limitations and selection bias.

CONCLUSION: Additional work is needed to address the socioeconomic and health care needs of APHAs.

Key Words: *Aboriginal peoples; Access to care; Cohort study; HIV; HIV diagnosis; Quality of care*

Despite increases in HIV research and advances in care and support programs in Canada, the Aboriginal population remains both over-represented in the Canadian HIV epidemic and under-represented in research. In 2006, 27.3% of positive HIV test reports were attributable to Aboriginal peoples in Canadian provinces and territories that reported ethnicity data for HIV testing. In these provinces and territories, Aboriginal peoples represent 6.0% of the total population; therefore, Aboriginal people are over-represented by approximately 4.6 times in the HIV epidemic in Canada (1).

*Deceased

¹Faculty of Medicine, University of Toronto; ²Ontario Aboriginal HIV/AIDS Strategy; ³University Health Network; ⁴Dalla Lana School of Public Health, University of Toronto, Toronto; ⁵Mushkego Cree, Weenusk First Nation, Ontario; ⁶Ontario HIV Treatment Network; ⁷Department of Psychiatry, University of Toronto; ⁸Keenan Research Centre in the Li Ka Shing Knowledge Institute, St Michael's Hospital; ⁹Women and HIV Research Program, Women's College Research Institute, Toronto, Ontario

Correspondence: Dr Mona Loutfy, Women and HIV Research Program, Women's College Research Institute, 790 Bay Street, 7th Floor, Suite 743, Toronto, Ontario M5G 1N8. Telephone 416-465-0856 ext 2444, fax 416-351-3746, e-mail mona.loutfy@wchospital.ca

La comparaison d'un diagnostic tardif de VIH comme marqueur des soins des Autochtones par rapport aux non-Autochtones qui vivent avec le VIH en Ontario

HISTORIQUE : Les études ont démontré que les Autochtones qui vivent avec le VIH ou le sida (AVVS) sont plus susceptibles que les non-Autochtones qui vivent avec le VIH ou le sida (NAVVS) de recevoir des soins sous-optimaux, mais présentent des issues cliniques similaires lorsqu'ils reçoivent des soins convenables.

OBJECTIF : Comparer la proportion d'AVVS et de non-AVVS de la cohorte OCS du réseau thérapeutique du VIH qui reçoivent un diagnostic tardif de VIH de l'Ontario.

MÉTHODOLOGIE : L'analyse incluait les participants de l'OCS qui avaient eu leur première visite avant novembre 2009. Deux définitions de l'issue de diagnostic tardif du VIH ont été utilisées : la proportion de participants ayant une maladie symptomatique du sida (MSS) avant ou dans les trois mois suivant le diagnostic du VIH, et la proportion de participants ayant une numération de CD4⁺ inférieure à 200 cellules/mL au diagnostic. Les chercheurs ont utilisé l'analyse de régression logistique pour évaluer l'association entre l'ethnie autochtone et le diagnostic tardif de VIH.

RÉSULTATS : Les AVVS étaient plus susceptibles d'être des femmes et d'avoir un revenu et une scolarisation plus faibles ainsi qu'un emploi moins bien rémunéré. Les chercheurs n'ont perçu aucune différence statistiquement significative dans la proportion qui avait reçu un diagnostic tardif de VIH défini par une MSS (Autochtones 5,2 %, non-Autochtones 6,3 %; $P=0,40$). L'analyse de régression logistique multivariée a révélé une association significative entre l'ethnie autochtone et un diagnostic tardif de VIH défini par la numération de CD4⁺ après rajustement compte tenu de l'âge et du facteur de risque de VIH (RRR=1,55; $P=0,04$).

EXPOSÉ : Les AVVS étaient plus susceptibles de présenter une numération de CD4⁺ inférieure à 200 cellules/mL au diagnostic, mais avaient des issues cliniques similaires de diagnostic tardif lorsqu'on le définissait par une MSS. Cependant, les différences sont peut-être sous-estimées en raison des limites de recrutement et du biais de sélection.

CONCLUSION : D'autres travaux s'imposent pour connaître les besoins socioéconomiques et en soins de santé des AVVS.

Studies have found that certain subpopulations of Aboriginal peoples have more HIV risk factors (2) and a higher incidence of seroconversion given these risk factors (3). In 2005, the proportion of new HIV diagnoses among Aboriginal peoples attributable to injection drug use (IDU) was 53%, while the proportion among all Canadians was 14% (1), suggesting that Aboriginal peoples have a different set of risk factors and that HIV-positive Aboriginal peoples represent a marginalized population with limited access to care and support services in Canada.

Limited access to primary health care services among Aboriginal populations in Ontario has been reported based on higher hospital admission rates for conditions that could effectively be managed in an ambulatory care setting when compared with the general population (4). For example, in Ontario, individuals from Aboriginal communities, rural communities and remote communities have been found to be diagnosed with diabetes at a later stage, and to be more likely to visit an emergency department or be admitted to hospital for diabetes management than individuals from urban and non-Aboriginal communities (5). Such a finding may apply to the HIV field, such that Aboriginal people may similarly experience a trend of late diagnosis for HIV. The high concentration of Canadian Aboriginal peoples in rural areas may also contribute to their limited access to health care. In 2004, 21.1% of the Canadian population, but only 9.4% of Canadian physicians, were located in rural areas (6). Additional barriers to accessing health care among Aboriginal populations include perceived racism, differences in cultural beliefs and values, and a shortage of Aboriginal physicians (7). Nearly all of the Aboriginal people living with HIV/AIDS (APHAs) in Canada have either been directly subjected to or had a family member who was subjected to the residential school system. Accordingly, access to health care services and the trust placed in health care providers by Aboriginal peoples is profoundly impacted by historical factors and the repercussions of the residential school system (8).

Late diagnosis of HIV has important consequences for clinical outcomes as well as on health care costs. For example, late diagnosis of HIV (CD4⁺ count <200 cells/mL) is associated with higher mortality despite earlier initiation of therapy (9,10). In Alberta, individuals diagnosed with HIV with a CD4⁺ count <200 cells/mL were found to incur medical care costs twice as high as those of patients diagnosed with a CD4⁺ count >200 cells/mL in the year following diagnosis. In addition, HIV-related hospital care costs were 15 times higher for those diagnosed late (11). Furthermore, earlier HIV diagnosis creates opportunities to reduce the risk of subsequent transmissions by offering earlier treatment and thorough behavioural modifications (12,13).

Several studies have identified predictors of late HIV diagnosis. In a Texan cohort, female sex and illicit drug use were associated with a higher CD4⁺ count at diagnosis, potentially from perceived increased risk in this population (14). In other studies, heterosexual contact and an absence of reported risk factors were often associated with late HIV diagnosis (15-17). In a study of 219 Aboriginal British Columbia residents, participants with an HIV risk factor, such as a previous positive test result for a sexually transmitted infection or needle sharing, were more likely to undergo HIV testing (18).

Factors such as cultural appropriateness of services may influence the acceptance of HIV testing within a community. An exploratory, qualitative analysis of the experiences of seven Aboriginal Canadian women identified fear of unfair judgment as a barrier to HIV testing, and this was linked to a lack of familiarity with the context of the lives of Aboriginal women. In addition, these women perceived HIV testing to infringe on the cultural norm of not disclosing problems to non-community members (19).

In addition to being at risk for late diagnosis of HIV, Aboriginal peoples may receive poorer quality of care once an HIV diagnosis is established. A study conducted in northern Alberta found that Aboriginal ethnicity was associated with a longer median time to accessing care after HIV diagnosis (20). A study conducted in British Columbia found that Aboriginal peoples are more likely to receive double versus triple antiretroviral therapy (ART), to be less adherent in the first year of treatment and to have a physician less experienced in treating HIV compared with non-Aboriginal peoples. However, when controlling for these factors, Aboriginal peoples were found to have comparable virological response to ART (21). Accordingly, there is a need for additional information regarding ART use among Aboriginal peoples in Ontario. In addition, a cohort study of HIV-positive pregnant women in Ontario, Manitoba and Saskatchewan found that Aboriginal women were more likely to experience delayed start of ART when compared with other ethnicities (22).

In the present study, we investigated the difference in the proportion of individuals diagnosed late with HIV between APHAs and non-APHAs within the Ontario HIV Treatment Network Cohort Study (OCS).

Late diagnosis of HIV was defined in two ways: an AIDS-defining illness (ADI) before or within three months of their HIV diagnosis; and a CD4⁺ count <200 cells/mL at diagnosis. Differences between female and male APHAs were also assessed.

METHODS

Study population and design: OCS

The OCS is a multisite, prospective, observational cohort of individuals living with HIV who, since 1997, have been recruited from primary and tertiary care sites throughout Ontario. Information is collected on demographics, HIV-related laboratory values, HIV- and AIDS-related illnesses, comorbidities, drug adverse events, HIV genotypes and sociobehavioural measures. Data are collected from multiple sources including electronic medical records, chart abstraction and linkages to other laboratory databases. Data are collected on each participant every six months.

For the present analysis, the inclusion criteria were: enrollment in the OCS; completed information on self-reported ethnicity; and completed data on date of HIV diagnosis. In the analysis of ADI before or within three months of HIV diagnosis, participants who did not have an ADI were excluded if their follow-up in the cohort was less than three months. The data included cross-sectional data from the baseline visit on participants who were enrolled until November 2009.

Study predictors and outcomes

One outcome of interest was an ADI before or within three months of the first HIV diagnosis. Another outcome was defined as a CD4⁺ count <200 cells/mL at the time of the first HIV diagnosis. Because CD4⁺ measurement is not routinely performed with HIV testing, the CD4⁺ count at diagnosis was defined as the first CD4⁺ count recorded within the first six months after HIV diagnosis. The primary and secondary outcomes were compared between Aboriginal and non-Aboriginal participants, and between male and female Aboriginal participants.

Participants were classified as Aboriginal participants if they indicated Aboriginal ancestry in response to any of the following questions: How do you characterize your racial background?; If Canadian Aboriginal, to which Canadian Aboriginal group do you belong?; If First Nations, are you: status / non-status / don't know / refused?; To which ethnic or cultural group(s) did your ancestors belong?

Statistical analysis

Baseline demographic and clinical characteristics were tabulated according to ethnicity (Aboriginal versus non-Aboriginal) and sex for the Aboriginal population (male versus female). Categorical variables were summarized with frequencies and proportions and compared between groups using χ^2 tests. Continuous variables were summarized with medians and interquartile ranges (IQR) and compared between groups using Wilcoxon rank sum tests. Logistic regression models were used to determine the association between Aboriginal ethnicity and late diagnosis. Separate analyses were conducted for each late HIV diagnosis outcome. Logistic regression models were also used to assess the association between sex and late diagnosis within the Aboriginal population. Data were analyzed using SAS statistical software version 9.2 (SAS Institute Inc, USA).

Ethical considerations

Written informed consent was obtained from all participants of the OCS. The present study was approved by the University of Toronto (Toronto, Ontario) Research Ethics Board and the OCS Governance Committee (the latter comprised of a majority of people living with HIV). Because the present study pertains to Aboriginal people in Canada, Ownership, Control, Access, and Possession (OCAP) principles were adhered to.

RESULTS

As of November 2009, 5044 participants were enrolled in the OCS. Of these, 4862 had a known date of HIV diagnosis. Of participants with a known date of diagnosis, 350 were Aboriginal peoples, 4235 were non-Aboriginal peoples and 277 had missing ethnicity data. Twelve non-Aboriginal and one Aboriginal participant had follow-up of less than three months or incomplete information for both the time of diagnosis and onset of an ADI that were in the same year and, therefore, it was not possible to determine the timing of the ADI relative to HIV diagnosis. Accordingly, the analysis according to ADI included 349 Aboriginal and 4223 non-Aboriginal participants. The analysis of CD4⁺ count <200 cells/mL at diagnosis included 114 Aboriginal and 1626 non-Aboriginal participants because CD4⁺ data at the time of HIV diagnosis were missing for all other participants.

Baseline characteristics

The demographic and clinical characteristics for APHAs versus non-APHAs are summarized in Table 1. When compared with non-Aboriginal participants, Aboriginal participants were younger, more likely to engage in IDU and heterosexual transmission as HIV risk factors, and were more likely to be living in northern Ontario. With regard to socioeconomic factors, Aboriginal participants were less likely to be employed, more likely to have a level of education less than a high school diploma and more likely to have a household annual income <\$20,000. Aboriginal participants were also more likely to be coinfecting with hepatitis C.

Table 2 describes the demographic and clinical characteristics of Aboriginal participants according to sex (male versus female). Among Aboriginal participants, women were younger and more likely to live in northern Ontario. Women were more likely to have IDU and heterosexual transmission as HIV risk factors. Women were less likely to be employed, more likely to have a level of education less than a high school diploma and more likely to have a household annual income <\$20,000. In addition, female Aboriginal participants were more likely to be hepatitis C coinfecting than male Aboriginal participants (42% versus 24% [$P<0.01$]). Female Aboriginal participants were less likely to have ever been on ART (73% versus 89% [$P<0.01$]) and the Kaplan-Meier estimate for median duration from HIV diagnosis to ART initiation for female and male Aboriginal participants were 3.0 years (95% CI 2.1 to 4.7) and 3.6 years (95% CI 2.9 to 4.0), respectively (log rank $P=0.73$).

Analysis of ADI before or within three months of HIV diagnosis

In the univariate analyses, the proportions of APHAs and non-APHAs who had an ADI before or within three months of their first HIV diagnosis were 5.2% and 6.3%, respectively ($P=0.40$). After adjusting for age and HIV risk factor in the logistic regression model, Aboriginal ethnicity remained unassociated with late diagnosis of HIV as defined according to diagnosis of an ADI before or within three months of HIV diagnosis (OR 0.89 [95% CI 0.54 to 1.47]; $P=0.65$) (Table 3).

Analysis of CD4⁺ count <200 cells/mL at HIV diagnosis

There were more non-APHAs ($n=1626$ [38%]) with available data on a CD4⁺ count within six months of HIV diagnosis compared with APHAs ($n=114$ [33%]) ($P=0.03$). The proportions of APHAs and non-APHAs who had a CD4⁺ count <200 cells/mL at the time of their HIV diagnosis were 35% and 29%, respectively ($P=0.18$). Median CD4⁺ counts at the time of HIV diagnosis for Aboriginal and non-Aboriginal participants were 299 cells/mL (IQR 111 cells/mL to 520 cells/mL) and 341 cells/mL (IQR 156 cells/mL to 518 cells/mL), respectively ($P=0.24$). After adjusting for age and HIV risk factors in the logistic regression model, Aboriginal ethnicity was significantly associated with having a CD4⁺ count <200 cells/mL at the time of HIV diagnosis (OR 1.55 [95% CI 1.03 to 2.35]; $P=0.04$) (Table 3).

Analyses of Aboriginal population according to sex

Analyses were performed comparing proportions of Aboriginal participants receiving a late diagnosis of HIV according to sex. Fifty-nine

TABLE 1
Participant demographic and clinical characteristics according to Aboriginal ethnicity

	Aboriginal (n=350)	Non-Aboriginal (n=4235)	P
Age, years, median (interquartile range)	45.0 (38.0–50.0)	48.0 (42.0–54.0)	<0.0001
Male sex	290 (83)	3692 (87)	0.02
Ever on antiretroviral treatment	302 (86)	3784 (89)	0.07
AIDS defining illness	116 (33)	1505 (36)	0.36
HIV risk factor			<0.0001
MSM	175 (50)	2718 (64)	
IDU/MSM-IDU	104 (30)	483 (11)	
Heterosexual transmission	52 (15)	428 (10)	
From country with high HIV prevalence	0 (0)	369 (9)	
Other	19 (5)	237 (6)	
Geographical location in Ontario			<0.0001
Metropolitan Toronto	123 (38)	2210 (55)	
Central	36 (11)	498 (13)	
Eastern	68 (21)	679 (17)	
Southwestern	37 (11)	418 (10)	
Northern	56 (17)	169 (4)	
Other	<5 (1)	9 (0)	
Employment status			<0.0001
Employed full or part time	93 (34)	1194 (50)	
Student	6 (2)	62 (3)	
Retired	15 (6)	198 (8)	
Disability	121 (45)	739 (31)	
Unemployed	35 (13)	210 (9)	
Missing data	80 (23)	1832 (43)	
Highest education level			<0.0001
Some high school	73 (27)	299 (12)	
Completed high school	49 (18)	426 (18)	
Some college/university	63 (23)	546 (23)	
Completed college/university	70 (26)	908 (38)	
Postgraduate education	16 (6)	233 (10)	
Missing data	79 (23)	1823 (43)	
Marital status			0.59
Married, living common-law	104 (38)	947 (39)	
Separated/divorced	17 (6)	195 (8)	
Widowed	9 (3)	60 (2)	
Single	141 (52)	1205 (50)	
Missing data	79 (23)	1828 (43)	
Household income/year, \$			<0.0001
<20,000	104 (43)	568 (26)	
20,000 to <40,000	41 (17)	462 (21)	
40,000 to <60,000	28 (12)	334 (15)	
60,000 to <80,000	24 (10)	249 (11)	
80,000 to <100,000	20 (8)	183 (8)	
≥100,000	26 (11)	410 (19)	
Missing data	107 (31)	2029 (48)	
Hepatitis B coinfection	32 (9)	449 (11)	0.40
Hepatitis C coinfection	94 (27)	666 (16)	<0.0001

Data presented as n (%) unless otherwise indicated. IDU Injection drug use; MSM Men who have sex with men

female Aboriginal participants and 290 male Aboriginal participants were included in a comparison of the proportions of individuals who had an ADI before or within three months of their HIV diagnosis. Many participants were missing data on CD4⁺ counts, resulting in only 20 female Aboriginal participants and 94 male Aboriginal

TABLE 2
Aboriginal participants' demographic and clinical characteristics according to sex

	Male (n=290)	Female (n=60)	P
Age, years, median (interquartile range)	46.0 (39.0–51.0)	40.5 (35.5–48.5)	<0.01
Ever on antiretroviral treatment	258 (89)	44 (73)	<0.01
AIDS-defining illness	99 (34)	17 (28)	0.38
HIV risk factor			<0.0001
MSM	175 (60)	0 (0)	
IDU/MSM-IDU	78 (27)	26 (43)	
Heterosexual transmission	23 (8)	29 (48)	
Other	14 (5)	5 (8)	
Geographical location in Ontario			<0.01
Metropolitan Toronto	112 (41)	11 (21)	
Central	27 (10)	9 (17)	
Eastern	57 (21)	11 (21)	
Southwestern	33 (12)	4 (8)	
Northern	39 (14)	17 (32)	
Other	2 (1)	1 (2)	
Employment status			<0.01
Employed full- or part-time	87 (39)	6 (13)	
Student	5 (2)	1 (2)	
Retired	13 (6)	2 (4)	
Disability	96 (43)	25 (54)	
Unemployed	23 (10)	12 (26)	
Missing data	66 (23)	14 (23)	
Highest education level			<0.001
Some high school	48 (21)	25 (53)	
Completed high school	41 (18)	8 (17)	
Some college/university	56 (25)	7 (15)	
Completed college/university	63 (28)	7 (15)	
Postgraduate education	16 (7)	0 (0)	
Missing	66 (23)	13 (22)	
Marital status			0.59
Married, living common-law	88 (39)	16 (34)	
Separated/divorced	14 (6)	3 (6)	
Widowed	6 (3)	3 (6)	
Single	116 (52)	25 (53)	
Missing	66 (23)	13 (22)	
Household income/year, \$			0.02
<20,000	80 (39)	24 (62)	
20,000 to <40,000	32 (16)	9 (23)	
40,000 to <60,000	25 (12)	3 (8)	
60,000 to <80,000	22 (11)	2 (5)	
80,000 to <100,000	20 (10)	0 (0)	
≥100,000	25 (12)	1 (3)	
Missing	86 (30)	21 (35)	
Hepatitis B coinfection	28 (10)	4 (7)	0.46
Hepatitis C coinfection	69 (24)	25 (42)	<0.01

Data presented as n (%) unless otherwise indicated. IDU Injection drug use; MSM Men who have sex with men

participants being included in the CD4⁺ count analysis. For the first late HIV diagnosis definition, 5.1% of female Aboriginal participants and 5.2% of male Aboriginal participants were diagnosed with an ADI within three months of HIV diagnosis (P=0.98). For the second late HIV diagnosis definition, 35% of female Aboriginal participants and 35% of male Aboriginal participants had CD4⁺ counts <200 cells/mL at the time of diagnosis (P=0.99). Median CD4⁺ counts at time of HIV diagnosis for male and female Aboriginal participants were 395 cells/mL (IQR 86 cells/mL to 542 cells/mL) and 294 cells/mL (IQR 117 cells/mL to 480 cells/mL), respectively (P=0.69).

TABLE 3
Logistic regression model of onset of an AIDS defining illness within three months of HIV diagnosis and a CD4⁺ count <200 cells/mL at the time of HIV diagnosis

Covariate	Onset of and AIDS defining illness within three months of HIV diagnosis (n=4572)		CD4 ⁺ count <200 cells/mL at time of HIV diagnosis (n=1740)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Aboriginal	0.81 (0.50–1.33)	0.89 (0.54–1.47)	1.31 (0.88–1.96)	1.55 (1.03–2.35)
Age (per 10 years)	1.17 (1.04–1.32)	1.17 (1.04–1.32)	1.30 (1.17–1.43)	1.34 (1.21–1.48)
Male sex	1.00 (0.70–1.44)		0.87 (0.66–1.16)	
HIV risk factor				
MSM	1	1	1	1
IDU/MSM-IDU	0.62 (0.39–0.97)	0.65 (0.41–1.03)	0.93 (0.66–1.31)	0.94 (0.66–1.33)
Heterosexual transmission	1.96 (1.42–2.72)	2.03 (1.47–2.82)	1.83 (1.35–2.48)	1.81 (1.33–2.46)
HIV-endemic	1.10 (0.71–1.71)	1.20 (0.77–1.88)	1.85 (1.32–2.59)	2.24 (1.58–3.16)
Other	0.79 (0.43–1.43)	0.79 (0.43–1.44)	1.58 (0.96–2.61)	1.44 (0.87–2.40)
Toronto	0.82 (0.64–1.05)		0.77 (0.62–0.95)	
Hepatitis B coinfection	1.26 (0.88–1.82)		1.27 (0.90–1.79)	
Hepatitis C coinfection	0.65 (0.45–0.94)		0.65 (0.47–0.91)	

Data presented as OR (95% CI). Employment status, education and household income were not included in the model because more than one-half of the data on these variables were missing. IDU Injection drug use; MSM Men who have sex with men

In unadjusted logistic regression models, male sex was not associated with either late diagnosis of HIV as defined according to timing of ADI (OR 1.02 [95% CI 0.29 to 3.63]; P=0.98) or according to CD4⁺ count <200 cells/mL (OR 1.00, [95% CI, 0.37, 2.76]; P=0.99) (Table 4). Logistic regression models, after adjusting for other covariates, showed no significant effect of sex on either definition of late HIV diagnosis.

DISCUSSION

In the present study, APHAs were more likely to have a CD4⁺ count <200 cells/mL at the time of HIV diagnosis than non-APHAs, suggesting potential late diagnosis within the Aboriginal population. However, data from these analyses failed to demonstrate a difference in late HIV diagnosis as defined according to ADI between Aboriginal and non-Aboriginal participants. The discrepancy in these findings may suggest that CD4⁺ count is a more sensitive marker for late HIV diagnosis. Also, in populations where access to care is an issue, including diagnosis of HIV, the diagnosis of ADIs may also be limited.

Significant differences in demographic and socioeconomic factors existed between Aboriginal and non-Aboriginal participants, and between male and female Aboriginal participants. Aboriginal participants were more likely to have lower levels of income, education and employment than non-Aboriginal participants. Other studies have also found APHAs to have lower socioeconomic status than non-APHAs (2,23), and identified poverty as a barrier to treatment uptake (24). Similarly, Aboriginal female participants were more likely to have lower levels of income, education and employment than male Aboriginal participants. It is imperative to address these gross discrepancies in socioeconomic factors and the structural factors that make certain populations, such as Aboriginal women, more vulnerable to poorer health outcomes.

Although female Aboriginal participants tended to have higher CD4⁺ counts at HIV diagnosis and shorter durations from HIV diagnosis to ART start than male Aboriginal participants, these differences were not statistically significant, due at least, in part, to the small numbers of Aboriginal participants and, as a result, low statistical power. In a Vietnamese study, male sex was associated with delayed HIV diagnosis (25). A Canadian study found that among Aboriginal people living off reserve, female sex was associated with an increased likelihood of undergoing an HIV test within the previous year (26). These trends may reflect the impact of prenatal HIV testing because pregnant women may be more likely to be diagnosed at an earlier stage of disease. However, female Aboriginal participants involved in the present study were significantly less likely to have ever been on ART, and this finding is concerning in the context of the prevention of vertical transmission of HIV. The data on ART use were limited in the present analysis, and additional analyses should take duration of ART, indications for ART initiation and reasons for discontinuation into consideration. In addition, female Aboriginal participants were nearly twice as likely to be hepatitis C coinfecting than male Aboriginal participants. This likely represents differences in the rates of IDU and highlights the importance of prevention efforts targeted at addressing the structural, social and historical factors that place Aboriginal women at risk of HIV and hepatitis C.

The findings from the present study have significant policy implications. They call attention to the need for interventions to increase HIV testing uptake among Aboriginal populations. A combination of public health and community-driven programs are needed to help make HIV testing more accessible and acceptable among Aboriginal populations, and to reduce barriers to testing, such as HIV-related stigma. Physicians should be more proactive in offering HIV counseling and testing, coupled with primary prevention efforts, to at-risk populations. Strategies that could lead to more timely HIV diagnoses include professional development and training for physicians and allied health care workers (27,28), as well as increasing access to alternative or newer HIV testing services such as anonymous (29,30), rapid point-of-care (31-33), home-based (34,35) or mobile (36) testing. The goal for increasing HIV testing in Aboriginal populations is to enable earlier diagnoses, which would lead to this population accessing care and ART at higher CD4⁺ counts and preventing ADIs. In addition, improving testing and diagnosis of HIV can also have prevention implications. Individuals diagnosed with HIV can be presented with information that will help them to reduce the risk of HIV transmission and HIV superinfection. Initiating individuals on ART may also have a role in the reduction of HIV transmission (37).

Our study has several limitations, one of which was the small sample size of Aboriginal participants. Despite over-representation in the Canadian and Ontario HIV epidemic, Aboriginal peoples are under-represented in the OCS, accounting for only 7.5% of all OCS participants. Over the past decade, Aboriginal peoples have comprised approximately 20% of new HIV-positive test results annually in Canada (1). Another limitation is that the OCS only recruits from primary and tertiary health care sites and, thus, only individuals receiving HIV care are included in the study. The individuals who are most at risk for late HIV diagnosis and poor quality of HIV care are likely those who are not accessing services at all and, as a result, are not captured in the study cohort. Because many AHPAs are not receiving care, this cohort fails to include some of the most vulnerable AHPAs in Ontario. This limitation leads to a likely underestimate of the true difference in the proportion of late HIV diagnosis in AHPAs versus non-AHPAs. In addition, the study participants may not accurately represent the geographical distribution of Aboriginal peoples in Ontario. Recruitment methods that focus on increasing the number of Aboriginal participants in the OCS are greatly needed and the OCS has included Aboriginal participants as a priority population for future recruitment efforts. Strategies could include expanding recruitment sites to community agencies and traditional healers, increasing the

TABLE 4
Unadjusted logistic regression model of onset of an AIDS defining illness within three months of HIV diagnosis and a CD4⁺ count <200 cells/mL at time of HIV diagnosis among Aboriginal participants

Covariate	Onset of an AIDS-defining illness within three months of HIV diagnosis (n=290 men, 59 women)	CD4 ⁺ count <200 cells/mL at time of HIV diagnosis (n=94 men, 20 women)
Male sex	1.02 (0.29–3.63)	1.00 (0.37–2.76)
Age (per 10 years)	1.51 (0.90–2.53)	1.25 (0.87–1.79)
HIV risk factor:		
MSM	1	
IDU/MSM-IDU	0.75 (0.22–2.48)	0.99 (0.38–2.58)
Heterosexual transmission	1.13 (0.29–4.33)	1.00 (0.35–2.88)
HIV-endemic	–	–
Other	2.17 (0.43–10.87)	1.24 (0.19–8.00)
Toronto	0.44 (0.14–1.38)	1.33 (0.59–2.98)
Hepatitis B coinfection	0.57 (0.07–4.42)	0.34 (0.07–1.62)
Hepatitis C coinfection	0.78 (0.25–2.42)	0.64 (0.23–1.79)

Data presented as OR (95% CI). IDU Injection drug use; MSM Men who have sex with men

number of recruitment sites in northern Ontario and involving Aboriginal peoples as research team members to advise on recruitment strategies for Aboriginal peoples. Aboriginal peoples and community leaders should be engaged as key partners in all research efforts involving Aboriginal peoples.

Another limitation was that less than one-half of all participants had a documented CD4⁺ count within six months of HIV diagnosis. Many participants are enrolled in the OCS through tertiary care clinics that do not usually have a complete history of CD4⁺ counts dating back to the time of HIV diagnosis, and this likely contributed to the missing data. The missing data limited the power of our analyses and also may have introduced a respondent bias to the sample. Factors associated with having no documented CD4⁺ count within six months of HIV diagnosis include history of an ADI, hepatitis C coinfection, receiving disability support and low income. In addition, data regarding employment, education and income were only available for participants enrolled after 2007, and it was not possible to adequately adjust for these factors in multivariate logistic regression analysis of the participants with a documented CD4⁺ count within six months of HIV diagnosis. These missing data represent a significant limitation, because a previous study (38) found low educational level to be associated with late diagnosis of HIV.

Our study was a preliminary analysis and found significant differences in the late diagnosis of HIV between Aboriginal and non-Aboriginal OCS participants when late diagnosis was defined according to CD4⁺ count <200 cells/mL at diagnosis. However, numerous study limitations have been noted. Data limitations can be addressed by targeted recruitment of AHPAs, and Aboriginal women living with HIV in particular, in cohorts such as the OCS. Furthermore, the present analysis should be repeated using Canada-wide data, and efforts should be made to collect data on AHPAs who are not receiving appropriate health care or for transient populations of Aboriginal peoples who are not often captured in longitudinal cohort studies. More research is also needed on the context of HIV diagnosis and ART among Aboriginal women. Finally, the present study highlights some of the many socioeconomic inequities between AHPAs and non-AHPAs, and between Aboriginal women and men living with HIV. Future research efforts should address the link between socioeconomic factors and vulnerability to HIV and hepatitis C among Aboriginal peoples.

ACKNOWLEDGEMENTS: The OHTN Cohort Study (Principal Investigator, Dr Sean B Rourke) is supported by the AIDS Bureau – Ontario Ministry of Health and Long-Term Care. Data collection sites and members of the Scientific Steering Committee include: Drs Irving Salit and Janet Raboud (Toronto General Hospital, Toronto, Ontario); Dr Ahmed Bayoumi (St Michael's Hospital, Toronto, Ontario); Drs Mona Loutfy, Graham Smith, Tony Antoniou and Fred Crouzat (Maple Leaf Medical Clinic, Toronto, Ontario); Dr Anita Rachlis, Dr Nicole Mittmann (Sunnybrook Health Sciences Centre, Toronto, Ontario); Dr Wendy Wobeser (Kingston General Hospital, Kingston, Ontario); Dr John Cairney (McMaster University and Centre for Addiction and Mental Health, Hamilton, Ontario); Dr Liviana Calzavara (University of Toronto, Toronto, Ontario); Dr Curtis Cooper (University of Ottawa, Ottawa, Ontario); Dr Marek Smieja (McMaster University, Hamilton, Ontario); Dr Ken Logue (St Clair Medical Associates, Toronto, Ontario); Dr Don Kilby (University of Ottawa Health Services, Ottawa, Ontario); Dr Anurag Markenday (St Joseph's Health Care, London, Ontario); Dr Roger Sandre (Sudbury Regional Hospital, Sudbury, Ontario); and Dr Jeff Cohen (Windsor Regional Hospital HIV Care Program, Windsor, Ontario). We gratefully acknowledge all of the people living with HIV who volunteered

to participate in the OHTN Cohort Study and the work and support of the inaugural OCS Governance Committee: Darien Taylor (Chair), Dr Evan Collins, Dr Greg Robinson, Shari Margoese, Patrick Cupido, Tony Di Pede, Rick Kennedy, Michael Hamilton, Ken King, Brian Finch, Lori Stoltz, Dr Ahmed Bayoumi, Dr Clemon George and Dr Curtis Cooper. The authors thank all the interviewers, data collectors, research associates and coordinators, nurses, and physicians who provided support for data collection and extraction. The authors thank the OHTN staff and their teams for data management and IT support (Mark Fisher, Director, Data Systems) and OCS management and coordination (Virginia Waring, Project Manager, OCS). The viral load data in the OCS was supplemented through a linkage with the viral load database of the Ontario Agency for Health Protection and Promotion. Three investigators are also the recipients of salary support from the Ontario HIV Treatment Network (JR) and the Canadian Institutes of Health Research (MRL, SR). Two investigators have been recipients of research funding from the Ontario HIV Treatment Network (MRL, DJ). SR is the Scientific and Executive Director of the OHTN and receives salary support from this agency. Part of this work was completed during the Comprehensive Research Experience for Medical Students of the Faculty of Medicine, University of Toronto.

REFERENCES

- Public Health Agency of Canada. HIV/AIDS Epi Updates, November 2007. Ottawa: Surveillance and Risk Assessment Division, Centre for Infectious Disease Prevention and Control, Public Health Agency of Canada, 2007:47-58.
- Heath KV, Comelisse PG, Strathdee SA, et al. HIV-associated risk factors among young Canadian Aboriginal and non-Aboriginal men who have sex with men. *Int J STD AIDS* 1999;10:582-7.
- Craib KJP, Spittal PM, Wood E, et al. Risk factors for elevated HIV incidence among Aboriginal injection drug users in Vancouver. *CMAJ* 2003;168:19-24.
- Shah BR, Gunraj N, Hux JE. Markers of access to and quality of primary care for Aboriginal people in Ontario, Canada. *Am J Public Health* 2003;93:798-802.
- Booth GL, Fang J, Hux JE, Chan BTB. Time trends and geographic disparities in acute complications of diabetes in Ontario, Canada. *Diabetes Care* 2005;28:1045-50.
- Pong RW, Pitblado JR. Geographic distribution of physicians in Canada: Beyond how many and where. Ottawa: Canadian Institute for Health Information, 2005:viii.
- Smylie J. A guide for health professionals working with Aboriginal peoples. *Journal SOGC* 2001;100:1-11.
- Jackson R, Reimer G. Canadian Aboriginal People Living with HIV/AIDS. Care, Treatment and Support Issues. Canadian Aboriginal AIDS Network. Revised 2008.
- Lanoy E, Mary-Krause M, Tattevin P, et al. Frequency, determinants and consequences of delayed access to care for HIV infection in France. *Antivir Ther* 2007;12:89-96.
- Chadborn TR, Delpech VC, Sabin CA, Sinka K, Evans BG. The late diagnosis and consequent short-term mortality of HIV-infected heterosexuals (England and Wales, 2000-2004). *AIDS* 2006;20:2371-9.
- Krentz HB, Auld MC, Gill MJ. The high cost of medical care for patients who present late (CD4 <200 cells/microL) with HIV infection. *HIV Med* 2004;5:93-8.
- Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med* 2011;365:493-505.
- Wood E, Milloy MJ, Montaner JS. HIV treatment as prevention among injection drug users. *Curr Opin HIV AIDS* 2012;7:151-6.
- Mayben JK, Kramer JR, Kallen MA, Franzini L, Lairson DR, Giordano TP. Predictors of delayed HIV diagnosis in a recently diagnosed cohort. *AIDS Patient Care STDS* 2007;21:195-204.
- Schwartz S, Hsu L, Dilley JW, Loeb L, Nelson K, Boyd S. Late diagnosis of HIV infection: Trends, prevalence, and characteristics of persons whose HIV diagnosis occurred within 12 months of developing AIDS. *J Acquir Immune Defic Syndr* 2006;43:491-4.
- Delpeire C, Dray-Spira R, Cuzin L, et al. Correlates of late HIV diagnosis: implications for testing policy. *Int J STD AIDS* 2007;18:312-7.
- McDonald AM, Li Y, Dore GJ, Ree H, Kaldor JM. Late HIV presentation among AIDS cases in Australia, 1992-2001. *Aust N Z J Public Health* 2003;27:608-13.
- Wardman D, Quantz D, Clement K. HIV/AIDS: Testing and risk behaviors among British Columbia's rural Aboriginal population. *Int J Circumpolar Health* 2006;65:313-21.
- Bucharski D, Reutter LL, Olgilvie LD. "You need to know where we're coming from": Canadian Aboriginal women's perspectives on culturally appropriate HIV counseling and testing. *Health Care Women Int* 2006;27:723-47.
- Plitt SS, Mihalicz D, Singh AE, Jayaraman G, Houston S, Lee BE. Time to testing and accessing care among a population of newly diagnosed patients with HIV with a high proportion of Canadian Aboriginals, 1998-2003. *AIDS Patient Care STDS* 2009;23:93-9.
- Miller CL, Spittal PM, Wood E, et al. Inadequacies in antiretroviral therapy use among Aboriginal and other Canadian populations. *AIDS Care* 2006;18:968-76.
- King SM and the Motherisk-HIV Network Members. Antiretroviral therapy (ART) in a cohort of HIV-positive pregnant women in Canada. *Can J Infect Dis* 2001;12:26B.
- Lima VD, Kretz P, Palepu A, et al. Aboriginal status is a prognostic factor for mortality among antiretroviral naïve HIV-positive individuals first initiating HAART. *AIDS Res Ther* 2006;3:14.
- Newman CE, Bonar M, Greville HS, et al. Barriers and incentives to HIV treatment uptake among Aboriginal people in Western Australia. *AIDS* 2007;21:S13-7.
- Nhac-Vu HT, Giard M, Phong ND, Vanhems P. Risk factors for delayed HIV diagnosis at the hospital of tropical diseases in Ho Chi Minh City, Vietnam. *Int J STD AIDS* 2010;21:802-5.
- Orchard TR, Druyts E, McInnes CW, et al. Factors behind HIV testing practices among Canadian Aboriginal peoples living off-reserve. *AIDS Care* 2010;22:324-31.
- Hsieh YH, Jung JJ, Shahan JB, et al. Emergency medicine resident attitudes and perceptions of HIV testing before and after a focused training program and testing implementation. *Acad Emerg Med* 2009;16:1165-73.
- Krakower D, Kwan CK, Yassa DS, Colvin RA. iAIDS: HIV-related internet resources for the practicing clinician. *Clin Infect Dis* 2010;51:813-22.
- Mahendradhata Y, Ahmad RA, Kusuma TA, et al. Voluntary counselling and testing uptake and HIV prevalence among tuberculosis patients in Jogjakarta, Indonesia. *Trans R Soc Trop Med Hyg* 2008;102:1003-10.
- Bindman AB, Osmond D, Hecht FM, et al. Multistate evaluation of anonymous HIV testing and access to medical care. Multistate Evaluation of Surveillance of HIV (MESH) Study Group. *JAMA* 1998;280:1416-20.
- Guenther D, Greer J, Barbara A, et al. Rapid point-of-care HIV testing in community-based anonymous testing program: A valuable alternative to conventional testing. *AIDS Patient Care STDS* 2008;22:195-204.
- Appiah LT, Havers F, Gibson J, et al. Efficacy and acceptability of rapid, point-of-care HIV testing in two clinical settings in Ghana. *AIDS Patient Care STDS* 2009;23:365-9.

33. Roberts KJ, Grusky O, Swanson AN. Outcomes of blood and oral fluid rapid HIV testing: A literature review, 2000-2006. *AIDS Patient Care STDS* 2007;21:621-37.
 34. Tumwesigye E, Wana G, Kasasa S, et al. High uptake of home-based, district-wide, HIV counseling and testing in Uganda. *AIDS Patient Care STDS* 2010;24:735-41.
 35. Matovu JK, Makumbi FE. Expanding access to voluntary HIV counselling and testing in sub-Saharan Africa: Alternative approaches for improving uptake, 2001-2007. *Trop Med Int Health* 2007;12:1315-22.
 36. van Schaik N, Kranzer K, Wood R, Bekker LG. Earlier HIV diagnosis – are mobile services the answer? *S Afr Med J* 2010;100:671-4.
 37. Donnell D, Baeten JM, Kiarie J, et al. Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: A prospective cohort analysis. *Lancet* 2010;375:2092-8.
 38. Sobrino-Vegas P, García-San Miguel L, Caro-Murillo AM, et al. Delayed diagnosis of HIV infection in a multicenter cohort: Prevalence, risk factors, response to HAART and impact on mortality. *Curr HIV Res* 2009;7:224-30.
-