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A longitudinal view of successful aging with HIV: role of resilience and environmental factors

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Abstract

Purpose The purpose of this study is to estimate the extent to which people aging with HIV meet criteria for successful aging as operationalized through HRQL and maintain this status over time. A second objective is to identify factors that place people at promise for continued successful aging, including environmental and resilience factors.

Methods Participants were members of the Positive Brain Health Now (BHN) cohort. People ≥ 50 years ($n = 513$) were classified as aging successfully if they were at or above norms on 7 or 8 of 8 health-related quality of life domains from the RAND-36. Group-based trajectory analysis, regression tree analysis, a form of machine learning, and logistic regression were applied to identify factors predicting successful aging.

Results 73 (14·2%) met criteria for successful aging at entry and did not change status over time. The most influential factor was loneliness which split the sample into two groups with the prevalence of successful aging 28·4% in the "almost never" lonely compared to 4·6% in the "sometimes/often" lonely group. Other influential factors were feeling safe, social network, motivation, stigma, and socioeconomic status. These factors identified 17 sub-groups with at least 30 members with the proportions classified as aging successfully ranging from 0 to 79·4%. The nine variables important to classifying successful aging had a predictive accuracy of 0.862. Self-reported cognition but not cognitive test performance improved this accuracy to 0.895. The two groups defined by successful aging status did not differ on age, sex or viral load, nadir and current.

Conclusion The results indicate the important role of social determinants of health in successful aging among people living with HIV.

Keywords HIV · Successful aging · Determinants of health · Resilience · Classification · Regression trees

Plain English summary

Everyone wants to age successfully even with a health condition such as HIV. Aging with HIV is most often described in terms of frailty and multimorbidity most likely because there is no consistent way in which successful aging is determined. This study asks about what people who are aging successfully look like by first proposing a method of measuring successful aging and then using a statistical method to sort people into groups according to how many were aging successfully. Of the 513 people over the age of 50, only 14% were classified as aging successfully and this status was maintained over 3 years. The factors associated with aging successfully were mostly non-medical, resilience and environmental factors. Those with the highest probability of successful aging (79%) were not lonely, felt safe, had a good social network, had neither arthritis nor ling disease, were motivated and optimistic, did not experience stigma, and had enough money to meet needs. Community organizations are best suited to promote successful aging.

Introduction

Much attention is paid to the negative aspects of aging with HIV [1] but less is paid to people who are doing well, yet much could be learned from those aging successfully [2, 3]. The classical definition of successful aging, proposed by Rowe and Kahn in 1997 [4] is the intersection of avoidance of disease and disability, maintenance of high physical and

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cognitive function, and sustained engagement in social and productive activities. Two reviews on successful aging [5, 6] have identified more than a dozen different definitions and over 100 different ways in which successful aging has been operationalized. Operational definitions include freedom from health conditions, values on specific physiological parameters, results on tests of physical capacity, and self-reports of health, functioning, and well-being. Depending on how successful aging was defined, the prevalence rate in the general population ranged from 1 to 94% with a median of 23% [5, 6].

In the context of people living with HIV, several models of successful aging have been proposed. Halkitis et al. [7]. Suggested a holistic conceptual framework that included variables related to the environment and health care access (macro), engagement (meso), and personal and social factors (micro). Health outcomes that this group considered to reflect successful aging included physical, mental cognitive, and sexual health outcomes.

Vance et al. [3] proposed that healthy aging is built upon length of life, biological health, cognitive efficiency, mental health, social competence, productivity, personal control, and life satisfaction. In people living with HIV, the proposed obstacles to healthy aging include shortened life span, compromised immune function, cognitive decline, depression and anxiety, stigma and social withdrawal, decreased work, loss of control, and dissatisfaction. Kahana and Kahana [8] proposed a model focusing on quality of life, well-being, positive affect, and morale rather than on physical and functional indicators.

A systematic review of factors associated with successful aging, mostly in non-clinical cohorts ($n = 163$) [9] published between 2000 and 2014 and with at least 5 years of follow-up, identified physical activity, healthy diet, and smoking abstinence or cessation as the most consistent factors associated with healthy aging. In contrast, there was a lack of evidence for the role of alcohol intake, weight change or degree of engagement in leisure or cognitive activities. This review also provided evidence that factors associated with healthy aging were not mirror images of factors associated with sub-optimal outcomes supporting the need for studies looking at healthy aging independently from disability or frailty. One study was of a cohort of people living with HIV but the focus was specifically on successful cognitive aging [10].

Most of the literature has focused on how non-clinical populations have aged. A common feature of these studies is extensive characterization at study entry and prospective follow-up to truly assess aging [5]. In people living with HIV, there has been less focus on successful aging hence the number of cohorts with relevant functional data at study entry and long follow-up are few. Existing work has tended to focus on frailty. The Positive Brain Health Now cohort was designed to assess longitudinal patterns of brain health. Hence, the cohort was fully characterized at study entry with follow-up to 36 months [11].

In the absence of a gold-standard measure of successful aging [6], we propose to use a measure of health-related quality of life (HRQL). According to the Dictionary of Quality of Life and Health Outcomes Measurement, HRQL is a term referring to the health aspects of quality of life, generally considered to reflect the impact of disease and treatment on disability and daily functioning. The HRQL construct encompasses the domains of physical, social, emotional, and psychological function and thus is well suited as an indicator of successful aging in a population aging with HIV. HRQL is also self-reported which makes it easier to implement clinically. Michel [6] recommended measuring successful aging using self-reports as an efficient way of long-term monitoring. This project would contribute to the identification of an optimal way to accomplish this goal.

The purpose of this study is to estimate the extent to which people aging with HIV meet criteria for successful aging as operationalized through HRQL and maintain this status over time. A second objective is to identify factors that place people at promise for continued successful aging, including environmental and resilience factors.

Methods

The participants in this study were enrolled in the Positive Brain Health Now cohort. This cohort has been described previously [11]. Briefly, cohort members were people ≥ 35 years diagnosed with HIV for at least one year, recruited between 2014 and 2016 from five Canadian sites and followed prospectively for 36 months with visits, 9 months apart. People with dementia, comorbidity affecting cognition, substance abuse, or life-threatening illnesses were excluded.

Each site had a dedicated research team to recruit participants, and to populate a web-based data capture platform with information gathered from the medical chart, face-to-face interviews, and self-completed questionnaires. To assess selection bias, one site had ethical approval to query people refusing study entry. The results have been reported previously [12]. The response rate was approximately 50% and those not entering the study were more likely to be working and less likely to report cognitive difficulties. A longitudinal design was used to track trajectories of successful aging over time. For this analysis, the sample was restricted to people 50 years of age or older at study entry.

The Canadian Institutes of Health Research funded the study and had no role in the study conduct or analysis.

Measurement

For the purposes of estimating prevalence, successful aging was operationalized using the RAND-36 [13] (public domain version of the SF-36), a well-known and widely used measure of HRQL, originally developed to reflect health status in a population seeking health care [14]. It comprises eight subscales: Physical Function (PF), Pain, Vitality (VIT), Social Function (SF), Role Physical (RP), Role Emotional (RE), Mental Health (MH) and General Health Perception (GHP). Successful aging was defined using 7 of the 8 subscales plus the single item from GHP for self-rated health. Each subscale can be scored if people complete half of the items. Participants were classified as aging successfully if they met 7 or 8 of 8 criteria: at or above Canadian norms[15] on 6 or 7 of the 7 subscales excluding GHP subscale and rated their health as excellent or very good on this single item from GHP subscale.

We defined two types of promise factors: path variables, i.e. those that were theoretically linked to the outcome (HIV factors, cognition) or already known to be associated with the outcome value (age, sex); and potential explanatory variables of education, disabling comorbidity, features of the environment, lifestyle, and factors associated with the resilience construct. Potential explanatory factors were drawn from well-known measures of associated constructs such as the WHOQOL-HIV BREF [16]. Two measures of cognition were available, one based on self-reports, Perceived Deficits Questionnaire (PDQ) [17], and one based on test performance, Brief Cognitive Ability Measure (B-CAM) [18]. These measures have been fully described in previous publications on this cohort [11]. As there was no specific measure of resilience included in the BHN platform, we chose items that matched ones from the Connor-Davidson Resilience Measure [19].

Statistical methods

Means, standard deviations (SD), and proportions were used to describe the sample according to sex; differences were tested using Chi-square tests or t-tests. The main analysis focused on trajectory of successful aging over time using Group-based trajectory analysis (GBTA). While successful aging was defined as a binary variable, we modeled evolution over time using all available data on the number of criteria met over time.

GBTA assumes the sample is composed of distinct groups of individuals who follow a similar evolution or trajectory over time. The number of unique trajectories is determined by theory, the distribution of the baseline values, and model fit criteria. The parameters estimated from GBTA with 4 time points are: the intercept and its standard error (SE), the linear slope and its SE, the quadratic term and its SE, and the average posterior probability of group membership, which is considered a measure of model fit. Posterior probabilities of mean greater than 70% indicate good fit. Other measures of model fit used were Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC). Where lower values indicate better fit. The model with the most optimal fit criteria and that makes theoretical sense is chosen as the best model. An advantage of this modeling approach is that people with missing data contribute to the defining the trajectories while in view. The number of time points each person contributes will affect their posterior probability of group membership. GBTA assigns people to trajectories probabilistically.

For the potential explanatory variables, binary recursive partitioning, specifically supervised Classification and Regression Tree (CaRT) was used. This is a non-parametric approach with the capacity to efficiently identify subgroups of a population. It identifies independent contributors that are most strongly associated with the outcome. CaRT performs a hierarchical classification of the sample to predict group membership by recursively partitioning the data until there were no further discriminating splits, which defines a terminal node. We also defined a priori that the algorithm had reached a terminal node if the node sample comprised 30 people or fewer because 95% confidence intervals (CI) around prevalence estimates at small sample sizes are very wide: $\pm \approx 15\%$ for $n = 30$ and $\pm \approx 20\%$ for $n = 20$.

For polytomous categorical predictor variables, CaRT identifies the binary split that best separates the groups. In instances where the data were sparse producing illogical splits, the variable was recoded to binary. Cognition was measured using two continuous variables which were not included in the CaRT model. Instead, they were added to a logistic regression model to estimate the predictive accuracy of the tree. Means and standard deviations of clinical variables measured on a continuous scale were calculated for the two groups defined by successful aging status.

All analyses were carried out using Statistical Analysis System (SAS version 9.4) using proc traj, proc HPSPLIT, and proc logistic.

The sample size for the original study ($n = 856$) was based on testing a model of brain health using structural equation modeling [11]. The sample size for this analysis was not planned a priori and was based on the size of the sample who were 50 years of age and over.

Results

A total of 546 participants from the original cohort of 856 were at or over the age of 50 at study entry. Of this group, 33 (6.0%) had missing data on the outcome measures used to estimate prevalence of successful aging. We report results

from 513 people (456 men and 57 women) with complete outcome data at entry.

Table 1 shows the characteristics of the 513 people involved in this analysis. There were differences between men and women on time since HIV diagnosis, nadir CD4 cell count, and current CD4 cell count. All had undetectable viral loads. Table 2 shows how the men and women scored on the outcome measures used to define successful aging and the proportion at or above norm for each measure. For men, these proportions ranged from 27% (Social Function) to 56·3% (Physical Function); for women the range was from 37·1% (several) to 54·8% (Role Emotional). Men scored higher than women on two of the subscales, Physical Function and Bodily Pain. However, the proportion at or above norm was only higher for men for Physical Function and reporting their health to be excellent or very good. The proportions with successful aging were closely similar between men and women.

Table 1 Characteristics of the men and women 50 years and older in the + BHN cohort at study entry

Characteristic	Men ($n=456$)	Women ($n=57$)
Age in years: Mean (SD)	57·9 (5·9)	56·7 (4·7)
50–54	188 (41·2%)	24 (42·1%)
55–59	119 (26·1%)	20 (35·1%)
60–64	86 (18·9%)	9 (15·8%)
65–69	45 (9·9%)	4 (7·0%)
70–74	15 (3·3%)	0
75 +	3 (0·7%)	0
Race*		
White	354 (77.8%)	26 (45.6%)
Presumed white	10 (2.2%)	2 (3.5%)
Black	26 (5.7%)	13 (22.8%)
Mixed	52 (11.4%)	11 (19.3%)
Unknown	14 (3.1%)	5 (8.8%)
Years since HIV diagnosis: mean (SD)*	18·8 (7·9)	16·5 (7·2)
Nadir CD4 in cells/mm^3: mean (SD)*	201·9 (150·4)	244·4 (189·2)
Current CD4 in cells/mm^3: mean (SD)*	612·5 (266·2)	738·4 (360·4)
Prior AIDS defining illnesses (ADI)*	270 (59·2%)	32 (56·1%)
Working/Volunteering	207/83 (45·4%/18·2%)	23/13 (40·4%/22·8%)

AIDS-defining illness: Nadir or current CD4 < 200 or any of the following

*Differences between men and women

Table 2 Mean values for men and women on the measures used to define successful aging and proportion meeting criterion for each measure

	Men ($n=456$)		Women ($n=57$)	
	Mean (SD)	*N* (%) at norm or above	Mean (SD)	*N* (%) at norm or above
Physical function	80·6(21·2)*	260 (57·0%)**	71.6 (25.9)	24 (42.1%)
Bodily pain	64·6 (24·2)*	147 (32·2%)	57.7 (27.5%)	20 (35.1%)
Vitality	54·8 (22·0)	127 (27·8%)	51.7 (25.2)	21 (36.8%)
Social function	71·0 (25·3)	125 (27·4%)	67.1 (26.6)	21 (36.8%)
Role emotional	60·6 (42·4)	217 (47·6%)	66.1 (43.0)	32 (56.1%)
Role physical	58·3 (41·4)	185 (40·6%)	55.1 (42.7)	21 (36.8%)
Mental health	68·7 (20·0)	157 (34·4)	69.7 (21.2)	24 (42.1%)
Self-rated health				
Excellent/very good		216 (47·4)**	19 (33.3%)	
Successful aging prevalence[#]	65 (14·2%) [11·3–17·8]		8 (14·0%) [7·5–25·3]	

*Difference in means; **difference in proportions

[#]Based on meeting 7 or 8 of RAND-36 subscales at norm; (%) [95% confidence interval]

A total of 73 people met our criteria for successful aging (14·2%; 95% CI 11.5–17.5%), 65 men and 8 women. For men, there were no meaningful differences in these proportions across age group as the sample sizes were small in any one group, yielding wide confidence intervals. For women, the numbers were too small to present meaningful values. As men and women were closely similar on these measures and as there were few women, the remaining results are for the combined sample.

The results of the GBTA are presented in Fig. 1. As 80% of people fit into stable trajectories, the subsequent analyses used the data from the first study visit.

The full CART model identified 71 terminal nodes. By applying our a priori criterion for termination ($n \leq 30$), we identified 17 terminal nodes, eight of which led to nodes with 0% of people classified as aging successfully. The first split was based on loneliness, with 208 participants reporting feeling "almost never" lonely and 305 reporting they sometimes or often felt lonely. The proportions of people classified as successfully aging in these two groups were 28·4% and 4·6%, respectively. The results of the regression tree are shown in Fig. 2a and b. Figure 2a shows the branches for those reporting they were almost never feeling lonely and Table 3 summarizes the path that led to the highest proportion of successful agers, 79·4%. Figure 2b shows the branches for those reporting they sometimes or quite often felt lonely. Among those in the branch for people reporting loneliness, feeling safe in daily life and being somewhat active was associated with a proportion of successful agers of 16·7%. The nine variables listed in Table 3 showed excellent prediction of successful aging (c-statistic: 0·862). Of the two cognition variables included, only self-reported cognitive deficits (PDQ: mean 66·4/100; SD: 17·5) was associated with predictive accuracy: odds ratio (OR) per 10 units difference, 2·0 (95% CI 1·5–2·7; c-statistic 0.895). The 18 variables that contributed to the full tree with 71 branches are listed in Table 4, along with their relative importance and prevalence in the whole sample. The constructs covered were features of the environment including social network and socioeconomic status ($n=9$), resilience including motivation ($n=6$), lifestyle ($n=2$), and comorbidity ($n=1$).

The mean age of those classified as successful agers (58.8 years; SD: 5.8) was not different from those not successful aging (57.6 years; SD: 6.1); nor did the two groups differ on Nadir CD4 (190.2 vs. 209.1 cells/mm^3), current CD4 (632.9 vs. 624.9) or sex.

Discussion

Here we defined successful aging taking a multi-dimensional approach using self-report as advocated by Michel [6]. The World Health Organization (WHO) has suggested a model of intrinsic capacities [20], the composite of all the physical and mental capacities of an individual, to explain and support healthy aging. This is based on the WHO's International Classification of Functioning, Disability and Health (ICF) and includes the capacities, the environment, and their

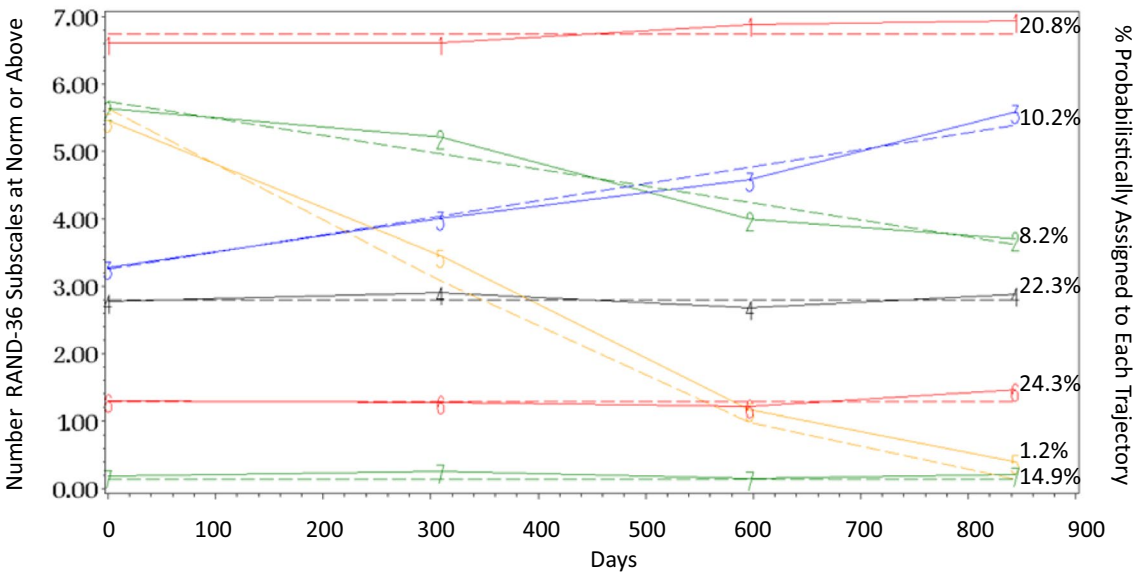

Fig. 1 Trajectories for number of subscales of the RAND-36 met at norm of above over 900 days of follow-up. The subscales of the SF-36 are: Physical Function, General Health (one item only, How do you rate your health?), Pain, Social Function, Role Physical, Role Emotional, Vitality and Mental Health. This figure depicts how many of these eight subscales a person met at age- and sex-specific norm or above

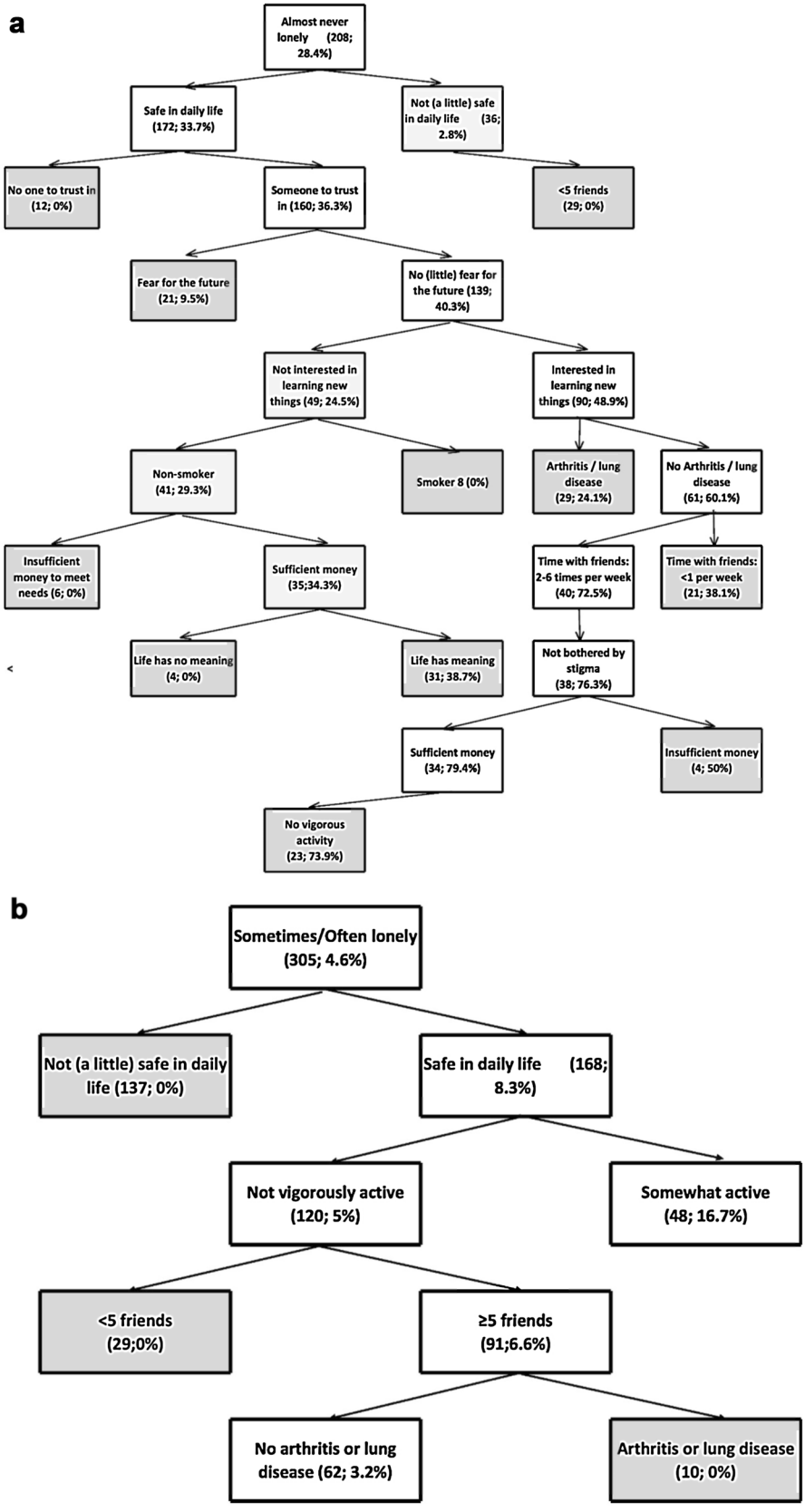

Fig. 2 **a** Regression tree for those almost never lonely. **b** Regression tree for those sometimes or often lonely

Table 3 Branches leading to the highest cumulative proportion of successful agers

Successful aging: 7–8 RAND-36 subscales at norm or above	Overall	14.2%
Questions asked	Optimal factor level	% Successful aging if optimal response
Do you find yourself feeling lonely?	Almost never	26·8
How safe do you feel in your daily life?	Very much to Extremely	33·0
Do you have someone you trust and can confide in?	Yes	36·0
How much do you fear the future?	Not at all	40·3
Having arthritis or lung disease	No	48·7
Are you interested in learning new things?	A lot	60·0
Time with someone who does not live with you	More than once a week	72·5
Bothered by people blaming you for your HIV status?	Not at all	76·3
Have you enough money to meet your needs?	Mostly to completely	79·4

Table 4 Most influential factors in defining groups of people aging successfully with HIV

Construct	Question	Relative Importance*	$N^{\#}$	$\%^{\#}$
Resilience	Do you find yourself feeling lonely?	1	208	40.7
Resilience	How safe do you feel in your daily life?	0.811	340	67.3
Comorbidity	Having arthritis or lung disease	0.699	337	65.7
Resilience	How much do you fear the future?	0.679	124	24.4
Social network	Time with someone who does not live with you	0.622	222	43.5
Lifestyle	Physically active past 6 months	0.612	144	28.2
Lifestyle	Current smoker	0.604	133	26.3
Resilience	To what extent do you feel your life to be meaningful?	0.601	412	81.3
Motivation	Interested in learning new things	0.524	293	57.7
SES	Enough money to meet your needs	0.475	261	51.3
SES	University education	0.474	172	33.9
Social network	Someone to trust and can confide in	0.460	458	89.5
Resilience	Bothered by people blaming you for your HIV status	0.426	346	68.2
Resilience	Worry about death	0.406	219	43.3
Social network	Number of people know well enough to visit within their homes	0.357	280	54.6
Environment	Healthy physical environment	0.208	361	71.6
Environment	Satisfied with conditions of living place	0.174	200	39.1
Motivation	Plans and goals for the future	0.123	170	34.1

*Relative importance for refining groups

#Prevalence in the whole cohort, sample size ranges from 502 to 513 depending on missing data

Factors in grey shading are those defining terminal nodes with 30 or more people in the groups

interaction. For aging the core capacities are cognition, locomotion, sensory, psychological, and vitality. The RAND-36 measure we used to define successful aging covers these domains directly (locomotion, psychological, vitality) and indirectly (work, social function). The items included in our definition of successful aging relate to many of the criteria identified by older persons, living with HIV or not, as being important for successful aging [21–24].

Only 14·2% of this research cohort of people living with HIV in Canada who were 50 or older met our criterion for successfully aging. A recent review reported a range of successful aging in mainly non-clinical populations to vary depending on definition [5]. With a researcher defined definition (based on physiological variables, well-being, engagement, personal resources, and/or environmental/financial factors) the prevalence was 26.0% (95% CI 22.1–29.9%). Using one, two, three or four constructs, the prevalences were 32.5%, 33.4%, 20.2% and 23.3%, respectively. The highest prevalence was if people were asked

for their opinion on whether they were a successful ager: 71.3% self-reported successful aging.

There is limited information on the prevalence of successful aging among people living with HIV using a criterion approach. Most recently, Fazeli et al. [25] reported that 18% of an HIV + cohort ($n = 174$) met criteria for successful aging which was defined by the absence of cognitive symptoms or limitations in instrumental activities of daily living. Predictors of successful aging were socioeconomic status, depression, and neurocognitive impairment. Different from our study, Fazeli et al. used successful aging as a predictor of HRQL, rather than using HRQL to define successful aging.

In addition to the large, well-characterized sample and advanced analytic approach, a strength of the present study is the availability of longitudinal data allowing for the stability of the classification at study entry to be assessed. There were 7 unique trajectories (see Fig. 1), with 80% of the sample assigned to stable trajectories. This stability could have several interpretations. The follow-up time (approximately 900 days or 2·5 years) may not be long enough to show change, although change for both the better and the worse was detectable in 20% of the sample. Stability might reflect resilience, which can be defined as the psychological ability to adapt in the face of tragedy, trauma, adversity, hardship, and ongoing significant life stressors [26] and as physical resilience, a characteristic which determines an individual's ability to resist functional decline or recover physical health following a stressor [27].

Stability among those who are not aging successfully, may also be due to a lack of services targeting these HRQL domains (physical function, role participation, mental health, pain, and fatigue) in this clinical population where the focus of care is often medical. A 2009 survey of Canadian HIV health professionals ($n = 214$; 36% of pool) found that 74% perceived barriers to people living with HIV accessing services to meet their disability needs [28]. Rehabilitation for people living with HIV is not commonplace; a 2016 scoping review identified only 31 studies of rehabilitation interventions for this population [29].

In addition to these broad resilience constructs, the observation that the proportion of people meeting the successful aging criterion at study entry did not differ by age, when a decline with age would have been expected, may be explained by a specific form of resilience thrown in sharp relief in people living with HIV, i.e., survivor bias. Older members of the cohort (≥ 65 years) are likely to be "survivors" and not representative of the entire cohort of people infected during the 1980s, many of whom would be deceased.

The promise factors found here, the resilience factors related to not feeling lonely, unsafe, fearful, stigmatized, or unmotivated (see Table 3), and the environmental factors such as good social network and adequate resources have been proposed in theoretical models of successful aging in HIV [3, 7]. This study provides empirical evidence for their importance. The only clinical factors related to successful aging were the absence of arthritis or lung disease, perhaps because these co-morbidities restrict physical activity and cause discomfort and fatigue. Not smoking and being physically active were also associated with successful aging. How people perceived their everyday cognitive deficits contributed over and above these resilience and environmental factors. However, how people performed on cognitive testing was not associated.

In a thoughtful paper on the challenges faced by people aging with HIV, Althoff et al. [30] conclude that, while combination antiretroviral therapy has led to increasing longevity, this has not enabled a complete return to health. This observation is supported by work from our team measuring what matters to people with burdensome health conditions [31]. People living with HIV ($n = 691$) almost unanimously (97%) named health as a top concern affecting their quality of life. These health concerns included fearing return of the virus, always having to be careful, always having to take medication, and always worrying about minor illnesses turning into serious health events. These health concerns are justified: as adults age with HIV, inflammation, the possible toxic effects of antiretroviral agents, the effects of unhealthy lifestyle (smoking, use of recreational drugs), and age-related co-morbidities take their toll on physiological reserves. Althoff et al. [30] comment, "We must move from the simplistic notion of HIV becoming a 'chronic controllable illness' to understanding the continually evolving 'treated' history of HIV infection with the burden of age-associated conditions and geriatric syndromes in the context of an altered and ageing immune system". The present study supports this view and underlines the need to consider social and clinical factors in promoting successful aging in HIV.

Limitations

In addition to survival bias, other sources of bias mean that the results of this study need to be interpreted with caution. We have previously reported that our cohort has a selection bias [12] as the main reason given for not entering the cohort was work responsibilities (61%). This would suggest that the proportion of people successfully aging reported here is under-estimated. Further selection bias [12] likely occurred as the study sample was assembled solely for the purposes of research and was not derived from routinely collected clinical data. The consent process can remove an important section of the population, notably in our case, those with busy working lives. On the other hand, studies based on routinely collected data do not usually include all relevant variables. This was a prevalent cohort and not an inception cohort. People entered at different times in their life-course

experience with HIV. It is not possible to know time of the onset of diminished HRQL, presuming that at one point in time all cohort members would have met our criterion. Changes may already have occurred by study entry and thus participants may have reached a plateau, so expected change would be small. Survival bias may have affected the results for the older age groups, resulting in healthier older people entering the cohort. This study also differs from standard cohort studies as the classification of successful aging was assigned at study entry and longitudinal follow-up was used to identify the stability of this designation. Finally, the results of this study apply to people with good viral control and only to those meeting our inclusion criteria.

Conclusion

This study provides a detailed portrait of successful aging in people living with HIV and indicates that the best predictor of the future is the present, with only 20% of the cohort showing changing trajectories. The promise factors identified here are not those usually targeted by medical care: they were largely social determinants of health [32], with the exception of arthritis and lung disease. People without these promise factors may benefit from closer monitoring and referral to resources that can help overcome some of these disadvantages and promote successful aging for all.

Authors contribution NEM: conception of project, supervision of analysis, drafted the paper, tables and figures, verified accuracy of all data in the paper, made edits to paper based on co-authors comments. MJB: recruitment of participants, interpretation of results, editorial comments to paper. LN: carried out the analysis under supervision of NM an ND; verified accuracy of all data in the paper, editorial comments on the paper. ND: provided guidance on the data analysis, provided comments on the paper. MH, recruitment of participants, interpretation of results, editorial comments to paper. FS, recruitment of participants, interpretation of results, editorial comments to paper. GS, recruitment of participants, interpretation of results, editorial comments to paper. RT, recruitment of participants, interpretation of results, editorial comments to paper. LK, interpretation of results, editorial comments to paper.

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Declarations

Conflict of interest Authors declare that they have no conflicts of interest.

Ethical approval All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The project was approved by the Research Ethics Board of each of the participating institutions.

Informed consent All participants provided informed consent.

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