




Short Communication

Assessing the impact of food insecurity on HIV medication adherence in the context of an integrated care programme for people living with HIV in Vancouver, Canada

Katrina Koehn^{1,2} , Taylor McLinden¹, Alexandra B Collins^{2,3}, Patrick McDougall⁴, Rosalind Baltzer-Turje⁴, Christiana Miewald⁵, Lu Wang¹, Jenny Li¹, Kate A Salters^{1,2}, Robert S Hogg^{1,2} and Surita Parashar^{1,2,*}

¹Epidemiology and Population Health Program, BC Centre for Excellence in HIV/AIDS, St. Paul's Hospital, 608-1081 Burrard Street, Vancouver, British Columbia, Canada V6Z 1Y6; ²Faculty of Health Sciences, Simon Fraser University, Burnaby, Canada; ³BC Centre on Substance Use, Vancouver, Canada; ⁴Dr. Peter AIDS Foundation, Vancouver, Canada; ⁵Department of Geography, Simon Fraser University, Burnaby, Canada

Submitted 21 December 2018: Final revision received 3 May 2019: Accepted 4 June 2019: First published online 11 September 2019

Abstract

Objective: Food insecurity, or self-reports of inadequate food access due to limited financial resources, remains prevalent among people living with HIV (PLHIV). We examined the impact of food insecurity on combination antiretroviral therapy (cART) adherence within an integrated care programme that provides services to PLHIV, including two meals per day.

Design: Adjusted OR (aOR) were estimated by generalized estimating equations, quantifying the relationship between food insecurity (exposure) and cART adherence (outcome) with multivariable logistic regression.

Setting: We drew on survey data collected between February 2014 and March 2016 from the Dr. Peter Centre Study based in Vancouver, Canada.

Participants: The study included 116 PLHIV at baseline, with ninety-nine participants completing a 12-month follow-up interview. The median (quartile 1–quartile 3) age was 46 (39–52) years at baseline and 87% (*n* 101) were biologically male at birth.

Results: At baseline, 74% (*n* 86) of participants were food insecure (≥ 2 affirmative responses on Health Canada's Household Food Security Survey Module) and 67% (*n* 78) were adherent to cART $\geq 95\%$ of the time. In the adjusted regression analysis, food insecurity was associated with suboptimal cART adherence (aOR = 0.47, 95% CI 0.24, 0.93).

Conclusions: While food provision may reduce some health-related harms, there remains a relationship between this prevalent experience and suboptimal cART adherence in this integrated care programme. Future studies that elucidate strategies to mitigate food insecurity and its effects on cART adherence among PLHIV in this setting and in other similar environments are necessary.

Keywords
Food insecurity
HIV
Integrated care
Treatment adherence

Advances in combination antiretroviral therapy (cART) have improved morbidity and mortality for people living with HIV (PLHIV)^(1–3). However, social and structural barriers, such as food insecurity (FI), homelessness, and poverty continue to prevent marginalized PLHIV from fully benefiting from cART^(4–6). Notably, FI, or self-reports of uncertain or inadequate food access due to limited financial

resources, is associated with adverse HIV-related clinical outcomes^(7–9); FI has a known association with incomplete HIV viral load suppression^(10,11), lower CD4 cell counts⁽¹²⁾ and a heightened risk for mortality^(4,13).

Research has suggested that the impact of FI on adverse HIV-related outcomes is due, in part, to its negative association with adherence to cART^(9,14,15). A study based in San

*Corresponding author: Email sparashar@cfenet.ubc.ca



Francisco revealed that PLHIV who were food insecure were almost half as likely to be adherent to cART than their food-secure counterparts⁽¹¹⁾. Additional research has illustrated mechanisms through which FI may impact cART adherence^(16–19). For example, individuals may skip doses or discontinue treatment to mitigate the actual or anticipated side-effects of taking cART without food (e.g. nausea, stomach pain)^(9,16).

While past studies have established a link between FI and suboptimal cART adherence^(16,18,20), this relationship has yet to be explored within the context of integrated care programmes that aim to attenuate the consequences of socio-structural inequities among PLHIV. For example, the Dr. Peter Centre (DPC) is an integrated care programme serving PLHIV in Vancouver, British Columbia (BC), Canada. PLHIV are eligible to access DPC programming if they are at risk of health deterioration and demonstrate a need (e.g. limited financial or social supports) for assistance to maintain independence⁽²¹⁾. The DPC aims to reduce barriers to access and retention in HIV care by offering a wide array of harm reduction services⁽²¹⁾. These services include counselling, therapies (e.g. art, music, recreational), nursing (e.g. wound care, foot clinic, cART support) and amenity access (e.g. nap room, showers)⁽²¹⁾. DPC clients can also access two nutrient-rich meals per day, including balanced portions of meat/alternatives, dairy products, fruits and vegetables, and whole grains⁽²²⁾. While we acknowledge that food provision does not directly address the root cause of FI in resource-rich settings, which is inadequate financial resources^(23,24), we hypothesize that this service, along with other supports that are offered in this setting, may help mitigate the relationship between FI and cART adherence. Therefore, we undertook a study to examine this relationship among clients of the DPC. Further understanding this relationship within an integrated care setting may have implications for optimizing HIV care among structurally vulnerable PLHIV.

Methods

The present study used data from a community-based observational study exploring the impact of the DPC's services on health outcomes and HIV-related care for marginalized PLHIV. The quantitative study, described in detail elsewhere^(21,25), is comprised of a longitudinal cohort of DPC clients who participated in baseline (*n* 121) and follow-up (*n* 102) socio-behavioural surveys. Participant recruitment was conducted by peer research associates (i.e. individuals with common experiences to DPC clients) and DPC staff. Study invitations were placed at the DPC reception desk and included the study coordinator's number, whom participants could call if interested in participating.

Individuals were eligible for the current analysis if they had been enrolled as a DPC client after 27 February 2011, had completed a baseline survey and were on cART at

baseline. Baseline surveys that collected sociodemographic, behavioural and FI-related data were administered by the peer research associates to the DPC clients between February 2014 and March 2016. Follow-up surveys were conducted approximately 12 months after the baseline surveys. Participants received \$CAN 30 honoraria as compensation for their involvement.

Survey data were supplemented with comprehensive clinical data from the HIV Drug Treatment Program (DTP) held at the BC Centre for Excellence in HIV/AIDS. The DTP provides cART free-of-charge to all PLHIV in the province of BC⁽²⁶⁾. As described in detail elsewhere, individuals are enrolled in the DTP when they are first prescribed cART by any physician in BC and all subsequent measures of HIV-related clinical variables (e.g. CD4 count, HIV viral load, cART refill compliance) are stored in the DTP database⁽²⁶⁾. Because our analysis required that DPC clients be on cART at baseline, all the participants in the present study were enrolled in the DTP.

Measures

The primary explanatory variable of interest was FI in the past 12 months, which was measured using the ten-item adult scale of Health Canada's Household Food Security Survey Module (HFSSM)^(27,28). This tool classifies FI status based on the number of affirmative responses to the ten items. In accordance with Health Canada's guidelines, zero or one affirmative response on the HFSSM indicates food security, while two or more affirmative responses denotes FI⁽²⁸⁾.

The outcome variable of interest for the current analysis was cART adherence, based on refill compliance, which is a previously validated method of estimating adherence when direct observation of medication consumption is not feasible⁽²⁹⁾. Refill compliance is calculated as the number of days that cART was dispensed divided by the number of days of follow-up during the 12 months prior to the interview date^(30,31). This measure was expressed as a percentage and dichotomized as optimal (adhering to $\geq 95\%$ of prescribed cART) or suboptimal (adhering to $< 95\%$ of prescribed cART) adherence; this cut-off has been validated as having clinical relevance for HIV viral load suppression^(31,32). Potential confounding variables for inclusion in the statistical models were selected *a priori* based on their hypothesized relationship with FI (exposure) and cART adherence (outcome).

Data analyses

Descriptive *P* values were calculated using Pearson χ^2 tests and Wilcoxon rank-sum tests for binary/categorical variables and continuous variables, respectively. Adjusted OR (aOR) were estimated by generalized estimating equations, quantifying the relationship between binary FI (food secure *v.* moderate/severely food insecure) and binary cART adherence (adhering to $< 95\%$ of prescribed cART *v.* adhering to $\geq 95\%$ of prescribed cART) with logistic regression^(33,34).



Generalized estimating equations were used to account for the longitudinal nature of the baseline and follow-up measures taken from individual participants using an exchangeable correlation structure with robust SE^(35,36). To select the variables for the multivariable model, a change-in-estimate approach to confounder selection was used^(37,38). Specifically, if the coefficient for FI changed by less than 5% after the omission of a given confounder, the variable was not adjusted for in the final model^(37,39). All data were analysed using the statistical software package SAS version 9.4.

Results

Among the 121 DPC clients in the total cohort, 116 individuals and 215 total visits (observations) were included in the current analysis after excluding those who were not on cART at

baseline or who were missing data on the FI or cART adherence measures. Table 1 reveals no significant differences in the proportions of responses to the HFSSM questions or overall FI status between baseline and follow-up. As shown in Table 2, at baseline, 74% (*n* 86) of participants reported experiencing FI in the past 12 months and 67% (*n* 78) of participants were adherent to cART in the past 6 months. The median (quartile 1–quartile 3) age of participants at baseline was 46 (39–52) years and 87% (*n* 101) of participants were biologically male at birth. Notably, 35% (*n* 41) identified as Indigenous, 70% (*n* 81) had been diagnosed with hepatitis C and 53% (*n* 62) had used illicit drugs (excluding marijuana) in the past 6 months.

In the unadjusted analysis (Table 3), experiences of FI were associated with suboptimal cART adherence (unadjusted OR = 0.44, 95% CI 0.24, 0.82). Furthermore, after adjustment for potential confounding factors, FI remained associated with

Table 1 Baseline and follow-up responses to the ten-item adult scale of the Household Food Security Survey Module (HFSSM) of Dr. Peter Centre clients in Vancouver, Canada (February 2014–March 2016)

HFSSM item	Response options	Baseline response (<i>n</i> 116)		Follow-up response (<i>n</i> 99)		<i>P</i> value
		<i>n</i>	%	<i>n</i>	%	
1. You and other household members worried that food would run out before you got money to buy more. Was that often true, sometimes true, or never true in the past 12 months?	Often true*	38	34.23	35	35.71	0.975
	Sometimes true	37	33.33	32	32.65	
	Never true	36	32.43	31	31.63	
2. The food that you and other household members bought just didn't last, and there wasn't any money to get more. Was that often true, sometimes true, or never true in the past 12 months?	Often true*	45	40.54	32	32.99	0.513
	Sometimes true	35	31.53	33	34.02	
	Never true	31	27.93	32	32.99	
3. You and other household members couldn't afford to eat balanced meals. In the past 12 months was that often true, sometimes true, or never true?	Often true*	43	38.39	26	26.80	0.193
	Sometimes true	40	35.71	39	40.21	
	Never true	29	25.89	32	32.99	
4. In the past 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	Yes*	64	78.05	54	72.97	0.461
	No	18	21.95	20	27.03	
5. How often did this happen? (Referring to item 4)	Almost every month*	39	48.75	30	40.54	0.378
	Some months but not every month	19	23.75	23	31.08	
	Only 1 or 2 months	4	5.00	1	1.35	
	Not applicable ('No' to item 4)	18	22.50	20	27.03	
6. In the past 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?	Yes*	68	79.07	48	65.75	0.060
	No	18	20.93	25	34.25	
7. In the past 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?	Yes*	69	80.23	52	69.33	0.110
	No	17	19.77	23	30.67	
8. In the past 12 months, did you lose weight because you didn't have enough money for food?	Yes*	60	71.43	42	56.76	0.054
	No	24	28.57	32	43.24	
9. In the past 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?	Yes*	49	60.49	37	59.68	0.921
	No	32	39.51	25	40.32	
10. How often did this happen? (Referring to item 9)	Almost every month*	22	27.85	16	25.81	0.965
	Some months but not every month	19	24.05	17	27.42	
	Only 1 or 2 months	6	7.59	4	6.45	
	Not applicable ('No' to item 9)	32	40.51	25	40.32	
Food security status	Food insecure	86	74.14	69	69.70	0.469
	Food secure	30	25.86	30	30.30	

*An affirmative response on the HFSSM.

Table 2 Baseline descriptive characteristics of 116 Dr. Peter Centre (DPC) clients in Vancouver, Canada (February 2014–March 2016)

Variable	Total <i>n</i> 116	
	<i>n</i>	%
cART adherence in the past 12 months (outcome)		
<95 %	38	32.76
≥95 %	78	67.24
Food security (exposure)		
Food secure	30	25.86
Food insecure	86	74.14
Potential confounders (categorical variables)		
Often have a drink containing alcohol		
Never	46	39.66
Sometimes	70	60.34
Illicit drug use in the past 6 months (excluding marijuana)		
No	54	46.55
Yes	62	53.45
Biological sex at birth		
Male	101	87.07
Female	15	12.93
Homeless in the past 12 months		
No	89	76.72
Yes	27	23.28
Self-reported anxiety and/or depression		
Not anxious or depressed	29	25.00
Anxious or depressed	87	75.00
Prison or jail ever		
No	57	49.14
Yes	59	50.86
Ever diagnosed with hepatitis C		
No	35	30.17
Yes	81	69.83
Food assistance for most recent regimen		
Taken without food/with or without food	26	22.41
Taken with food	81	69.83
With DPC less than 1 year at baseline		
No	50	43.10
Yes	66	56.90
Currently working for pay		
No	107	92.24
Yes	9	7.76
Current smoking status		
No	35	30.17
Yes	81	69.83
Currently living with someone		
Alone	100	86.21
With others	16	13.79
Indigenous ancestry		
No	75	64.66
Yes	41	35.34
Highest level of education		
Some post-secondary and above	46	39.66
High school and below	70	60.34
Issues with performing usual activities due to health state		
No issues	67	57.76
Some issues/unable	49	42.24
Three antiretrovirals in current regimen		
Yes	108	93.10
No	8	6.90
	Median	Q1–Q3
Potential confounders (continuous variables)		
Age at interview date	46	39–52
Household monthly income before taxes (\$CAN)	1100	1064.5–1151
Cumulative months on cART at visit	47	21–97

cART, combination antiretroviral therapy; Q1, quartile 1; Q3, quartile 3.

**Table 3** Univariable and multivariable analyses of the relationship between food insecurity and $\geq 95\%$ combination antiretroviral therapy (cART) adherence among clients of the Dr. Peter Centre (DPC) in Vancouver, Canada (February 2014–March 2016)

Variable	Total <i>n</i> 116				Unadjusted logistic regression models		Adjusted logistic regression models	
	<95% cART adherent (<i>n</i> 77)		$\geq 95\%$ cART adherent (<i>n</i> 138)		(estimated by generalized estimating equations)			
	<i>n</i>	%	<i>n</i>	%	Outcome: $\geq 95\%$ v. <95% cART adherent (total observations = 215)			
					Unadjusted OR	95% CI	Adjusted OR	95% CI
Food security (exposure)								
Food secure	13	16.88	47	34.06	Ref.	–	Ref.	–
Food insecure	64	83.12	91	65.94	0.44	0.24, 0.82	0.47	0.24, 0.93
Confounders (categorical variables)								
Often have a drink containing alcohol								
Never	32	41.56	56	40.48	Ref.	–		
Sometimes	45	58.44	82	59.42	0.99	0.53, 1.85	Not selected*	
Illicit drug use in the past 6 months (excluding marijuana)								
No	30	38.96	81	58.70	Ref.	–	Ref.	–
Yes	47	61.04	57	41.30	0.51	0.28, 0.92	0.59	0.32, 1.09
Biological sex at birth								
Male	68	88.31	118	85.51	Ref.	–		
Female	9	11.69	20	14.49	1.31	0.47, 3.63	Not selected	
Homeless in the past 12 months								
No	61	79.22	114	82.61	Ref.	–		
Yes	16	20.78	24	17.39	0.88	0.43, 1.80	Not selected	
Self-reported anxiety and/or depression								
Not anxious or depressed	18	23.38	44	31.88	Ref.	–	Ref.	–
Anxious or depressed	59	76.62	94	68.12	0.64	0.32, 1.29	0.77	0.35, 1.70
Prison or jail ever								
No	35	45.45	70	50.72	Ref.	–		
Yes	42	54.55	68	49.28	0.84	0.45, 1.59	Not selected	
Ever diagnosed with hepatitis C								
No	18	23.38	46	33.33	Ref.	–	Ref.	–
Yes	59	76.62	92	66.67	0.63	0.30, 1.33	0.56	0.25, 1.26
Food assistance for most recent regimen								
Taken without food/with or without food	13	16.88	37	26.81	Ref.	–		
Taken with food	64	83.12	101	73.19	0.63	0.32, 1.21	Not selected	
With DPC less than 1 year at baseline								
No	34	44.16	62	44.93	Ref.	–		
Yes	43	55.84	76	55.07	0.97	0.52, 1.84	Not selected	
Currently working for pay								
No	71	92.21	124	89.86	Ref.	–		
Yes	6	7.79	14	10.14	0.91	0.33, 2.49	Not selected	
Current smoking status								
No	19	24.68	49	35.51	Ref.	–		
Yes	58	75.32	89	64.49	0.68	0.35, 1.34	Not selected	
Currently living with someone								
Alone	71	92.21	114	82.61	Ref.	–	Ref.	–
With others	6	7.79	24	17.39	2.55	1.09, 5.94	3.32	1.47, 7.50
Indigenous ancestry								
No	46	59.74	93	67.39	Ref.	–		
Yes	31	40.26	45	32.61	0.75	0.40, 1.42	Not selected	
Highest level of education								
Some post-secondary and above	30	38.96	56	40.58	Ref.	–		
High school and below	47	61.04	82	59.42	0.98	0.54, 1.78	Not selected	
Issues with performing usual activities due to health state								
No issues	45	58.44	81	58.70	Ref.	–		
Some issues/unable	32	41.56	57	41.30	0.87	0.49, 1.56	Not selected	
Three antiretrovirals in current regimen								
Yes	74	96.10	125	90.58	Ref.	–		
No	3	3.90	13	9.42	2.14	0.61, 7.57	Not selected	

Table 3 *Continued*

	Median	Q1–Q3	Median	Q1–Q3	Unadjusted OR	95 % CI	Adjusted OR	95 % CI
Confounders (continuous variables)								
Age at interview date	45	37–51	49	42–54	1.41 per 10-year increase	1.03, 1.93	1.16	0.82, 1.63
Household monthly income before taxes (\$CAN)	1100	1071–1111	1100	1091–1245	1.05 per \$CAN 100 increase	0.98, 1.13	Not selected	
Cumulative months on cART at visit	38	19–70	70.5	35–121	1.15 per 12-month increase	1.07, 1.24	1.14	1.05, 1.23

Ref., reference category; Q1, quartile 1; Q3, quartile 3.

*Not selected after change-in-estimate approach: if the coefficient for food insecurity changed by less than 5 % after the omission of a given confounder, the variable was not adjusted for in the final model.

suboptimal adherence (aOR = 0.47, 95 % CI 0.24, 0.93). In other words, those who experienced FI were approximately half as likely to be adherent to cART ($\geq 95\%$) compared with those who were food secure.

Discussion

The present study examined the relationship between FI and cART adherence among a cohort of PLHIV who were clients of the DPC in Vancouver, Canada. Nearly three-quarters of DPC participants reported experiencing FI in the past 12 months. The high prevalence of FI among DPC clients was similar to that documented in other Canadian studies of PLHIV^(7,8,40,41). Two studies conducted in BC (2011 and 2016) found the percentage of food-insecure PLHIV to be almost identical to the 74 % of participants identified in the present study^(8,40). Also in line with other studies, individuals who were food insecure were approximately half as likely to be adherent to cART after adjusting for potential clinical, social and demographic confounders of the FI–cART adherence relationship^(9,42).

The present study's results must be interpreted in the context of previous literature detailing how interventions that focus on food provision (e.g. food banks, community gardens) do not necessarily alleviate FI over an extended period of time, particularly in resource-rich settings^(23,43–45). While food provision can provide other benefits (e.g. the mitigation of hunger⁽²⁴⁾ (a physical sensation experienced by those with severe FI)⁽⁴⁶⁾, entry points to health-care services⁽²⁵⁾, promotion of social interactions^(41,47) and support for development of daily routines^(25,45), the root driver of FI in resource-rich settings is inadequate financial resources^(43,48–50). Our study further demonstrates this as FI remains prevalent among DPC clients despite the provision of food. In addition, there remains a relationship between this prevalent experience and suboptimal cART adherence in this integrated care programme.

While our study cannot evaluate any of the potential mechanisms by which FI leads to suboptimal cART adherence, our work provides impetus for additional research to better understand how to attenuate the relationship between these two factors in this setting and in other similar environments. For example, FI has a known association with depression^(51,52) and dependence on drugs and alcohol⁽⁵³⁾, all of which are linked with suboptimal cART adherence^(39,54–56). FI, along with other needs (e.g. housing, transportation) that stem from limited financial resources, may also impact cART adherence when meeting these needs interferes with medication access or medical appointments^(19,57,58). Analyses that explicate how these pathways may be leveraged to attenuate the impact of FI on cART adherence among structurally vulnerable PLHIV are necessary.

The findings of the present study also point to a need to consider the broader implications of food provision within integrated care models, beyond the scope of mitigating FI. In particular, the food programme at the DPC can be conceptualized within the organization's broader harm reduction mandate, which aims to improve health and reduce health- and drug-related harms^(21,41,45). For example, the food programme at the DPC has been shown to be an integral element of the Centre and a primary access point for individuals interacting with the space^(25,45). Overall, the benefits of integrated care models that include food provision must consider how programming may positively impact clients through a harm reduction approach, even if experiences, such as FI, remain prevalent.

The DPC offers a unique environment in which to study FI and adherence to cART. However, our study warrants consideration of some potential limitations. Participants of the present study were not randomly selected and are thus not representative of the general population of PLHIV in BC. In fact, because the admission requirements for the DPC necessitate a deteriorating health status⁽²¹⁾, the sample in the present study may over-represent individuals with complex health needs. In addition, while the HFSSM is a



validated measurement tool for FI, fluctuations in FI within a 12-month period is an inherent limitation to the use of the HFSSM⁽⁴⁶⁾. Another limitation of the study is that we are unable to stratify our analysis or adjust our regression models by whether a participant in fact received meals at the DPC. Therefore, we cannot directly attribute the impact of this particular service on the relationship between FI and adherence. However, previous work conducted among thirty DPC clients who used illicit drugs showed that 100% (*n* 30) of clients surveyed accessed the DPC food programme for some of their meals, with 80% (*n* 24) using the programme daily and the other 20% (*n* 6) using the programme weekly (C Miewald, unpublished results). Our findings are contextualized based on this understanding, as well as other published literature including DPC clients^(25,45).

Conclusion

In conclusion, the present study documented a high prevalence of FI among DPC clients in Vancouver, Canada. As such, while food provision may have benefits related to harm reduction, there remains a relationship between this prevalent experience and cART adherence in this integrated care programme. Future studies that elucidate strategies to mitigate FI among PLHIV in this setting and in other similar environments are necessary.

Acknowledgements

Acknowledgements: The authors would like to thank the participants in the Dr. Peter Centre Study, the peer research associates, the DPC Community Advisory Committee, and study co-investigators: Rolando Barrios, Stuart Skinner, Silvia Guillemi, Susan Kirkland, M.-J. Milloy, Carol Strike, Bernadette Pauly, Hasina Samji, Kate Salters and Ciro Panessa. *Financial support:* The Dr. Peter Centre Study is funded by the Canadian Institutes of Health Research (CIHR; grant number CIHR R-PHE-122186); the DTP receives funding from the British Columbia provincial government through PharmaCare; T.M. is supported by a Canadian HIV Observational Cohort (CANOC) Centre Postdoctoral Award, a joint programme of CANOC and the CIHR Canadian HIV Trials Network (grant number CTN 242); and A.B.C. is supported by a Vanier Canada Graduate Scholarship. The funders had no role in the design, analysis or writing of this article. *Conflict of interest:* None. *Authorship:* R.S.H. and S.P. contributed to the study's conception and implementation. K.K. and T.M. conceptualized the study design and analysis plan. L.W. and J.L. analysed the data. K.K. and A.B.C. prepared the original manuscript draft, with subsequent drafts led by K.K. and T.M. P.M., R.B.-T., C.M., K.A.S., R.S.H. and S.P. provided critical feedback on further revisions. All authors read and approved the final manuscript. *Ethics of human subject participation:* This study was conducted according to the

guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Simon Fraser University and Providence Healthcare/University of British Columbia research ethics boards. Written informed consent was obtained from all subjects.

References

- Cheung CC, Ding E, Sereda P *et al.* (2016) Reductions in all-cause and cause-specific mortality among HIV-infected individuals receiving antiretroviral therapy in British Columbia, Canada: 2001–2012. *HIV Med* **17**, 694–701.
- Montaner JSG, Lima VD, Harrigan PR *et al.* (2014) Expansion of HAART coverage is associated with sustained decreases in HIV/AIDS morbidity, mortality and HIV transmission: the 'HIV Treatment as Prevention' experience in a Canadian setting. *PLoS One* **9**, e87872.
- Samji H, Cescon A, Hogg RS *et al.* (2013) Closing the gap: increases in life expectancy among treated HIV-positive individuals in the United States and Canada. *PLoS One* **8**, e81355.
- Anema A, Chan K, Chen Y *et al.* (2013) Relationship between food insecurity and mortality among HIV-positive injection drug users receiving antiretroviral therapy in British Columbia, Canada. *PLoS One* **8**, e61277.
- McMahon J, Wanke C, Terrin N *et al.* (2011) Poverty, hunger, education, and residential status impact survival in HIV. *AIDS Behav* **15**, 1503–1511.
- Krüsi A, Wood E, Montaner J *et al.* (2010) Social and structural determinants of HAART access and adherence among injection drug users. *Int J Drug Policy* **21**, 4–9.
- Strike C, Rudzinski K, Patterson J *et al.* (2012) Frequent food insecurity among injection drug users: correlates and concerns. *BMC Public Health* **12**, 1058.
- Anema A, Fielden SJ, Shurgold S *et al.* (2016) Association between food insecurity and procurement methods among people living with HIV in a high resource setting. *PLoS One* **11**, e0157630.
- Kalichman SC, Washington C, Grebler T *et al.* (2015) Medication adherence and health outcomes of people living with HIV who are food insecure and prescribed antiretrovirals that should be taken with food. *Infect Dis Ther* **4**, 79–91.
- Aibibula W, Cox J, Hamelin A-M *et al.* (2017) Association between food insecurity and HIV viral suppression: a systematic review and meta-analysis. *AIDS Behav* **21**, 754–765.
- Weiser SD, Yuan C, Guzman D *et al.* (2013) Food insecurity and HIV clinical outcomes in a longitudinal study of urban homeless and marginally housed HIV-infected individuals. *AIDS* **27**, 2953–2958.
- Aibibula W, Cox J, Hamelin A-M *et al.* (2016) Food insecurity and low CD4 count among HIV-infected people: a systematic review and meta-analysis. *AIDS Care* **28**, 1577–1585.
- Lima V, Anema A, Bangsberg D *et al.* (2009) The association between food insecurity and mortality among HIV-infected individuals on HAART. *J Acquir Immune Defic Syndr* **52**, 342–349.
- de Pee S, Grede N, Mehra D *et al.* (2014) The enabling effect of food assistance in improving adherence and/or treatment completion for antiretroviral therapy and tuberculosis treatment: a literature review. *AIDS Behav* **18**, 531–541.
- Anema A, Kerr T, Milloy M *et al.* (2014) Relationship between hunger, adherence to antiretroviral therapy and plasma HIV RNA suppression among HIV-positive illicit drug users in a Canadian setting. *AIDS Care* **26**, 459–465.
- Young S, Wheeler AC, McCoy SI *et al.* (2014) A review of the role of food insecurity in adherence to care and treatment among adult and pediatric populations living with HIV and AIDS. *AIDS Behav* **18**, 505–515.



17. Frega R, Duffy F, Rawat R *et al.* (2010) Food insecurity in the context of HIV/AIDS: a framework for a new era of programming. *Food Nutr Bull* **31**, 292–312.
18. Singer AW, Weiser SD & McCoy SI (2015) Does food insecurity undermine adherence to antiretroviral therapy? A systematic review. *AIDS Behav* **19**, 1510–1526.
19. Hatcher AM, Tsai AC, Cohen CR *et al.* (2011) Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *Am J Clin Nutr* **94**, issue 6, 1729S–1739S.
20. Anema A, Vogenthaler N, Frongillo EA *et al.* (2009) Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Curr HIV/AIDS Rep* **6**, 224–231.
21. Fernando S, McNeil R, Closson K *et al.* (2016) An integrated approach to care attracts people living with HIV who use illicit drugs in an urban centre with a concentrated HIV epidemic. *Harm Reduct J* **13**, 31.
22. Dr Peter AIDS Foundation (2016) Food and Nutrition. <https://www.drpeter.org/dr-peter-centre/programs-and-services/food-and-nutrition/> (accessed March 2019).
23. Tarasuk V (2001) A critical examination of community-based responses to household food insecurity in Canada. *Health Educ Behav* **28**, 487–499.
24. Tarasuk V & Eakin JM (2003) Charitable food assistance as symbolic gesture: an ethnographic study of food banks in Ontario. *Soc Sci Med* **56**, 1505–1515.
25. Collins AB, Parashar S, Hogg RS *et al.* (2017) Integrated HIV care and service engagement among people living with HIV who use drugs in a setting with a community-wide treatment as prevention initiative: a qualitative study in Vancouver, Canada. *J Int AIDS Soc* **20**, 21407.
26. Hogg RS, Yip B, Chan KJ *et al.* (2001) Rates of disease progression by baseline CD4 cell count and viral load after initiating triple-drug therapy. *JAMA* **286**, 2568–2577.
27. Kirkpatrick SI & Tarasuk V (2008) Food insecurity in Canada: considerations for monitoring. *Can J Public Health* **99**, 324–327.
28. Health Canada (2007) *Canadian Community Health Survey, Cycle 2.2, Nutrition (2004): income-Related Household Food Insecurity in Canada*. Ottawa: Health Canada.
29. Steiner JF & Prochazka AV (1997) The assessment of refill compliance using pharmacy records: methods, validity, and applications. *J Clin Epidemiol* **50**, 105–116.
30. Gross R, Yip B, Lo V *et al.* (2006) A simple, dynamic measure of antiretroviral therapy adherence predicts failure to maintain HIV-1 suppression. *J Infect Dis* **194**, 1108–1114.
31. Palepu A, Tyndall MW, Joy R *et al.* (2006) Antiretroviral adherence and HIV treatment outcomes among HIV/HCV co-infected injection drug users: the role of methadone maintenance therapy. *Drug Alcohol Depend* **84**, 188–194.
32. Low-Beer S, Yip B, O'Shaughnessy MV *et al.* (2000) Adherence to triple therapy and viral load response. *Acquir Immune Defic Syndr* **23**, 360–361.
33. Weiser SD, Leiter K, Bangsberg DR *et al.* (2007) Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. *PLoS Med* **4**, 1589–1598.
34. Shannon K, Kerr T, Milloy M *et al.* (2011) Severe food insecurity is associated with elevated unprotected sex among HIV-seropositive injection drug users independent of HAART use. *AIDS* **25**, 2037–2042.
35. Ballinger GA (2004) Using generalized estimating equations for longitudinal data analysis. *Organ Res Methods* **7**, 127–150.
36. Zorn CJW (2001) Generalized estimating equation models for correlated data: a review with applications. *Midwest Polit Sci Assoc* **45**, 470–490.
37. Maldonado G & Greenland S (1993) Simulation study of confounder-selection strategies. *Am J Epidemiol* **138**, 923–936.
38. Mickey RM & Greenland S (1989) The impact of confounder selection criteria on effect estimation. *Am J Epidemiol* **129**, 125–137.
39. Lima VD, Geller J, Bangsberg DR *et al.* (2007) The effect of adherence on the association between depressive symptoms and mortality among HIV-infected individuals first initiating HAART. *AIDS* **21**, 1175–1183.
40. Anema A, Weiser SD, Fernandes KA *et al.* (2011) High prevalence of food insecurity among HIV-infected individuals receiving HAART in a resource-rich setting. *AIDS Care* **23**, 221–230.
41. Miewald C, Granger B, Grieve S *et al.* (2017) *Food as Harm Reduction: Summary Report Examining the Intersections of Food Security, Food Access and Harm Reduction Services for PLWHA Who Use Drugs in Vancouver, BC*. Burnaby: Simon Fraser University.
42. Kalichman SC, Hernandez D, Cherry C *et al.* (2014) Food insecurity and other poverty indicators among people living with HIV/AIDS: effects on treatment and health outcomes. *J Community Health* **39**, 1133–1139.
43. Kirkpatrick SI & Tarasuk V (2009) Food insecurity and participation in community food programs among low-income. *Can J Public Health* **100**, 135–139.
44. Bazerghi C, McKay FH & Dunn M (2016) The role of food banks in addressing food insecurity: a systematic review. *J Community Health* **41**, 732–740.
45. Miewald C, McCann E, Temenos C *et al.* (2019) 'I do my best to eat while I'm using': mapping the foodscapes of people living with HIV/AIDS who use drugs. *Soc Sci Med* **226**, 96–103.
46. Tarasuk VS (2001) *Discussion Paper on Household and Individual Level Food Insecurity*. Ottawa: Health Canada.
47. Miewald C, McCann E, McIntosh A *et al.* (2018) Food as harm reduction: barriers, strategies, and opportunities at the intersection of nutrition and drug-related harm. *Crit Public Health* **28**, 586–595.
48. Che J & Chen J (2001) Food insecurity in Canadian households. *Health Rep* **12**, issue 4, 11–22.
49. Vozoris NT & Tarasuk VS (2003) Household food insufficiency is associated with poorer health. *J Nutr* **133**, 120–126.
50. McIntyre L, Connor SK & Warren J (2000) Child hunger in Canada: results of the 1994 national longitudinal survey of children and youth. *CMAJ* **163**, 961–965.
51. Palar K, Kushel M, Frongillo EA *et al.* (2015) Food insecurity is longitudinally associated with depressive symptoms among homeless and marginally-housed individuals living with HIV. *AIDS Behav* **19**, 1527–1534.
52. Vogenthaler NS, Hadley C, Rodriguez AE *et al.* (2011) Depressive symptoms and food insufficiency among HIV-infected crack users in Atlanta and Miami. *AIDS Behav* **15**, 1520–1526.
53. Kalichman SC, Grebler T, Amaral CM *et al.* (2014) Food insecurity and antiretroviral adherence among HIV positive adults who drink alcohol. *J Behav Med* **37**, 1009–1018.
54. Mugavero M, Ostermann J, Whetton K *et al.* (2006) Barriers to antiretroviral adherence: the importance of depression, abuse, and other traumatic events. *AIDS Patient Care STDS* **20**, 418–428.
55. Vagenas P, Azar MM, Copenhaver MM *et al.* (2015) The impact of alcohol use and related disorders on the HIV continuum of care: a systematic review. *Curr HIV/AIDS Rep* **12**, 421–436.
56. Anema A, Wood E, Weiser SD *et al.* (2010) Hunger and associated harms among injection drug users in an urban Canadian setting. *Subst Abuse Treat Prev Policy* **5**, 20.
57. Kushel MB, Gupta R, Gee L *et al.* (2006) Housing instability and food insecurity as barriers to health care among low-income Americans. *J Gen Intern Med* **21**, 71–77.
58. Cunningham WE, Andersen RM, Katz MH *et al.* (1999) The impact of competing subsistence needs and barriers on access to medical care for persons with human immunodeficiency virus receiving care in the United States. *Med Care* **37**, 1270–1281.