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A CROSS-SECTIONAL EXAMINATION OF HIV, AGING, AND CHRONIC HEALTH CONDITIONS AMONG GAY AND BISEXUAL MEN

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ABSTRACT

Purpose

The purpose of this study was to evaluate the association between HIV status and the presence of chronic health conditions among gay and bisexual men (gbMSM). Most existing on this topic studies fail to account for behavioral factors—such as smoking and alcohol consumption—or focus on the general population without attention to the unique circumstances of gbMSM.

Methods

Sexually active gbMSM, aged ≥16 years, were recruited using respondent-driven sampling (RDS) between February 2012 and February 2015. HIV serology confirmed the HIV status. Chronic health conditions were classified into one of six broader categories (i.e., cardiovascular, cancer, gastrointestinal, respiratory, mental health, and other). Logistic regression models tested whether HIV status was associated with any of the six categories. All these models used an interaction term between HIV status and age, and adjusted for race/ethnicity, annual income, body mass index, daily smoking, and "risky drinking".

Results
Overall, 223 HIV-positive gbMSM and 551 HIV-negative gbMSM reported histories of cardiovascular disease (16.1%), cancer (5.1%), gastrointestinal illness (7.2%), respiratory problems (16.1%), mental health conditions (49.2%), and "other" co-/morbidities (13.1%). Compared with older HIV-negative gbMSM, those with HIV were more likely to report cardiovascular (aOR=1.15, 95% CI:1.07, 1.24) and respiratory (aOR = 1.08, 95% CI:1.02, 1.14) disease. There were no differences by HIV status for other co-/morbidities.

Conclusion
Findings support the need for increased resources focused on aging, HIV, and cardiovascular and respiratory health among gbMSM aging with HIV.

Keywords: *aging; comorbidities; chronic health; gay and bisexual men; people living with HIV*

INTRODUCTION

The expansion of antiretroviral therapy has contributed to sustained decreases in HIV-related morbidity and mortality.[1] Where antiretroviral therapy is accessible, the life expectancy of people living with HIV (PLWH) is now approaching that of the general population.[2,3] As such, there has been a shift in morbidity and mortality among PLWH, with an increasing number of deaths attributed to non-HIV-related causes.[4,5] HIV is now widely considered as a chronic disease[6]—complicated, of course, by other chronic health conditions[7,8] and the aging population of PLWH.[9,10]

This shift in the epidemic has significantly improved the life expectancy of gay, bisexual, and other men who have sex with men (gbMSM) living in developed countries, who in addition to accounting for the majority of the epidemic in these areas[11,12] are also subject to many other disparities.[13] For instance, gbMSM are reportedly at elevated risk for cardiovascular disease,[14] certain cancers,[15] respiratory and gastrointestinal health problems,[16] and mental health problems.[17,18] Contextualizing these disparities, Meyer's minority stress theory posits that gbMSM are subjected to unique stressors associated with their stigmatized status.[19] Syndemics theory has also been used to highlight the ways in which psychological distress, driven by overlapping and reinforcing structural drivers contributes to biological degradation.[20] In one potential causal pathway, these stressors are hypothesized to contribute to maladaptive coping and physiological degradation, thereby inhibiting normal immune response and healthy bodily function.[21–23]

gbMSM with HIV experience additional stressors associated with HIV-related trauma,[24] stigma,[25] infection,[26] and treatment side-effects[27]—though pharmaceutical advancements have significantly improved the safety and tolerability of contemporary antiretroviral therapy regimens.[28,29] Yet, research comparing general populations of PLWH to those without HIV has shown that they are at increased risk for cause-specific and all-cause mortality.[2] Further, HIV infection is associated with worse health-related quality of life and with a higher prevalence of other co-/morbidities.[9,30–32] However, most analyses assessing the relationship between HIV status and physical health have been conducted in the general population and therefore this intersection remains relatively unexamined among gbMSM.

Some evidence suggests that the additive effects of multiple overlapping minority statuses (e.g., being a sexual minority and living with HIV) may synergistically contribute to poorer health[33]—an insight also shared by investigations of syndemics (i.e., *two or more co-occurring diseases*

or conditions which act synergistically to promote poor health) among gbMSM.[20,34,35] One pathway by which these proposed stressors could contribute to poorer health is through increased substance use, including consumption of tobacco, alcohol, or other drugs.[36–38] Indeed, people living with HIV are at increased risk for substance use.[39,40] Therefore, the health disparities associated with HIV infection may be largely attributable to other behavioral factors such as tobacco or alcohol use.[38]

While several general population studies have taken into account the role of lifestyle factors,[41–45] studies investigating chronic health among gbMSM have not always accounted for this factor. This is frequently because studies based on administrative data do not always aggregate by sexual orientation as well as limitations in administrative and medical record datasets. For example, Patel et al.[46] reported that cancer was associated with HIV infection. However, as they were not able to measure behavioral factors such as smoking, they concluded that "*because the prevalence of smoking varies among specific groups in the United States (for example, by sex, race, or HIV risk), some characteristics associated with cancer in our analyses may have been surrogates for smoking status*" (p. 734). In other words, these lifestyle factors may play a confounding role in the association between HIV and poorer chronic health—particularly when considering gbMSM who report higher rates of smoking and alcohol consumption compared to the general population.[46,47]

Further, increased awareness and sensitivity to HIV health concerns among gbMSM, operationalized through social and medical supports, ameliorate some of the health disparities associated with HIV.[48,49] Indeed, healthcare access is an important antecedent to the prevention, diagnosis, and treatment of co-/morbidities.[50] Regardless of which hypothesis proves most salient, the intersection between HIV status and chronic health conditions among gbMSM is an important research area to assess, especially as more PLWH are surviving into older age. We designed a study to provide respondent-driven sampling (RDS)-adjusted estimates of chronic health conditions and to examine the association between HIV status, aging, and these chronic health conditions among gbMSM in Metro Vancouver.

Methods

Study protocol

Participants were enrolled into the Momentum Health Study, a prospective cohort of sexually active gbMSM, aged >16 years, residing in Metro Vancouver, Canada. Baseline cross-sectional data, collected between February 2012 and February 2015, were used. Participants were recruited through RDS.[51] Individuals presenting RDS coupons were screened for eligibility and provided written informed consent before completing a computer-administered questionnaire in English. The RDS was selected as it is now a widely accepted gold standard for gathering point estimates that are more representative of hidden and hard to reach populations, such as gbMSM.[51] Also, RDS leverages participant networks to reach diverse participants and uses sample weights to adjust for unequal probabilities of recruitment arising from network characteristics.[51] The study questionnaire was used to collect demographic, psychosocial, and behavioral variables. Upon completion of the survey, participants completed a short interview with a study nurse wherein they completed a brief medical history and underwent serology for HIV, Hepatitis C, and syphilis and specimen collection for other sexually transmitted infections. Participants received a $50 honorarium for the study visit and $10 for each eligible participant they recruited into the study.

Ethics, consent, and permissions

Ethics approval was granted by the research ethics boards at Simon Fraser University, the University of British Columbia, and the University of Victoria. All participants provided informed consent.

Dependent variables

Participants were asked, "have you ever been told by a doctor that you have any of the following chronic diseases or conditions?" and were provided with a list of conditions as well as the opportunity to provide free-field text for other chronic health conditions that are not assessed. Response items were broadly categorized into six categories: cardiovascular (i.e., coronary artery disease/angina, congestive heart failure, high blood pressure, high cholesterol, stroke or transient stroke), cancer (e.g., leukemia, prostate), gastrointestinal (i.e., stomach ulcers), respiratory (i.e., asthma, chronic bronchitis or chronic obstructive pulmonary disorder), mental health (i.e., anxiety, depression, bipolar, schizophrenia), and "other" (i.e., diabetes, chronic kidney disease, enlarged prostate) co-/morbidities. If the free-field text were relevant to one of the defined categories, then they were reclassified (e.g., "colitis", "Crohn's", or "gastroesophageal reflux disease" were classified under the gastrointestinal category).

Independent variables

We compared participants by HIV status based on serological tests. The primary exposure variable was an interaction term between HIV status and age. This was hypothesized a priori given that most co-/morbidities do not present until middle and older age. Potential confounders considered in this analysis included age (continuous), race/ethnicity (White, Asian, Aboriginal, other), annual income in Canadian dollars (<$30,000, ≥$30,000), body mass index (BMI; <25, ≥25), whether the participant smoked daily (i.e., "On average, how many cigarettes do you smoke on a typical day?": dichotomized as 0, ≥1), and whether they engaged in "risky drinking" (defined by the Alcohol Use Disorders Identification Test AUDIT with scores ≥16).[52] We note that clinical cut-offs for the AUDIT scale frequently promote intervention with scores greater than 7. However, based on sensitivity analyses, higher baseline prevalence of alcohol use and binge drinking among gbMSM, and focusing on increasing specificity of identifying chronic health conditions, we selected a cut point that discriminated between harmful/dependent use and low-risk/risky use. That said, we recommend that intervention-based studies in clinical settings should continue to use the cut-score of 8 to investigate potential problems related to alcohol use.

Statistical analysis

All statistical analyses were performed in SAS v.9.4. All analyses were RDS-adjusted using RDSAT v.7.1.46. Logistic regression was used to show the bivariable association between HIV-status and any of the disease categories described above (i.e., cardiovascular, cancer, gastrointestinal, respiratory, mental health, other), as well as age and all potential confounders. Multivariable confounding models (i.e., logistic regression models controlling for confounding variables) for each health category were constructed with the interaction between HIV status and age as main exposure, controlling for race/ethnicity, annual income, body mass index, daily smoking, and risky drinking. As our primary explanatory variable tested an interaction term, we also calculated the age at which the association between HIV status and co-/morbidities reversed/inflected. For each model described above, two-sided tests were used and considered significant if $P < 0.05$.

RESULTS

Data from 223 HIV-positive gbMSM and 551 HIV-negative gbMSM were collected. Crude and RDS-adjusted descriptive statistics, stratified by HIV status, are provided in Table 1. Overall, the sample was predominantly white, had annual incomes <$30,000, and had a median age of 34 years (Q_1, Q_3:26, 47). Almost half of the sample (49.1%) reported "fair" or "poor" overall physical health, 35.1% reported "good" health, and 15.8% reported "very good" or "excellent" health. One-third (32.8%) of men had a body mass index ≥25.

TABLE 1 RDS-Adjusted Descriptive Statistics and Univariate Associations with HIV Status

	gbMSM without HIV (n = 551)		gbMSM with HIV (n = 223)		Univariate
	Frequency	**RDS%**	**Frequency**	**RDS%**	**OR (95% CI)**
Age *(Median in years, Q1, Q3)*	*Median: 30*	*(Q_1, Q_3): 24, 39*	*Median: 47*	*(Q_1, Q_3): 39, 53*	**1.09 (1.07, 1.11)**
Race/Ethnicity					
White	412	69.5	173	70.3	Ref
Asian	61	10.2	13	6.0	0.58 (0.29, 1.18)
Aboriginal	27	6.8	23	15.4	**2.24 (1.31, 3.83)**
Other	51	13.5	14	8.3	0.61 (0.33, 1.12)
Annual income (CAD)					
Less than $30,000	325	68.1	160	76.4	Ref
$30,000–$59,999	226	31.9	63	23.6	**0.66 (0.44, 0.98)**
Self-rated overall physical health					
Fair/Poor	321	54.7	110	44.8	Ref
Good	172	32.3	71	36.8	1.39 (0.95, 2.05)
Very good/Excellent	56	13.1	40	18.3	**1.71 (1.04, 2.79)**
Doctor-diagnosed health conditions (Yes vs No)					
Cardiovascular	80	14.1	60	24.9	**2.01 (1.32, 3.06)**
Cancer	17	3.2	26	9.0	**3.00 (1.49, 6.04)**
Gastrointestinal	41	6.9	17	7.0	1.01 (0.51, 1.98)
Respiratory	84	15.0	31	16.8	1.14 (0.72, 1.81)
Mental Health	202	43.0	140	60.7	**2.05 (1.44, 2.92)**
Other	70	13.2	29	15.6	1.22 (0.75, 1.97)
Body mass index (≥ 25 vs <25)	182	30.6	83	34.8	1.21 (0.84, 1.73)
Daily smoking (Yes vs No)	122	26.3	66	28.5	1.11 (0.76, 1.64)
Risky drinking (AUDIT)					
Low risk (0–7)	296	56.7	165	76.9	Ref
Medium risk (8–15)	171	27.9	33	13.9	**0.37 (0.23, 0.60)**
Harmful/Possible dependence (≥16)	83	15.4	21	9.2	**0.44 (0.25, 0.79)**

Bold values indicate $P < 0.05$.
RDS = Respondent-driven sampling; OR = odds ratio; CI = Confidence interval; AUDIT = Alcohol Use Disorder Identification Test; CAD = Canadian dollars.

Daily smoking was reported by 31.5% of men (95% CI: 25.4%, 37.6%) and 13.4% (95% CI: 8.7%, 17.7%) of men were classified by the alcohol use disorder identification test as "harmful/possibly dependent" drinkers.

A total of 16.7% (95% CI: 12.0%, 21.6%) gbMSM reported having ever had a cardiovascular health condition, 5.1% (95% CI: 2.9%, 7.6%) reported a cancer diagnosis, 7.2% (95% CI: 4.9%, 10.0%) reported diagnosis of a gastrointestinal health condition, 16.1% (95% CI: 11.7%, 20.8%) reported diagnosis of a respiratory health condition, 49.2% (95% CI: 43.3%, 55.5%) reported a mental health diagnosis, and 13.3% (95% CI: 9.3%, 17.9%) reported a diagnosed health condition classified in this study as "other". Overall, we observed that the reported doctor diagnoses increased with age. In the older age groups (i.e., 60–64, 65+), cardiovascular disease, respiratory disease, and "other" conditions were the most commonly reported comorbidities.

Compared with HIV-negative gbMSM, gbMSM living with HIV were older (OR: 1.09, 95% CI: 1.07, 1.11). In fact, the median age of HIV-positive men was 17 years higher (HIV-negative men: median = 30 Q_1, Q_3 = 24, 39 vs HIV-positive men: median = 47 Q_1, Q_3 = 39, 53). Figure 1 shows the age distribution of the sample stratified by HIV status. In addition to being older, gbMSM with HIV were also more likely to be indigenous (OR: 2.24, 95% CI: 1.07, 1.11), had lower annual incomes (OR: 0.66, 95% CI: 0.44, 0.98), reported better subjective physical health overall (very good/excellent vs fair/poor, OR: 1.71, 95% CI: 1.04, 2.79), and had lower alcohol use disorder identification test scores. HIV-positive men did not differ with regards to daily smoking (OR: 1.11, 95% CI: 0.76, 1.64) or body mass index (OR: 1.21, 95% CI: 0.84, 1.73).

Table 2 provides the multivariable results testing an association between each co-/morbidity category and the included interaction between age and HIV status. The age at which associations inflect is also provided—most of which occur in the participant's late 40s or early 50s. Stratified odds ratios for the association between diagnoses and age are

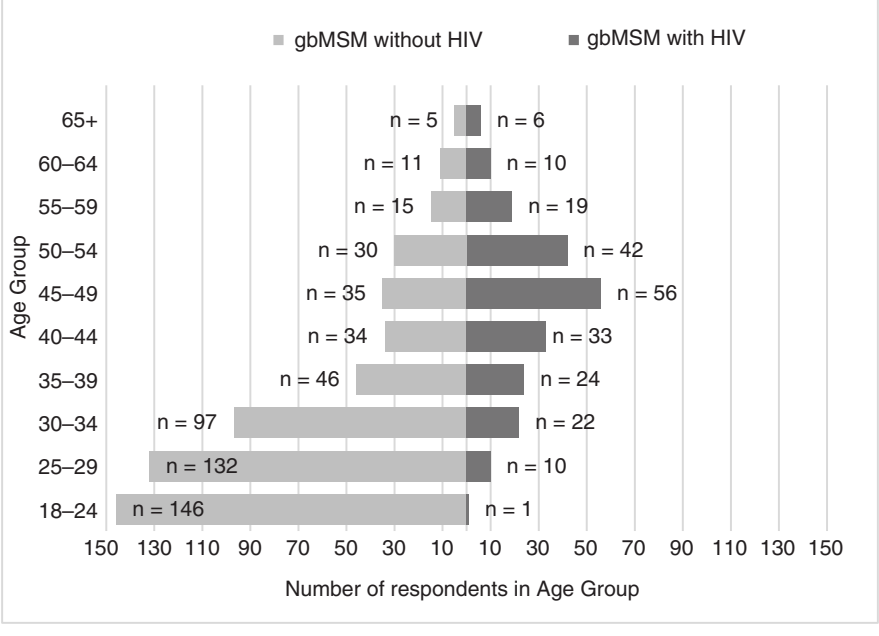

FIGURE 1 Age distribution for gbMSM in the momentum health study.

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TABLE 2 Multivariable Results for Each Chronic Health Condition Category

	Cardiovascular aOR (95% CI)	**Respiratory aOR (95% CI)**
HIV-status x age	**1.15 (1.07, 1.24)**	**1.08 (1.02, 1.14)**
Youngest (18): HIV + vs -	**0.01 (0.00, 0.14)**	**0.10 (0.02, 0.58)**
Young (26): HIV + vs -	**0.03 (0.01, 0.24)**	**0.18 (0.05, 0.71)**
Mid (34): HIV + vs -	**0.11 (0.03, 0.42)**	**0.33 (0.13, 0.89)**
Old (47): HIV + vs -	0.67 (0.36, 1.24)	0.89 (0.50, 1.59)
Oldest (80): HIV + vs -	**68.76 (6.65, 710.95)**	**10.75 (1.77, 65.21)**
Age association inflects	49.91	48.50
HIV-: Age	**1.08 (1.06, 1.11)**	1.01 (0.99, 1.03)
HIV+: Age	**1.25 (1.16, 1.34)**	**1.09 (1.04, 1.15)**
	Mental health aOR (95% CI)	**Gastrointestinal aOR (95% CI)**
HIV-status x age	0.98 (0.95, 1.02)	1.04 (0.97, 1.11)
Youngest (18): HIV + vs -	2.21 (0.77, 6.41)	0.43 (0.05, 3.53)
Young (26): HIV + vs -	1.96 (0.89, 4.33)	0.57 (0.12, 2.84)
Mid (34): HIV + vs -	1.74 (1.00, 3.02)	0.76 (0.24, 2.41)
Old (47): HIV + vs -	1.42 (0.92, 2.20)	1.22 (0.54, 2.73)
Oldest (80): HIV + vs -	0.86 (2.20, 3.66)	4.00 (0.31, 50.98)
Age association inflects	70.32	41.54
HIV-: Age	**1.04 (1.02, 1.05)**	1.00 (0.97, 1.02)
HIV+: Age	1.02 (0.99, 1.06)	1.03 (0.97, 1.10)
	Cancer aOR (95% CI)	**Other aOR (95% CI)**
HIV-status x age	0.99 (0.92, 1.07)	1.04 (0.98, 1.10)
Youngest (18): HIV + vs -	1.88 (0.16, 22.52)	0.18 (0.03, 1.18)
Young (26): HIV + vs -	1.72 (0.25, 11.83)	0.24 (0.06, 1.04)
Mid (34): HIV + vs -	1.58 (0.39, 6.41)	**0.33 (0.11, 0.95)**
Old (47): HIV + vs -	1.37 (0.62, 3.04)	**0.55 (0.30, 0.98)**
Oldest (80): HIV + vs -	0.96 (0.09, 10.4)	1.98 (0.32, 12.29)
Age association inflects	76.80	62.43
HIV-: Age	**1.07 (1.04, 1.10)**	**1.06 (1.04, 1.08)**
HIV+: Age	1.06 (0.99, 1.13)	**1.10 (1.04, 1.16)**

Bold values indicate P < 0.05.
Adjusted for ethnicity, income, BMI, tobacco use, and alcohol use.

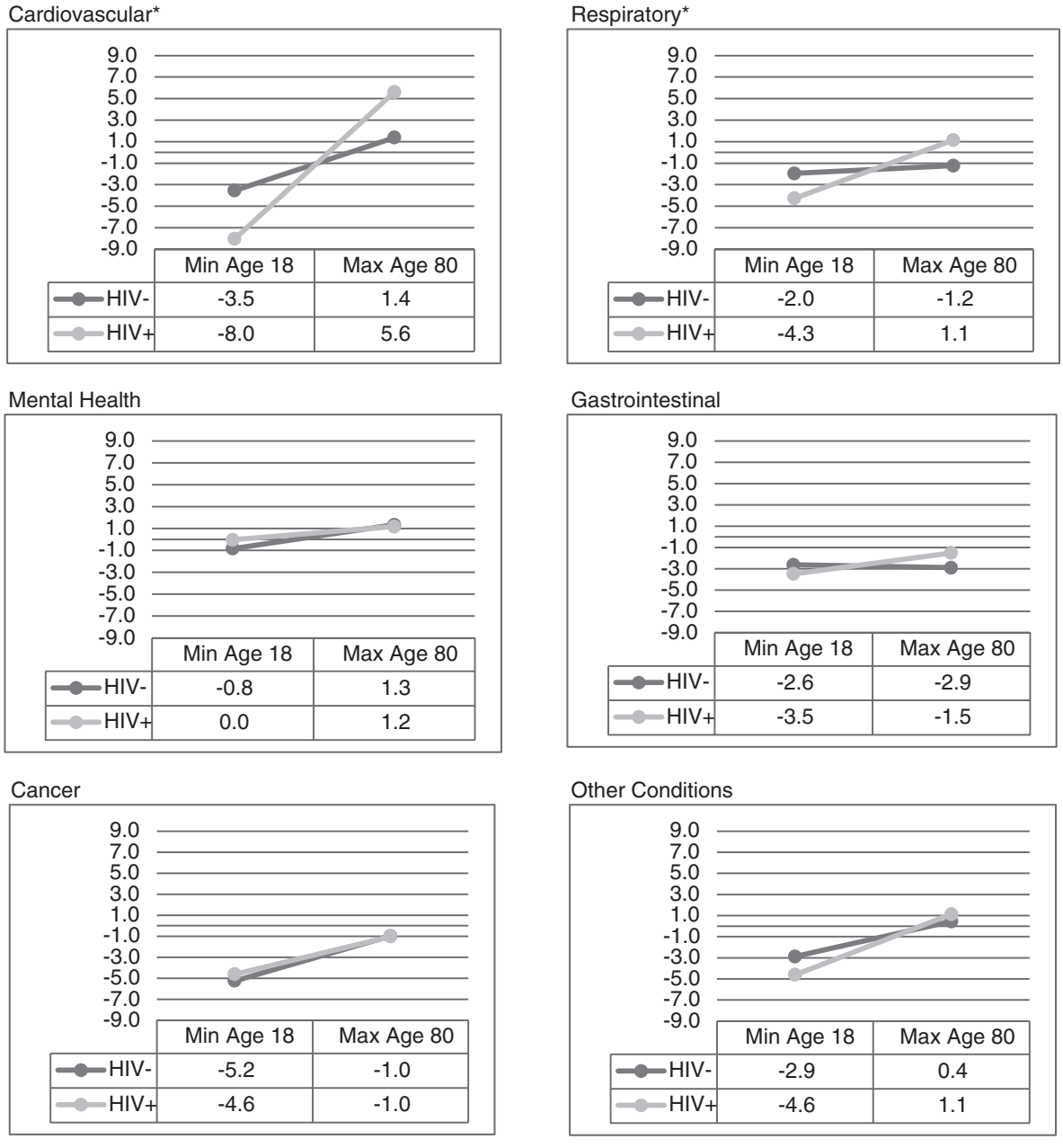

FIGURE 2 Log-odds probability of each outcome from minimum to maximum age (18 to 80). * indicates statistically significant interaction.

also reported separately for gbMSM with and without HIV. Visualizing these results, Figure 2 shows a series of interaction plots showing the log odds of each health condition comparing older and younger gbMSM, by HIV status. These results show that the HIV status/age interaction term is positively associated with cardiovascular (aOR = 1.15, 95% CI: 1.07, 1.24) and respiratory (aOR = 1.08, 95% CI: 1.02, 1.14) diagnoses. Meanwhile, the interaction terms were not significant in the models assessing cancer

(aOR = 0.99, 95% CI: 0.92, 1.07), gastrointestinal disorders (aOR = 1.04, 95% CI: 0.97, 1.11), mental health (aOR = 0.98, 95% CI: 0.95, 1.02), or other chronic health conditions (aOR = 1.04, 95% CI: 0.98, 1.10).

DISCUSSION

Our aim was to examine the intersection of lifetime co-/morbidity, HIV status, and aging among gbMSM in Vancouver, Canada. We found that older gbMSM with HIV had increased odds of being diagnosed with cardiovascular and respiratory diseases relative to older gbMSM without HIV. Additionally, we found that while gbMSM were more likely to report cancer and mental health diagnoses on the univariate level, these disparities did not persist after accounting for previously identified risk factors (e.g., age, ethnicity, income, body mass index, tobacco use, and alcohol use). As previous studies (e.g., those using administrative data) have not always been able to account for these potential confounders, the present study underscores their importance and suggests that at least some proportion of comorbidity among gbMSM living with HIV is preventable through traditional prevention and behavior modification programs.[53]

With that said, the differential health trajectories between gbMSM living with and without HIV should be interpreted within the growing body of literature which emphasizes the increasing importance of aging and chronic health among PLWH.[10,54,55] For example, regarding cardiovascular and respiratory health (i.e., the two comorbidity categories associated with HIV status in the present analysis), Brown et al. (2017) found that even after accounting for age, gender, smoking, body mass index, and depression, HIV infection was positively associated with poorer clinical respiratory health.[56] Similarly, van Zoest et al. (2016) found that even after accounting for age, sex, ethnicity, family history of hypertension, smoking, alcohol use, physical activity, and body mass index, HIV infection was significantly associated with hypertension.[57]

In agreement with these findings, the present study demonstrates that while younger HIV-positive gbMSM may enjoy a level of health compared with that of HIV-negative men, HIV-related disparities in these health categories begin to emerge after middle age. Contextualizing these patterns, it appears that while younger gbMSM living with HIV are attentive to their health needs—taking the necessary steps to promote and maintain their health and well-being[58–61]—lifestyle factors do not altogether prevent the onset of chronic health conditions later in life. One pathway by which HIV might contribute to poorer cardiovascular and respiratory health is through persistent inflammation and immune activation[56,62,63]—factors that might be associated with structural syndemic experienced by gbMSM as well as minority stressors that impact people living with HIV[14,20,23]. This may be partially attributable to a cohort effect, where older gbMSM who were treated under previous clinical regimens are now experiencing the long-term side-effects of these medications as they age.[4] Alternatively, these findings may suggest that event detection of chronic health conditions is simply higher among gbMSM living with HIV.[50] Indeed, as no causal mechanisms for increased co-/morbidity among older gbMSM with HIV were assessed in the present analysis, it is not clear which of these mechanisms may account for these findings. Future longitudinal analyses will need to assess these trends.

Another important factor to consider is the role that HIV medications might play in the physical health of gbMSM aging with HIV. Indeed, HIV medications have been recently documented as potential risk factors for several adverse chronic health conditions, including neurological disorders,[64] diabetes,[65] heart disease,[66,67] kidney disease,[68] and cancer.[69] However, recent research has shown that early adherence to contemporary antiretroviral therapy regimens may reduce the risk for some co-/morbidities (e.g., cancer),[70] suggesting that early initiation may be one strategy to improve the health of PLWH with the caveat that other co-/morbidities

are closely monitored and treated appropriately. However, despite improved safety and tolerability of current HIV medications,[3,29] additional research is needed to support the health of aging gbMSM who have successfully adhered to antiretroviral therapies for long periods.

Strengths and limitations

The present study offers several methodological strengths. First, the present study reports the association between HIV status, age, and several categories of co-/morbid health problems, providing a broad view of the phenomena under examination. Our analysis includes both HIV-negative and HIV-positive gbMSM of all ages, providing a unique opportunity to evaluate the contributions of age and HIV status to chronic health issues. Second, the use of RDS weightings allows for more representative population parameters within a study population with limitations to using gold standard random sampling. Finally, as many previous studies have not accounted for important chronic-disease risk-factors (e.g., smoking), the present study shows that the association between HIV status and other chronic health conditions persists even after accounting for primary lifestyle and behavioral factors often associated with comorbid health outcomes.

We should note, however, that while previous studies have shown that HIV-positive gbMSM are more likely to report substance use, the HIV-positive men in the present analysis were not more likely to report daily smoking, actually had lower alcohol use disorder identification test scores, and reported better subjective physical health than other gbMSM—though, regarding this last point, we should not necessarily assume that subjective health ratings are comparable between gbMSM living with HIV and those who are not.[71–73] Indeed, gbMSM living with HIV may have a lower baseline expectation for their well-being.[74–76] Alternatively, gbMSM with HIV may engage in greater levels of care thus allowing for primary prevention of chronic illness.[50]

Readers should also be aware of several limitations inherent to the present study. First, our measure of chronic disease relied on reported doctor diagnoses rather than objective measures of the disease. Therefore, it is impossible to ascertain the temporal ordering or etiology of the relationships between various health diagnoses and the factors explored here. For example, we do not know whether the explanatory factors assessed here are presented before or after the chronic health conditions. Further, these observed associations may occur due to better event detection among older and HIV-positive gbMSM, who are often more engaged in healthcare than younger and HIV-negative gbMSM.[50] Further, the use of categorical measures representing multiple chronic health conditions may obscure trends of specific chronic health conditions. Second, as the age structures were significantly different between gbMSM with and without HIV, and because there were fewer HIV-positive gbMSM enrolled in the study, we may not have had sufficient power to detect real differences in the health categories for which the null hypothesis was not rejected (i.e., those for which no significant difference was detected between HIV-positive and HIV-negative gbMSM). We strongly caution readers to be aware that the observed HIV-status-related differences, or lack thereof, in chronic health conditions may simply be an artifact of our sample composition and due to the differences in age for people living with and without HIV (i.e., the HIV-negative men in our sample may simply have yet to develop chronic health conditions). Third, as our sample is comprised of a predominantly gay, white, urban population—characteristics which have previously been linked to better health outcomes[77,78]—it should not be taken to represent all gbMSM. Fourth, we note that we did not collect past histories of smoking or alcohol consumption. Given the long-term health impacts of some substance use consumption patterns, future studies should include a lifetime history of these lifestyle factors. Lastly, some associations may not be significant due to an already elevated prevalence

among gbMSM, as is the case with mental health,[17] or due to the low overall prevalence of outcomes observed in this sample.

CONCLUSIONS

Our findings highlight how some well-documented health disparities among PLWH persists even after adjusting for known HIV risk factors (e.g., age, race/ethnicity, body mass index, smoking, drinking). In doing so, we emphasize the increasing importance that physical health and aging has and will undoubtedly continue to have in shaping the health of gbMSM.[79,80] This is particularly true regarding the intersection between HIV, chronic health, and aging—emphasizing the need for additional research and resources dedicated to addressing this crucial intersection in gbMSM communities.

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CONFLICT OF INTEREST

No competing financial interests exist.

REFERENCES

1. Montaner JSG, Lima VD, Harrigan PR, Lourenço L, Yip B, Nosyk B, et al. 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 2014;9:e87872. https://doi.org/10.1371/journal.pone.0087872.
2. Eyawo O, Franco-Villalobos C, Hull MW, Nohpal A, Samji H, Sereda P, et al. Changes in mortality rates and causes of death in a population-based cohort of persons living with and without HIV from 1996 to 2012. BMC Infect Dis 2017;17. https://doi.org/10.1186/s12879-017-2254-7.
3. Trickey A, May MT, Vehreschild J-J, Obel N, Gill MJ, Crane HM, et al. Survival of HIV-positive patients starting antiretroviral therapy between 1996 and 2013: A collaborative analysis of cohort studies. The Lancet HIV 2017;0. https://doi.org/10.1016/S2352-3018(17)30066-8.
4. Crum NF, Riffenburgh RH, Wegner S, Agan BK, Tasker SA, Spooner KM, et al. Comparisons of causes of death and mortality rates among HIV-infected persons: Analysis of the pre-, early, and late HAART (highly active antiretroviral therapy) eras. J Acquir Immune Defic Syndr 2006;41:194–200.
5. Palella FJ, Baker RK, Moorman AC, Chmiel JS, Wood KC, Brooks JT, et al. Mortality in the highly active antiretroviral therapy era: changing causes of death and disease in the HIV outpatient study. J Acquir Immune Defic Syndr 2006;43:27–34. https://doi.org/10.1097/01.qai.0000233310.90484.16.
6. Deeks SG, Lewin SR, Havlir DV. The end of AIDS: HIV Infection as a Chronic Disease. Lancet 2013;382:1525–33. https://doi.org/10.1016/S0140-6736(13)61809-7.
7. Rodriguez-Penney AT, Iudicello JE, Riggs PK, Doyle K, Ellis RJ, Letendre SL, et al. Co-morbidities in persons infected with HIV: increased burden with older age and negative effects on health-related quality of life. AIDS Patient Care STDS 2013;27:5–16. https://doi.org/10.1089/apc.2012.0329.

8. Vance DE, Mugavero M, Willig J, Raper JL, Saag MS. Aging With HIV: A Cross-Sectional Study of Comorbidity Prevalence and Clinical Characteristics Across Decades of Life. Journal of the Association of Nurses in AIDS Care 2011;22:17–25. https://doi.org/10.1016/j.jana.2010.04.002.
9. Langebeek N, Kooij KW, Wit FW, Stolte IG, Sprangers M a. G, Reiss P, et al. Impact of co-morbidity and aging on health-related quality of life in HIV-positive and HIV-negative individuals. AIDS 2017. https://doi.org/10.1097/QAD.0000000000001511.
10. Sabin CA, Reiss P. Epidemiology of ageing with HIV: What can we learn from cohorts? AIDS 2017;31 Suppl 2:S121–8. https://doi.org/10.1097/QAD.0000000000001374.
11. Centers for Disease Control and Prevention. HIV Infection Risk, Prevention, and Testing Behaviors among Men Who Have Sex with Men National HIV Behavioral Surveillance 20 U.S. Cities, 2014. Atlanta: Centers for Disease Control and Prevention; 2016.
12. Public Health Agency of Canada. Summary: Estimates of HIV incidence, prevalence and proportion undiagnosed in Canada, 2014. 2015.
13. Coker TR, Austin SB, Schuster MA. The health and health care of lesbian, gay, and bisexual adolescents. Annu Rev Public Health 2010;31:457–77. https://doi.org/10.1146/annurev.publhealth.012809.103636.
14. Caceres BA, Brody A, Luscombe RE, Primiano JE, Marusca P, Sitts EM, et al. A Systematic Review of Cardiovascular Disease in Sexual Minorities. Am J Public Health 2017;107:e13–21. https://doi.org/10.2105/AJPH.2016.303630.
15. Quinn GP, Sanchez JA, Sutton SK, Vadaparampil ST, Nguyen GT, Green BL, et al. Cancer and Lesbian, Gay, Bisexual, Transgender/Transsexual, and Queer/Questioning Populations (LGBTQ). CA Cancer J Clin 2015;65:384–400. https://doi.org/10.3322/caac.21288.
16. Sandfort TGM, Bakker F, Schellevis FG, Vanwesenbeeck I. Sexual Orientation and Mental and Physical Health Status: Findings From a Dutch Population Survey. Am J Public Health 2006;96:1119–25. https://doi.org/10.2105/AJPH.2004.058891.
17. Brennan DJ, Ross LE, Dobinson C, Velhuizen S, Steele LS. Men's Sexual Orientation and Health in Canada. Can J Public Health 2010;101:255–8. https://doi.org/10.17269/cjph.101.2361.
18. Pakula B, Shoveller JA. Sexual orientation and self-reported mood disorder diagnosis among Canadian adults. BMC Public Health 2013;13:209. https://doi.org/10.1186/1471-2458-13-209.
19. Meyer I. Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: Conceptual issues and research evidence. Psychol Bull 2003;129:674–97. https://doi.org/10.1037/0033-2909.129.5.674.
20. Singer M, Bulled N, Ostrach B, Mendenhall E. Syndemics and the biosocial conception of health. Lancet 2017;389:941–50. https://doi.org/10.1016/S0140-6736(17)30003-X.
21. Doyle DM, Molix L. Minority stress and inflammatory mediators: covering moderates associations between perceived discrimination and salivary interleukin-6 in gay men. J Behav Med 2016;39:782–92. https://doi.org/10.1007/s10865-016-9784-0.
22. Juster R-P, Hatzenbuehler ML, Mendrek A, Pfaus JG, Smith NG, Johnson PJ, et al. Sexual orientation modulates endocrine stress reactivity. Biol Psychiatry 2015;77:668–76. https://doi.org/10.1016/j.biopsych.2014.08.013.
23. Lick DJ, Durso LE, Johnson KL. Minority Stress and Physical Health Among Sexual Minorities. Perspectives on Psychological Science 2013;8:521–48. https://doi.org/10.1177/1745691613497965.
24. Theuninck AC, Lake N, Gibson S. HIV-related posttraumatic stress disorder: investigating the traumatic events. AIDS Patient Care STDS 2010;24:485–91. https://doi.org/10.1089/apc.2009.0231.
25. Mahajan AP, Sayles JN, Patel VA, Remien RH, Ortiz D, Szekeres G, et al. Stigma in the HIV/AIDS epidemic: A review of the literature and recommendations for the way forward. AIDS 2008;22:S67–79. https://doi.org/10.1097/01.aids.0000327438.13291.62.
26. Deeks SG, Tracy R, Douek DC. Systemic Effects of Inflammation on Health during Chronic HIV Infection. Immunity 2013;39:633–45. https://doi.org/10.1016/j.immuni.2013.10.001.
27. Hima Bindu A, Naga Anusha P. Adverse Effects of Highly Active Anti-Retroviral Therapy (HAART). Journal of Antivirals & Antiretrovirals 2011;3. https://doi.org/10.4172/jaa.1000037.

28. Astuti N, Maggiolo F. Single-Tablet Regimens in HIV Therapy. Infect Dis Ther 2014;3:1–17. https://doi.org/10.1007/s40121-014-0024-z.
29. Hughes CA, Robinson L, Tseng A, MacArthur RD. New antiretroviral drugs: A review of the efficacy, safety, pharmacokinetics, and resistance profile of tipranavir, darunavir, etravirine, rilpivirine, maraviroc, and raltegravir. Expert Opin Pharmacother 2009;10:2445–66. https://doi.org/10.1517/14656560903176446.
30. Lohse N. The road to success. Long-term prognosis for persons living with HIV in Denmark - time trends and risk factors. Dan Med J 2016;63.
31. Schouten J, Wit FW, Stolte IG, Kootstra NA, van der Valk M, Geerlings SE, et al. Cross-sectional comparison of the prevalence of age-associated comorbidities and their risk factors between HIV-infected and uninfected individuals: The AGEhIV cohort study. Clin Infect Dis 2014;59:1787–97. https://doi.org/10.1093/cid/ciu701.
32. Zlotorzynska M, Spaulding AC, Messina LC, Coker D, Ward K, Easley K, et al. Retrospective cohort study of cancer incidence and mortality by HIV status in a Georgia, USA, prisoner cohort during the HAART era. BMJ Open 2016;6:e009778. https://doi.org/10.1136/bmjopen-2015-009778.
33. Boone MR, Cook SH, Wilson PA. Sexual identity and HIV status influence the relationship between internalized stigma and psychological distress in black gay and bisexual men. AIDS Care 2016;28:764–70. https://doi.org/10.1080/09540121.2016.1164801.
34. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of Co-Occurring Psychosocial Health Problems and Increased Vulnerability to HIV/AIDS Among Urban Men Who Have Sex With Men. Am J Public Health 2003;93:939–42.
35. Pollard A, Nadarzynski T, Llewellyn C. Syndemics of stigma, minority-stress, maladaptive coping, risk environments and littoral spaces among men who have sex with men using chemsex. Culture, Health & Sexuality 2017;20:411–27. https://doi.org/10.1080/13691058.2017.1350751.
36. Baum MK, Rafie C, Lai S, Sales S, Page JB, Campa A. Alcohol use accelerates HIV disease progression. AIDS Res Hum Retroviruses 2010;26:511–8. https://doi.org/10.1089/aid.2009.0211.
37. Carrico AW. Substance use and HIV disease progression in the HAART era: implications for the primary prevention of HIV. Life Sci 2011;88:940–7. https://doi.org/10.1016/j.lfs.2010.10.002.
38. Marshall MM, McCormack MC, Kirk GD. Effect of Cigarette Smoking on HIV Acquisition, Progression, and Mortality. AIDS Educ Prev 2009;21:28–39. https://doi.org/10.1521/aeap.2009.21.3_supp.28.
39. Lachowsky NJ, Dulai JJS, Cui Z, Sereda P, Rich A, Patterson TL, et al. Lifetime Doctor-Diagnosed Mental Health Conditions and Current Substance Use Among Gay and Bisexual Men Living in Vancouver, Canada. Subst Use Misuse 2017;52:785–97. https://doi.org/10.1080/10826084.2016.1264965.
40. Weinberger AH, Smith PH, Funk AP, Rabin S, Shuter J. Sex Differences in Tobacco Use Among Persons Living With HIV/AIDS: A Systematic Review and Meta-Analysis. J Acquir Immune Defic Syndr 2017;74:439–53. https://doi.org/10.1097/QAI.0000000000001279.
41. Petoumenos K, Law MG. Smoking, alcohol and illicit drug use effects on survival in HIV-positive persons. Current Opinion in HIV and AIDS 2016;11:514. https://doi.org/10.1097/COH.0000000000000306.
42. Strategies for Management of Antiretroviral Therapy (SMART) Study Group, El-Sadr WM, Lundgren JD, Neaton JD, Gordin F, Abrams D, et al. CD4+ count-guided interruption of antiretroviral treatment. N Engl J Med 2006;355:2283–96. https://doi.org/10.1056/NEJMoa062360.
43. Anderson JP, Tchetgen Tchetgen EJ, Lo Re V, Tate JP, Williams PL, Seage GR, et al. Antiretroviral therapy reduces the rate of hepatic decompensation among HIV- and hepatitis C virus-coinfected veterans. Clin Infect Dis 2014;58:719–27. https://doi.org/10.1093/cid/cit779.
44. Moore RD, Forney D. Anemia in HIV-infected patients receiving highly active antiretroviral therapy. J Acquir Immune Defic Syndr 2002;29:54–7.
45. Freiberg MS, Chang C-CH, Kuller LH, Skanderson M, Lowy E, Kraemer KL, et al. HIV infection and the risk of acute myocardial infarction.

JAMA Intern Med 2013;173:614–22. https://doi.org/10.1001/jamainternmed.2013.3728.
46. Patel P, Hanson DL, Sullivan PS, Novak RM, Moorman AC, Tong TC, et al. Incidence of Types of Cancer among HIV-Infected Persons Compared with the General Population in the United States, 1992–2003. Annals of Internal Medicine 2008;148:728. https://doi.org/10.7326/0003-4819-148-10-200805200-00005.
47. Hagger-Johnson G, Taibjee R, Semlyen J, Fitchie I, Fish J, Meads C, et al. Sexual orientation identity in relation to smoking history and alcohol use at age 18/19: cross-sectional associations from the Longitudinal Study of Young People in England (LSYPE). BMJ Open 2013;3:e002810. https://doi.org/10.1136/bmjopen-2013-002810.
48. Hubach RD, Dodge B, Schick V, Ramos WD, Herbenick D, Li MJ, et al. Experiences of HIV-positive gay, bisexual and other men who have sex with men residing in relatively rural areas. Culture, Health & Sexuality 2015;17:795–809. https://doi.org/10.1080/13691058.2014.994231.
49. Slater LZ, Moneyham L, Vance DE, Raper JL, Mugavero MJ, Childs G. Support, stigma, health, coping, and quality of life in older gay men with HIV. J Assoc Nurses AIDS Care 2013;24:38–49. https://doi.org/10.1016/j.jana.2012.02.006.
50. Makoroka L. Health Service Utilization among Men who Have Sex with Men (MSM) who Live in Toronto: Secondary Analysis of a Cross-sectional Study. McMaster University, 2014.
51. Heckathorn D. Respondent-Driven Sampling: A New Approach to the Study of Hidden Populations*. Society for the Study of Social Problems 1997;44.
52. Saunders JB, Aasland OG, Babor TF, de la Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption--II. Addiction 1993;88:791–804.
53. Petoumenos K, Worm S, Reiss P, de Wit S, d'Arminio Monforte A, Sabin C, et al. Rates of cardiovascular disease following smoking cessation in patients with HIV infection: Results from the D:A:D study. HIV Med 2011;12:412–21. https://doi.org/10.1111/j.1468-1293.2010.00901.x.
54. Guaraldi G, Palella FJ. Clinical implications of aging with HIV infection: Perspectives and the future medical care agenda. AIDS 2017;31 Suppl 2:S129–35. https://doi.org/10.1097/QAD.0000000000001478.
55. Hawkins KL, Brown TT, Margolick JB, Erlandson KM. Geriatric syndromes: New frontiers in HIV and sarcopenia. AIDS 2017;31 Suppl 2:S137–46. https://doi.org/10.1097/QAD.0000000000001444.
56. Brown J, McGowan JA, Chouial H, Capocci S, Smith C, Ivens D, et al. Respiratory health status is impaired in UK HIV-positive adults with virologically suppressed HIV infection. HIV Med 2017. https://doi.org/10.1111/hiv.12497.
57. van Zoest RA, Wit FW, Kooij KW, van der Valk M, Schouten J, Kootstra NA, et al. Higher Prevalence of Hypertension in HIV-1-Infected Patients on Combination Antiretroviral Therapy Is Associated With Changes in Body Composition and Prior Stavudine Exposure. Clin Infect Dis 2016;63:205–13. https://doi.org/10.1093/cid/ciw285.
58. Emlet CA, Shiu C, Kim H-J, Fredriksen-Goldsen K. Bouncing Back: Resilience and Mastery Among HIV-Positive Older Gay and Bisexual Men. Gerontologist 2017;57:S40–9. https://doi.org/10.1093/geront/gnw171.
59. Harper GW, Bruce D, Hosek SG, Fernandez MI, Rood BA. Resilience Processes Demonstrated by Young Gay and Bisexual Men Living with HIV: Implications for Intervention. AIDS Patient Care STDS 2014;28:666–76. https://doi.org/10.1089/apc.2013.0330.
60. Lyons A. Resilience in lesbians and gay men: A review and key findings from a nationwide Australian survey. Int Rev Psychiatry 2015;27:435–43. https://doi.org/10.3109/09540261.2015.1051517.
61. McParland J, Camic PM. Psychosocial factors and ageing in older lesbian, gay and bisexual people: a systematic review of the literature. J Clin Nurs 2016;25:3415–37. https://doi.org/10.1111/jocn.13251.
62. Longenecker CT, Sullivan C, Baker JV. Immune Activation and Cardiovascular Disease in Chronic HIV Infection. Curr Opin HIV AIDS 2016;11:216–25. https://doi.org/10.1097/COH.0000000000000227.
63. Nou E, Lo J, Grinspoon SK. Inflammation, immune activation, and cardiovascular disease in HIV.

AIDS 2016;30:1495–509. https://doi.org/10.1097/QAD.0000000000001109.
64. Liner KJ, Ro MJ, Robertson KR. HIV, antiretroviral therapies, and the brain. Curr HIV/AIDS Rep 2010;7:85–91. https://doi.org/10.1007/s11904-010-0042-8.
65. Feeney ER, Mallon PWG. Insulin resistance in treated HIV infection. Best Pract Res Clin Endocrinol Metab 2011;25:443–58. https://doi.org/10.1016/j.beem.2010.11.002.
66. Lang S, Mary-Krause M, Cotte L, Gilquin J, Partisani M, Simon A, et al. Impact of individual antiretroviral drugs on the risk of myocardial infarction in human immunodeficiency virus-infected patients: A case-control study nested within the French Hospital Database on HIV ANRS cohort CO4. Arch Intern Med 2010;170:1228–38. https://doi.org/10.1001/archinternmed.2010.197.
67. Sension M, Deckx H. Lipid metabolism and lipodystrophy in HIV-1-infected patients: The role played by nonnucleoside reverse transcriptase inhibitors. AIDS Rev 2015;17:21–36.
68. Campos P, Ortiz A, Soto K. HIV and kidney diseases: 35 years of history and consequences. Clin Kidney J 2016;9:772–81. https://doi.org/10.1093/ckj/sfw104.
69. Chao C, Leyden WA, Xu L, Horberg MA, Klein D, Towner WJ, et al. Exposure to Antiretroviral Therapy and Risk of Cancer in HIV-infected Persons. AIDS 2012;26:2223–31. https://doi.org/10.1097/QAD.0b013e32835935b3.
70. Castel AD, Young H, Akiwumi A-M, Vargas A, Rogers K, West T, et al. Trends in cancer diagnoses and survival among persons with AIDS in a high HIV prevalence urban area. AIDS Care 2015;27:860–9. https://doi.org/10.1080/09540121.2015.1011074.
71. Huynh KP, Jung J. Subjective health expectations. Journal of Policy Modeling 2015;37:693–711. https://doi.org/10.1016/j.jpolmod.2015.04.001.
72. Koyama T, McHaffie JG, Laurienti PJ, Coghill RC. The subjective experience of pain: Where expectations become reality. PNAS 2005;102:12950–5. https://doi.org/10.1073/pnas.0408576102.
73. Ursin H, Eriksen HR. Sensitization, subjective health complaints, and sustained arousal. Ann N Y Acad Sci 2001;933:119–29.
74. Heywood W, Lyons A. Change in subjective social status following HIV diagnosis and associated effects on mental and physical health among HIV-positive gay men in Australia. Psychol Health 2017;32:860–75. https://doi.org/10.1080/08870446.2017.1307374.
75. Mosack KE, Weinhardt LS, Kelly JA, Gore-Felton C, McAuliffe TL, Johnson MO, et al. Influence of Coping, Social Support, and Depression on Subjective Health Status Among HIV-Positive Adults With Different Sexual Identities. Behav Med 2009;34:133–44. https://doi.org/10.3200/BMED.34.4.133-144.
76. Siziya S, Fylkesnes K. Impact of HIV infection on self-rated health in a high-prevalence population with low awareness of own HIV status. Norsk Epidemiologi 2009;15. https://doi.org/10.5324/nje.v15i2.215.
77. Barrett DC, Pollack LM. Whose Gay Community? Social Class, Sexual Self-Expression, and Gay Community Involvement. Sociological Quarterly 2005;46:437–56. https://doi.org/10.1111/j.1533-8525.2005.00021.x.
78. Green AI. Health and Sexual Status in an Urban Gay Enclave: An Application of the Stress Process Model. Journal of Health and Social Behavior 2008;49:436–51. https://doi.org/10.1177/002214650804900405.
79. Boehmer U, Miao X, Linkletter C, Clark MA. Health Conditions in Younger, Middle, and Older Ages: Are There Differences by Sexual Orientation? LGBT Health 2014;1:168–76. https://doi.org/10.1089/lgbt.2013.0033.
80. Ramirez-Valles J, Dirkes J, Barrett HA. GayBy Boomers' social support: exploring the connection between health and emotional and instrumental support in older gay men. J Gerontol Soc Work 2014;57:218–34. https://doi.org/10.1080/01634372.2013.843225.