Published in final edited form as:

Lancet HIV. 2022 October ; 9(10): e709–e716. doi:10.1016/S2352-3018(22)00198-9.

Differences in healthy longevity by HIV status and viral load among older South African adults: an observational cohort modelling study

Collin F. Payne, PhD[1], **Brian Houle, PhD**[1,2], **Chido Chinogurei, MA**[3], **Carlos Riumallo Herl, PhD**[4], **Chodziwadziwa Whiteson Kabudula, PhD**[2], **Lindsay C. Kobayashi, PhD**[5], **Prof. Joshua A. Salomon, PhD**[6], **Jennifer Manne-Goehler, PhD**[7,8]

[1]School of Demography, Research School of Social Sciences, The Australian National University, Canberra, Australia

[2]MRC/Wits Rural Public Health and Heath Transitions Research Unit (Agincourt), School of Public Health, Faculty of Health Sciences, University of Witwatersrand, Johannesburg, South Africa

[3]Centre for Infectious Diseases and Epidemiology Research, School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa

[4]School of Economics, Erasmus University, Rotterdam, Netherlands

[5]Center for Social Epidemiology and Population Health, Department of Epidemiology, School of Public Health, University of Michigan

[6]Center for Primary Care and Outcomes Research, Stanford University, Palo Alto, USA

[7]Division of Infectious Diseases, Brigham and Women's Hospital, Boston, USA

[8]Center for Population and Development Studies, Harvard T.H. Chan School of Public Health, Cambridge, USA

Summary

Background—The population of people living with HIV (PLHIV) in South Africa is rapidly ageing due to increased survivorship attributable to antiretroviral therapy (ART). We sought to understand how the combined impacts of HIV and ART have led to differences in healthy longevity by HIV status and viral suppression in this context.

Contributors

CFP, BH, and JM-G conceived the study. CFP wrote the analytic plan with input from BH, CC, CRH, CWK, LCK, JAS, and JM-G. CFP carried out the analysis and wrote the first draft. All authors critically revised the manuscript and approved the final version. CFP, BH, and JM-G had access to and verified all the data. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Methods—We use longitudinal data from the 2015 and 2018 waves of the population-based "Health and Ageing in Africa: A Longitudinal Study of an INDEPTH Community in South Africa" (HAALSI) study to estimate life expectancy (LE) and disability-free life expectancy (DFLE) of adults aged 40 and older in rural South Africa. We estimate LE and DFLE by HIV status and viral suppression (defined as <200 copies/ml) using Markov-based microsimulation.

Findings—Among the 4,322 eligible participants from the HAALSI study, we find a clear gradient in remaining LE and DFLE based on HIV serostatus and viral suppression. At age 45, LE of an HIV- man was 27.2 [95% CI: 25.8 – 29.1] years, compared to 24.1 [95% CI: 20.9 – 27.2] years for an HIV-infected, virally suppressed man and 17.4 [95% CI: 15.0 – 20.3] years for an HIV-infected, unsuppressed man. LE patterns were similar among women. Men and women achieving viral suppression could expect to live nearly as many years of DFLE as HIV-uninfected individuals at ages 45 and 65.

Interpretation—These results highlight the tremendous benefits of ART for population health in high HIV prevalence contexts, and reinforce the need for continued work in making ART treatment accessible to ageing populations.

Introduction

From the late 1980s through the 2000s, life expectancy (LE) declined in the populations of sub-Saharan Africa (SSA) due to the HIV pandemic.(1) Since the mid-2000s, the large-scale roll-out of antiretroviral therapy (ART) in SSA has reversed these trends, successfully leading to declines in both HIV-related and all-cause mortality at the population level.(2–4) ART leads to immunologic recovery from HIV infection, and when taken regularly can improve the survival of people living with HIV (PLHIV) to levels almost on par with HIV-uninfected people.(5) Due to these mortality reductions in combination with demographic changes including declining fertility rates, the population in much of SSA is now ageing rapidly.(6) However, the overall rate of ageing is being considerably outpaced by the ageing of the population of PLHIV, resulting from both increased survival through ART treatment and persistently high rates of new infections among older adults despite declining trends in incidence trends among younger age-groups.(7,8) This intersection of population ageing and a high HIV burden means that understanding the combined impacts of HIV and ART on healthy longevity is of key importance for public health in SSA.(9)

Despite the considerable evidence base on ART and mortality in SSA, two key areas remain understudied. First, recent improvements in population-level lifespan are likely to be unevenly distributed. LE may be increasing for some individuals (i.e., those who can consistently access ART and achieve viral suppression), while other groups (i.e., those not on ART or who do not achieve effective viral suppression) are unlikely to see such increases. Most prior research investigating the impacts of ART on mortality has treated PLHIV as a uniform group in exploring how the introduction of ART has impacted mortality at the population level.(2,3) Researchers and policymakers do not currently have a clear understanding of how LE may differ across subpopulations of older adults living with HIV who have and have not attained viral suppression, and how these groups compare to the HIV-uninfected population.

Second, research on the impact of HIV and ART on population health in SSA has overwhelmingly focused on mortality as the sole outcome. There is ample clinical evidence that uncontrolled HIV has negative impacts on physical function, frailty, and self-rated health of older adults,(10,11). resulting in substantial gaps in healthy and comorbidity-free LE between HIV-infected and HIV-uninfected individuals.(12,13) The proposed drivers of these relationships include HIV-related changes in body composition, higher levels of systemic inflammation, and HIV-associated cognitive impairment.(10,11) HIV may also have implications for the healthy ageing process among individuals attaining viral suppression, who have been shown to experience higher rates of functional impairment, disability, premature ageing, elevated risks of cardiovascular disease, diabetes, neurocognitive impairment, and osteoporosis.(11,14)

These gaps in the evidence-base are of particular importance in South Africa, which has one of the world’s highest rates of HIV prevalence, the largest public ART program, and the largest and fastest growing population of older adults in SSA.(6) The country also has high levels of non-communicable diseases among older adults,(15) a burden that will increase in coming years due to both population ageing and the potential effects of HIV and ART on incident hypertension.(16) Research investigating the HIV treatment cascade in South Africa has found that, at older ages, there remain challenges to linking HIV+ individuals to ART treatment.(17)

To the best of our knowledge, no existing study has explored how life expectancy and healthy longevity vary across individuals who are HIV-uninfected, HIV-infected but virally suppressed, and HIV-infected but not fully virally suppressed in a population-based setting. Additionally, no existing research in SSA has directly measured differences in health expectancies among older individuals by HIV status and viral suppression. We use longitudinal data from adults aged 40+ in the population-based “Health and Ageing in Africa: A Longitudinal Study of an INDEPTH Community in South Africa” (HAALSI) study to explore LE and health expectancies in a rural South African setting. We present estimates of LE and healthy longevity in HIV-uninfected and HIV-infected populations estimated directly from longitudinal survey data, providing novel insights into health and longevity in a high HIV-prevalence context.

Methods

Data source

Data come from the 2015 baseline interview (conducted 13 November 2014 to 30 November 2015) and 2018 longitudinal follow-up interview (conducted 12 October 2018 to 7 November 2019) from the HAALSI study. HAALSI is an International Partner Study of the US Health and Retirement Study, and is representative of the population aged 40 and over in the Agincourt sub-district, Mpumalanga province, South Africa.(18) As compared to most studies of older adults, the HAALSI cohort uses a lower starting age for two primary reasons. Firstly, a key study objective is to understand the risk of incident cognitive impairment and its relationship to both HIV and cardiometabolic disease risk factors in aging adults. Secondly, HAALSI was designed to be synergistic with the NIH-funded Human Heredity and Health in Africa (H3Africa) study, which includes people over

40 years old. More details of the HAALSI cohort, interview scope, data collection, and sampling frame are available in a Cohort Profile.(18) Incident mortality of individuals in the HAALSI dataset is tracked by the Agincourt Health and Demographic Surveillance System. Ethical approval for HAALSI was obtained from the University of the Witwatersrand Human Research Ethics Committee (no. M141159), the Harvard T.H. Chan School of Public Health Office of Human Research Administration (no. 13–1608), and the Mpumalanga Provincial Research and Ethics Committee.

Measures

Our primary measure of functional health is based on the Activities of Daily Living (ADL) scale. (19) We generated two distinct states of physical health: **disability-free** individuals with no reported limitations to ADL activities, and **ADL disabled** individuals with one or more limitation to ADL activities. ADL disability is defined as reporting difficulty on any of the following six activities: dressing, bathing, eating, getting in/out of bed, toileting, and walking across a room. Where necessary, proxy responses on ADL disability were used (N=79 (1.7%) in 2015, N=203 (4.4%) in 2018). Of the proxy responses to the ADL questionnaire, 33/79 (42%) in wave 1 and 39/203 (19%) in wave 2 were reported as ADL disabled. Individuals who refused to respond to the ADL items were excluded from analyses (N=12 (<1%) in 2015, N=34 (<1%) in 2018)). As a robustness check, we additionally examined an alternative measure of physical health based on objective measures of gait speed and grip strength (Supplemental Text 1).

Dried blood spots (DBS) were collected at the 2015 interview and screened for HIV, ART exposure (emtricitabine (FTC) or lamivudine (3TC)), and viral load. Viral suppression was defined as <200 copies/mL.(20)

A total of 5,059 out of 5,890 eligible men and women aged 40 years or over consented to participate and were included in the baseline survey in 2015 (85.9% response rate). A total of 4,582 respondents provided a dried blood spot for HIV testing in 2015, and 4,555 returned a conclusive result and responded to the ADL items. Of these 4,555, 3,818 (84%) were re-interviewed in 2018, 504 (11%) had died between survey waves, 205 (4%) refused to be re-interviewed, and 28 (<1%) could not be found. The final sample used in analyses (those with non-missing information on ADL questions, and who were either interviewed in both 2015 and 2018 or who died between waves) was 4,322 individuals.

Statistical analysis

Our primary analyses compared total life expectancy (LE) and disability-free life expectancy (DFLE), across the HIV-infected and HIV-uninfected populations. DFLE distinguishes between life-years spent with and without ADL disability, providing a more nuanced view of population-level health than simple estimates of LE or prevalence of disabilities at a single point in time. We estimated LE and DFLE by HIV status and level of viral suppression for males and females using microsimulation-based multistate life tables.(21) Individuals were classified into one of three health states: disability-free (no reported ADL disability), ADL disabled individuals (difficulty with 1+ ADL activities), and dead. In our analysis, individuals were allowed to transition between all alive states—meaning that respondents were allowed to experience both onset and recovery from ADL disability. The state space is depicted in Figure 1. Our analysis method initially converted the HAALSI data to a person-year time scale, assuming that transition between disability states occurred at random times during the three years between survey waves. Annual transition probabilities were modelled with a multinomial logistic regression model, stratified by initial disability state. The model included age and age^2 as continuous predictors, sex, and HIV status (HIV-uninfected; HIV-infected, virally suppressed; HIV-infected, not virally suppressed) as categorical variables, and several interaction terms: age * HIV status, age * sex, and sex * HIV status. Inverse probability weights were used to account for attrition at the 2018 follow-up wave.(22) We then predicted matrices of age-specific transition probabilities for each combination of sex and HIV status, separately by initial disability state. Graphs of transition probabilities for each group are included as Supplemental Figures 1 and 2. Parameter estimates from this model are included as Supplemental Table 1.

These estimated transition probabilities are used as the input for the microsimulation-based multistate life table model, using an adapted version of the SPACE suite of SAS programs.(21) First, we generated synthetic cohorts of 100,000 individuals at initial ages of 45 and 65. These synthetic cohorts are assigned the same sex, HIV status, and health state distribution as observed in the HAALSI data: the average characteristics of the HAALSI cohort aged 40–49 were used to generate the synthetic cohort at age 45, and the average characteristics of the HAALSI cohort aged 60–69 were used to generate the synthetic cohort at age 65. We then “aged” these individuals forward year by year via microsimulation, using the age-, sex-, and HIV-status-specific mortality rates and probabilities of transitioning in and out of disability estimated above. The resulting synthetic cohort, representing the simulated life courses of 100,000 individuals subjected to the transition rates observed in the HAALSI data between 2015 and 2018, was analysed to estimate total LE and DFLE. Point estimates shown were from the transition probabilities estimated from the full sample. Confidence intervals (CIs), which reflect both the uncertainty of the estimated parameters and the uncertainty from the microsimulation, were created by re-estimating the above analysis sequence using 499 bootstrap re-samples for each age group under study. We took the central 95% of the distribution of these bootstrapped parameters as the 95% confidence interval.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Baseline characteristics

Table 1 compares sociodemographic characteristics of the HIV-uninfected, HIV-infected, virally suppressed, and HIV-infected, not virally suppressed populations. The HIV-infected population (both virally suppressed and unsuppressed groups) were on average younger than the HIV-uninfected population, and had commensurately lower prevalence of ADL disability and physical limitation. In all groups, the HAALSI sample had more females than males, a result of sex differences in both survivorship and labour migration. Approximately 40% (N=1516) of respondents were classified as physically limited based on the gait speed and grip strength tasks. HIV prevalence was 23% (N=1010). Of the respondents who were HIV-infected, slightly more than half (59%, N=601) were virally suppressed, and 41% (N=409) were virally unsuppressed (>200 copies per ml). Supplemental Table 2 compares these characteristics between men and women in the HAALSI sample.

Life and disability-free life expectancies by HIV status and viral suppression

Table 2 and Figure 1 present LE and DFLE for men and women in the HAALSI cohort at ages 45 and 65 by HIV status and viral suppression. At age 45, an HIV-uninfected man could expect to live an additional 27.2 [95% CI: 25.8 – 29.1] years, nearly seven years longer than the life expectancy of an HIV-infected man, which was 20.7 [18.4 – 22.7] years. However, this HIV-infected grouping hides substantial heterogeneity by viral suppression. An HIV-infected, virally suppressed man had a life expectancy of 24.1 [20.9 – 27.2] years at age 45, only three years less than that of an HIV-uninfected man. In contrast, an HIV-infected, not virally suppressed man could only expect to live an additional 17.4 [15.0 – 20.3] years at age 45—nearly a decade less than an HIV-uninfected man. Remaining life expectancies were higher for women, but similar trends were seen—LE at age 45 was 33.2 [32.0 – 34.6] among HIV-uninfected women, less than two years longer than the 31.6 [29.2 – 34.1] year LE for HIV-infected, virally suppressed women. Life expectancies were nearly seven years shorter for those who are HIV-infected and not virally suppressed (26.4 [23.1 – 29.1] years). Trends in LE by HIV status and viral load were broadly similar at age 65, although the magnitude of differences was somewhat smaller due to the overall lower remaining life expectancy.

Similar to our results for LE differences, we found substantial differences in DFLE between HIV-infected and HIV-uninfected individuals (Table 2). An HIV-uninfected man at age 45 could expect to spend 22.6 [20.7 – 24.1] additional years free of disability, as compared to 17.8 [15.4 – 19.7] years for a 45-year-old man who was HIV-infected. Again, however, we found that these differences are overwhelmingly located among the HIV-infected, not virally suppressed group. An HIV-infected, virally suppressed 45-year-old man could expect to spend 20.9 [17.8 – 23.4] disability- free years, as compared to only 14.9 [12.3 – 17.7] years for an HIV-infected man who was not virally suppressed. These patterns were also found among females, although the magnitude of differences was somewhat smaller. At age 65, DFLE of the HIV-infected, virally suppressed groups only slightly trailed that of HIV-uninfected individuals. Although we found quite substantial differences in the level of DFLE by HIV status and viral load, we found no substantial differences across groups in terms of the proportion of remaining life spent with ADL disabilities.

Alternative parameterization of physical health

As an alternative to the self-rated ADL disability measure, we estimated a model using physical performance tests (gait speed and grip strength) to measure differences in physically healthy life expectancy (PHLE) between HIV-uninfected, HIV-infected, virally suppressed, and HIV-infected, not virally suppressed individuals (Supplemental Text 1). Supplemental Table 2 presents estimates of LE and PHLE by sex, age, and HIV status.

Estimated total LEs differ somewhat from the figures in Table 2 for two reasons: first, individuals who refused or were unable to complete the physical performance tasks were excluded (N=704); second, the microsimulation procedure introduces some inherent random fluctuations around these estimates. However, the overall pattern of results was similar to our above findings on DFLE. At age 45, the HIV-infected, not virally suppressed population appeared to spend a lower proportion of remaining life physically healthy—at age 45, an HIV-infected, not virally suppressed man could expect to live only 44% [0.37 – 0.57] of his remaining life physically healthy, as compared to 55% [0.50 – 0.59] for the HIV-uninfected population. We found a similar trend for women at age 45, but these gradients in the proportion of remaining life spent physically healthy are smaller for both sexes at age 65.

Discussion

We found a clear gradient in remaining LE based on HIV serostatus. However, LEs for those who were HIV-infected and virally suppressed were only slightly lower than those of HIV-uninfected individuals. The LE differences between HIV-uninfected and HIV-infected populations were predominantly driven by the HIV-infected group who were not virally suppressed. These findings represent the first population-level estimates of life expectancy differences based on HIV status and viral load, and reinforce prior population-based analyses from South Africa that showed widespread roll-out of ART has been associated with large gains in adult life expectancy of over 11 years, particularly among women (2,23).

Additionally, we found that individuals' HIV status and control over their viral load had substantial implications for later-life health and functional well-being. At the population level, individuals with virally suppressed HIV could expect to live nearly as many disability-free years as individuals who were HIV-uninfected at ages 45 and 65. The HIV-infected, not virally suppressed group had much lower levels of DFLE and was responsible for almost all of the overall difference LE between HIV-uninfected and HIV-infected individuals. As a proportion of total remaining life, DFLE among HIV-infected individuals not achieving viral control looked similar to the other groups. However, we theorize that this may be due to their overall substantially lower life expectancy—that is, fewer of these individuals survive to older ages, where ADL prevalence rises substantially.(24)

Our findings highlight the major population health and longevity gains that are possible when the UNAIDS 90-90-90 goals are realized.(25) Achievement of viral suppression for millions of PLHIV in high prevalence contexts is critical for ensuring healthy population ageing and to avoid premature frailty and its related health complications. Impairments in physical functioning are part of geriatric syndromes that place people ageing with HIV at higher risk of adverse clinical outcomes.(11) As such, achieving high rates of viral suppression among those ageing with HIV is important to reduce premature onset of these syndromes, their associated complications, and the healthcare costs of such adverse outcomes. Finally, preserved physical function at older ages is critical to ensure participation in other healthcare activities that are a part of healthy aging, including self-care of comorbid cardiovascular and metabolic diseases that are now highly prevalent in South Africa and similar settings.

The population captured in the HAALSI cohort may not be representative of all adults with HIV in South Africa. This cohort focuses on older adults in a single province that has been previously shown to have among the lowest rates of retention in HIV care. (26) Among people with HIV in the HAALSI cohort, 41% are virally suppressed, a figure that is slightly lower than the 52% reported in the South Africa 2017 National HIV survey. (26) However, our findings broadly align with the rates of viral suppression in the Mpumalanga province (where the HAALSI cohort is located), which had the lowest rate of viral suppression in this survey. (26)

Relatedly, our estimates of LE for the HAALSI cohort are slightly below UN 2019 estimates for South Africa. In the HAALSI population (combining the HIV-infected and HIV-uninfected groups), we estimate remaining life expectancy for men at age 45 at 25.8 years (vs 26.9 years as estimated by the UN) and remaining life expectancy for women at age 45 at 30.3 years (vs 31.8 years as estimated by the UN). (6) The HAALSI cohort is located in a relatively rural and poorer area of South Africa, so it is not unexpected that life expectancy in this cohort trails the South African average. To our knowledge, no other analyses have produced life expectancy estimates that are directly comparable to our figures comparing LE and DFLE by HIV status and viral suppression. The closest analyses we found compared LE between those initiating ART and HIV-uninfected individuals. (27) They found that individuals initiating ART at age 45 had remaining life expectancies 70–80% as long as those who were HIV-uninfected. However, these results are not directly comparable to ours—we do not know the age of ART initiation in our sample, nor do we differentiate between individuals who are newly infected or long-term HIV infected.

Removing barriers to ART treatment and supporting treatment adherence is critical for older adults. Given different barriers and motivations for older adults as compared to younger populations, there is a need for tailored approaches to improve their entry and retention into the HIV care cascade.(28) Efforts to maintain and improve the accessibility of care are even more salient given the ongoing COVID-19 global pandemic, as service disruptions and hesitancy to travel have resulted in declines in HIV service utilization in a number of contexts.(29)

Limitations

Our results stratified participants by viral suppression based on one viral load measurement, though prior research from this cohort has demonstrated the strength of this measure as compared to self-report alone (30). Given less-than-perfect ART adherence in South Africa, our estimates are best interpreted as the difference between individuals with above-average ART compliance (the HIV-infected, virally suppressed group) and those with below-average compliance (the HIV-infected, non-suppressed group). The HIV-infected, not virally suppressed group represents a heterogeneous group of individuals, where some were sampled at a point in time when they were off their ART medication, some had never started ART treatment, and some were likely recently infected or did not know their HIV status. Similarly, the HIV-infected, virally suppressed group likely contains some individuals who were observed while on their ART medication, but who are not consistently adherent. We also lack data on other nuanced parameters relevant to understanding lifelong history of immunosuppression such as duration on ART, cumulative viral load or nadir CD4 count. Furthermore, our analyses are not able to account for individuals who move between states of viral suppression between 2015 and 2018, as we lack follow-up information on viral load for individuals who died between waves. However, in supplemental analyses we found that for individuals who survived from 2015 to 2018 and consented to having DBS taken, 60% of HIV+, not virally suppressed individuals moved to having successful suppression, and 13% of those who had achieved viral suppression in 2015 had a non-suppressed viral load in 2018. Data from future waves of the HAALSI cohort will be key for understanding whether these positive trends in viral suppression will lead to continued improvements in total and healthy life expectancy among the HIV-infected population. In addition, ADL disability represents a fairly severe level of functional limitation. Although we found similar results in analyses exploring physical performance tests, we suggest caution when generalizing our results to other facets of health including co-morbidities or trends in lower-level functional limitations, as these may not follow similar patterns as ADL disability.

Our estimates of life and health expectancies are driven by the transition probabilities estimated from our data, which, given the sample size and limited follow-up available in the HAALSI survey, come with considerable uncertainty. We believe that our bootstrap-based approach represents a fairly conservative approach to modelling uncertainty around these transition probabilities, and commensurately around our estimates of LE and DFLE. However, this limited sample size does lead our results in the HIV-positive, virally suppressed and HIV-positive, not virally suppressed populations to have considerable uncertainty around them. A limitation of our methodological approach is that the multistate analyses follow a simple Markov logic and are not state-duration-dependent. Individuals who experience a disability-state transition between survey waves are assumed to experience only a single transition over this period, which likely misses shorter-term fluctuations in functional health. The Markov assumption of no unobserved transitions means that the model makes the somewhat unrealistic assumption that individuals who were observed as disability-free and died before the next wave experienced no disability prior to death.

Conclusions

In a hyperendemic context in rural South Africa, we found that HIV-uninfected individuals have substantially longer life expectancies than HIV-infected individuals. However, in analyses stratified by viral load among HIV-infected individuals, we found that the gaps in overall life expectancy and disability-free life expectancy between HIV-uninfected and HIV-infected individuals is almost entirely due to the lower life expectancies of HIV-infected individuals who are not virally suppressed. These results highlight the tremendous benefits of ART for population health in high HIV prevalence contexts, and reinforce the need for continued work in making ART treatment accessible to ageing populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

This work was supported by the National Institute of Aging at the National Institutes of Health (grant numbers 1P01AG041710-01A1, HAALSI – Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The HAALSI study is nested within the Agincourt Health and socio-Demographic Surveillance System, a node of the South African Population Research Infrastructure Network (SAPRIN) supported by the Department of Science and Innovation, the University of the Witwatersrand, and the Medical Research Council, South Africa, and previously the Wellcome Trust, UK (Grants 058893/Z/99/A; 069683/Z/02/Z; 085477/Z/08/Z; 085477/B/08/Z). CFP is supported by an Australian Research Council Discovery Early Career Researcher Award (project number DE210100087) funded by the Australian Government, and by an ANU Futures Scheme Award funded by the Australian National University. CRH received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No 840591.

Funding

National Institutes of Health.

Data sharing

Data from the HAALSI study are publicly available at https://dataverse.harvard.edu/dataverse/haalsi.

References:

1. Joint United Nations Programme on HIV/AIDS (UNAIDS). UNAIDS report on the global AIDS epidemic 2013. 2013.
2. Bor J, Herbst AJ, Newell ML, Bärnighausen T. Increases in adult life expectancy in rural South Africa: valuing the scale-up of HIV treatment. Science [Internet]. 2013 Feb 22 [cited 2016 Oct 28];339(6122). Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3860268/
3. Reniers G, Blom S, Calvert C, Martin-Onraet A, Herbst AJ, Eaton JW, et al. Trends in the burden of HIV mortality after roll-out of antiretroviral therapy in KwaZulu-Natal, South Africa: an observational community cohort study. The Lancet HIV. 2017 Mar 1;4(3):e113–21. [PubMed: 27956187]
4. Payne C, Kohler HP. The population-level impact of public-sector antiretroviral therapy rollout on adult mortality in rural Malawi. Demographic Research. 2017 Apr 5;36(37):1081–108. [PubMed: 29780281]
5. May MT, Gompels M, Delpech V, Porter K, Orkin C, Kegg S, et al. Impact on life expectancy of HIV-1 positive individuals of CD4+ cell count and viral load response to antiretroviral therapy. AIDS. 2014 May 15;28(8):1193–202. [PubMed: 24556869]
6. United Nations Population Division. World Population Prospects [Internet]. 2019 [cited 2021 Apr 16]. Report No.: ESA/P/WP.241. Available from: https://population.un.org/wpp/
7. Akullian A, Vandormael A, Miller JC, Bershteyn A, Wenger E, Cuadros D, et al. Large age shifts in HIV-1 incidence patterns in KwaZulu-Natal, South Africa. Proc Natl Acad Sci U S A. 2021 Jul 13;118(28):e2013164118. [PubMed: 34244424]
8. Hontelez JA, de Vlas SJ, Baltussen R, Newell ML, Bakker R, Tanser F, et al. The impact of antiretroviral treatment on the age composition of the HIV epidemic in sub-Saharan Africa. AIDS. 2012 Jul 31;26(0 1):10.1097/QAD.0b013e3283558526.
9. Harris TG, Rabkin M, El-Sadr WM. Achieving the fourth 90: healthy aging for people living with HIV. AIDS. 2018 Jul 31;32(12):1563–9. [PubMed: 29762172]
10. Edwards A, Siedner MJ, Nash S, Neuman M, Danaviah S, Smit T, et al. HIV serostatus, inflammatory biomarkers and the frailty phenotype among older people in rural KwaZulu-Natal, South Africa. Afr J AIDS Res. 2020 Sep;19(3):177–85. [PubMed: 32892699]

11. Erlandson KM, Schrack JA, Jankowski CM, Brown TT, Campbell TB. Functional Impairment, Disability, and Frailty in Adults Aging with HIV-Infection. Curr HIV/AIDS Rep. 2014 Sep;11(3):279–90. [PubMed: 24966138]
12. Hogg RS, Eyawo O, Collins AB, Zhang W, Jabbari S, Hull MW, et al. Health-adjusted life expectancy in HIV-positive and HIV-negative men and women in British Columbia, Canada: a population-based observational cohort study. Lancet HIV. 2017 Jun;4(6):e270–6. [PubMed: 28262574]
13. Marcus JL, Leyden WA, Alexeeff SE, Anderson AN, Hechter RC, Hu H, et al. Comparison of Overall and Comorbidity-Free Life Expectancy Between Insured Adults With and Without HIV Infection, 2000–2016. JAMA Netw Open. 2020 Jun 1;3(6):e207954–e207954. [PubMed: 32539152]
14. 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 Dec 15;59(12):1787–97. [PubMed: 25182245]
15. Mayosi BM, Flisher AJ, Lalloo UG, Sitas F, Tollman SM, Bradshaw D. The burden of non-communicable diseases in South Africa. The Lancet. 2009 Sep;374(9693):934–47.
16. Dillon DG, Gurdasani D, Riha J, Ekoru K, Asiki G, Mayanja BN, et al. Association of HIV and ART with cardiometabolic traits in sub-Saharan Africa: a systematic review and meta-analysis. Int J Epidemiol. 2013 Dec;42(6):1754–71. [PubMed: 24415610]
17. Rohr JK, Manne-Goehler J, Gómez-Olivé FX, Wagner RG, Rosenberg M, Geldsetzer P, et al. HIV treatment cascade for older adults in rural South Africa. Sex Transm Infect. 2020;96(4):271–6. [PubMed: 31243144]
18. Gómez-Olivé FX, Montana L, Wagner RG, Kabudula CW, Rohr JK, Kahn K, et al. Cohort Profile: Health and Ageing in Africa: a Longitudinal Study of an INDEPTH Community in South Africa (HAALSI). Int J Epidemiol [Internet]. 2018 [cited 2018 Jan 14]; Available from: https://academic.oup.com/ije/advance-article/doi/10.1093/ije/dyx247/4791962
19. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. STUDIES OF ILLNESS IN THE AGED. THE INDEX OF ADL: A STANDARDIZED MEASURE OF BIOLOGICAL AND PSYCHOSOCIAL FUNCTION. JAMA. 1963 Sep 21;185:914–9. [PubMed: 14044222]
20. Rodger AJ, Cambiano V, Bruun T, Vernazza P, Collins S, van Lunzen J, et al. Sexual Activity Without Condoms and Risk of HIV Transmission in Serodifferent Couples When the HIV-Positive Partner Is Using Suppressive Antiretroviral Therapy. JAMA. 2016 Jul 12;316(2):171–81. [PubMed: 27404185]
21. Cai L, Hayward MD, Saito Y, Lubitz J, Hagedorn A, Crimmins E. Estimation of multi-state life table functions and their variability from complex survey data using the SPACE Program. Demographic Research. 2010 Jan 26;22:129–57. [PubMed: 20463842]
22. Harvard Center for Population and Development Studies (Harvard T.H. Chan School of Public Health). Wave 2 Sample Weights Documentation, HAALSI Wave 2 Survey [Internet]. V3 ed. Harvard Dataverse; 2021 Oct. Available from: 10.7910/DVN/UELYSV
23. Bor J, Rosen S, Chimbindi N, Haber N, Herbst K, Mutevedzi T, et al. Mass HIV Treatment and Sex Disparities in Life Expectancy: Demographic Surveillance in Rural South Africa. PLOS Medicine. 2015 Nov 24;12(11):e1001905. [PubMed: 26599699]
24. Payne CF, Gómez-Olivé FX, Kahn K, Berkman L. Physical Function in an Aging Population in Rural South Africa: Findings From HAALSI and Cross-National Comparisons With HRS Sister Studies. J Gerontol B Psychol Sci Soc Sci [Internet]. 2017 [cited 2017 Jun 9]; Available from: https://academic.oup.com/psychsocgerontology/article/doi/10.1093/geronb/gbx030/3091725/Physical-Function-in-an-Aging-Population-in-Rural
25. UNAIDS. 90–90–90 - An ambitious treatment target to help end the AIDS epidemic [Internet]. Geneva, Switzerland: UNAIDS; 2014 [cited 2021 Mar 31]. Report No.: JC2684. Available from: https://www.unaids.org/en/resources/documents/2017/90-90-90
26. Marinda E, Simbayi L, Zuma K, Zungu N, Moyo S, Kondlo L, et al. Towards achieving the 90–90–90 HIV targets: results from the south African 2017 national HIV survey. BMC Public Health. 2020 Sep 9;20(1):1375. [PubMed: 32907565]

27. Johnson LF, Mossong J, Dorrington RE, Schomaker M, Hoffmann CJ, Keiser O, et al. Life Expectancies of South African Adults Starting Antiretroviral Treatment: Collaborative Analysis of Cohort Studies. PLOS Medicine. 2013 Apr 9;10(4):e1001418. [PubMed: 23585736]
28. Schatz E, Houle B, Mojola SA, Angotti N, Williams J. How to "Live a Good Life": Aging and HIV Testing in Rural South Africa. J Aging Health. 2019 Apr 1;31(4):709–32. [PubMed: 29318924]
29. Celestin K, Allorant A, Virgin M, Marinho E, Francois K, Honoré JG, et al. Short-Term Effects of the COVID-19 Pandemic on HIV Care Utilization, Service Delivery, and Continuity of HIV Antiretroviral Treatment (ART) in Haiti. AIDS Behav [Internet]. 2021 Mar 18 [cited 2021 Mar 31]; Available from: 10.1007/s10461-021-03218-8
30. Manne-Goehler J, Rohr J, Montana L, Siedner M, Harling G, Gómez-Olivé FX, et al. ART denial: results of a home-based study to validate self-reported antiretroviral use in rural South Africa. AIDS Behav. 2019 Aug;23(8):2072–8. [PubMed: 30523490]

RESEARCH IN CONTEXT

Evidence before the study

We searched PubMed on November 23, 2021, without language or date restrictions using the search terms "HIV" AND ("health-adjusted life expectancy" OR "disability-adjusted life expectancy" OR "disability-free life expectancy" OR "health-adjusted life expectancy" OR "comorbidity-free life expectancy" OR "healthy life expectancy" OR "disabled life expectancy") in all fields. This search yielded two studies examining health-adjusted life expectancy in people with HIV, though these studies did employ different types of life expectancies among adults of all ages. The first was a retrospective analysis of health-adjusted life expectancy from electronic health record data for adults including all known PLHIV and a 10% random sample of the general population of British Columbia. They found that at 20 years of age, health-adjusted life expectancy was greater for men and women without HIV (58 and 63 years, respectively) than for men and women with HIV (31 and 27 years, respectively). In a second matched cohort study using data from insured adults with and without HIV infection from the medical centres of Kaiser Permanente in the US, the authors found a difference of 9.5 years in comorbidity-free life expectancy between people without HIV and those with HIV who initiated antiretroviral therapy (ART) at a CD4 cell count of 500/μL or greater.

Added value of the study

In this study, we used data from a large population-based cohort of ageing adults in rural Agincourt sub-district, Mpumalanga province, South Africa to estimate both life expectancy and disability-free life-expectancy by HIV and viral suppression status using Markov-based microsimulation modelling. Our study adds value to the current literature in three ways. First, to the best of our knowledge, this study is the first to estimate differences in disability-free life expectancy in a population-based cohort in sub-Saharan Africa according to HIV status and viral suppression status among those living with HIV. Second, this study derives estimates of disability-free life expectancy based on direct measures of limitations in the performance of activities of daily living and incident mortality from over 4,500 ageing adults as tracked by the Agincourt Health and Demographic Surveillance System. Third, this study collected not only HIV antibody status but also HIV viral load and exposure to emtricitabine (FTC) or lamivudine (3TC) by dried blood spot within a population-based cohort of older adults; this allowed for a highly reliable categorization of cohort participants by HIV and ART use status.

Implications of all the available evidence

The population-level benefits of ART delivery and viral suppression for people living with HIV extend beyond life expectancy, such that those who are virally suppressed may also have a longer disability-free lifespan. Interventions to increase ART uptake and adherence offer an important strategy to promote healthy ageing among PLHIV, especially in high prevalence settings.

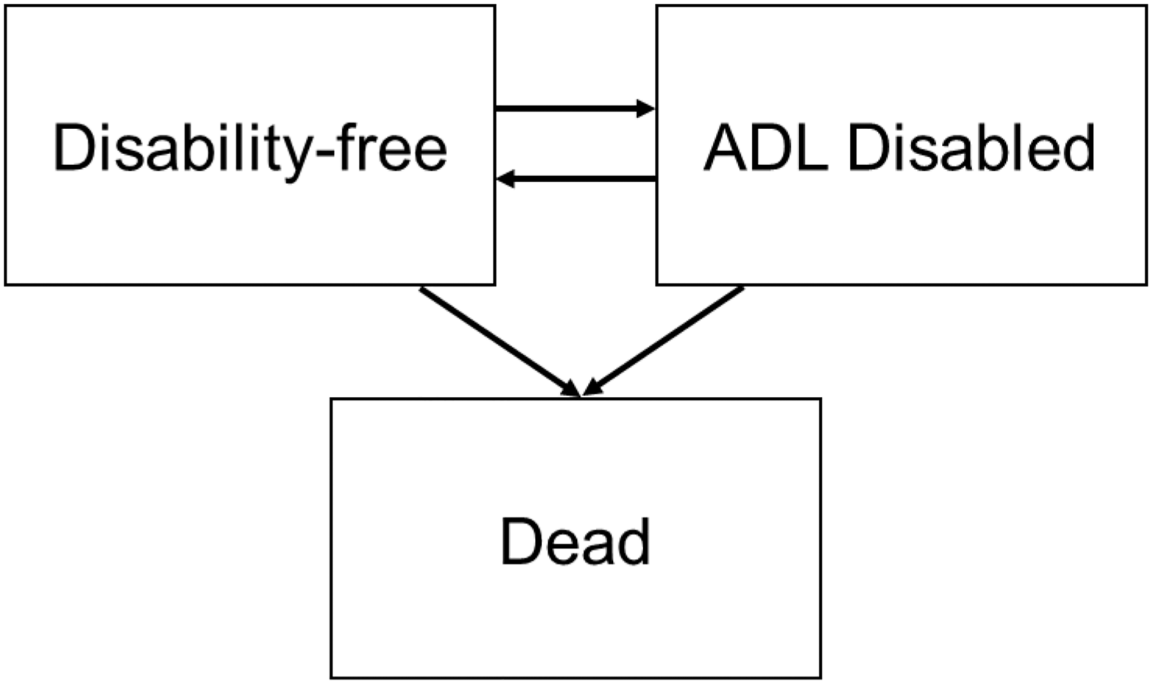

Figure 1:
State-space for multistate model

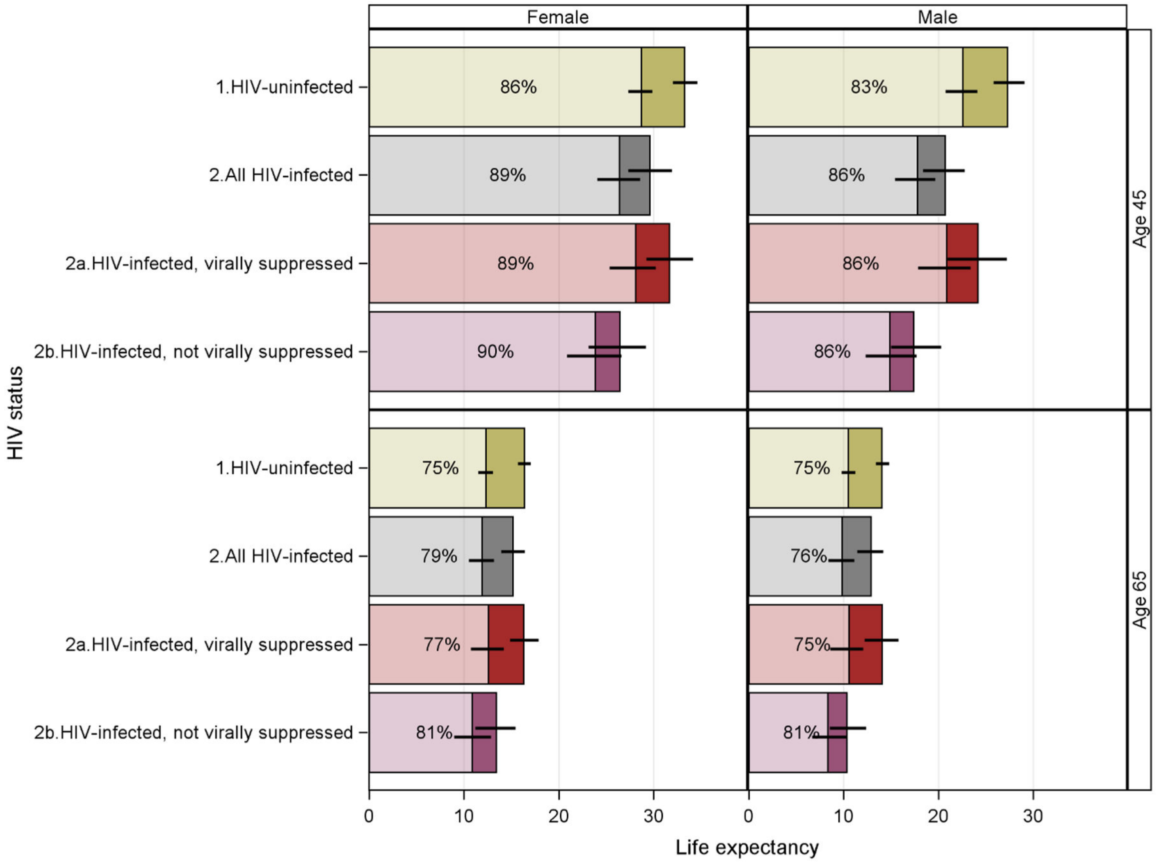

Figure 2:
Microsimulation estimated disability-free, disabled, and total remaining life expectancy at ages 45 and 65 by HIV status and viral suppression, HAALSI 2015–2018
Notes: Black bars represent the 95% confidence interval around point estimates of total LE and DFLE. Percentage figures refer to the percent of LE spent disability-free.

Table 1:

Baseline sample characteristics by HIV status and viral suppression, HAALSI 2015

	HIV-uninfected	HIV-infected, virally suppressed	HIV-infected, not virally suppressed	Total
N (%)	3312 (77%)	601 (14%)	409 (9%)	4322 (100%)
Age group				
40–49	442 (13%)	154 (26%)	130 (32%)	726 (17%)
50–59	779 (24%)	223 (37%)	148 (36%)	1150 (27%)
60–69	905 (27%)	160 (27%)	85 (21%)	1150 (27%)
70+	1186 (36%)	64 (11%)	46 (11%)	1296 (30%)
Respondent sex				
Male	1516 (46%)	270 (45%)	187 (46%)	1973 (46%)
Female	1796 (54%)	331 (55%)	222 (54%)	2349 (54%)
ADL Limitation				
Disability-free	2995 (90%)	567 (94%)	376 (92%)	3938 (91%)
ADL disabled	317 (10%)	34 (6%)	33 (8%)	384 (9%)
Physical health[a]				
Physically healthy	1927 (63%)	332 (58%)	239 (62%)	2498 (62%)
Physically limited	1133 (37%)	236 (42%)	147 (38%)	1516 (38%)

[a]The measure of physical health was based on measured grip strength and gait speed as described in Supplemental Text 1. Information on physical health were missing for 157 male and 150 female respondents due to refusals or inability to complete the grip strength or gait speed tasks

Table 2:

Microsimulation estimated disability-free, disabled, and total remaining life expectancy at ages 45 and 65 by HIV status and viral suppression, HAALSI 2015–2018

	Total LE	Disability-free LE	ADL disabled LE	Proportion disability-free
	Estimate [95% CI]	Estimate [95% CI]	Estimate [95% CI]	Estimate [95% CI]
Males				
Age 45				
HIV-uninfected	27.2 [25.8 – 29.1]	22.6 [20.7 – 24.1]	4.2 [3.4 – 5.8]	0.83 [0.78 – 0.86]
HIV-infected	20.7 [18.4 – 22.7]	17.8 [15.4 – 19.7]	2.4 [1.8 – 3.5]	0.86 [0.81 – 0.89]
Virally suppressed	24.1 [20.9 – 27.2]	20.9 [17.8 – 23.4]	2.8 [1.8 – 4.5]	0.86 [0.80 – 0.90]
Not virally suppressed	17.4 [15.0 – 20.3]	14.9 [12.3 – 17.7]	2.0 [1.3 – 3.5]	0.86 [0.78 – 0.90]
Age 65				
HIV-uninfected	14.0 [13.4 – 14.8]	10.5 [9.8 – 11.2]	2.9 [2.5 – 3.5]	0.75 [0.71 – 0.78]
HIV-infected	12.9 [11.4 – 14.2]	9.8 [8.4 – 11.1]	2.6 [1.7 – 3.8]	0.76 [0.68 – 0.82]
Virally suppressed	14.1 [12.2 – 15.8]	10.6 [8.6 – 12.1]	3.0 [1.9 – 4.5]	0.75 [0.64 – 0.82]
Not virally suppressed	10.3 [8.5 – 12.4]	8.3 [6.7 – 10.3]	1.5 [0.7 – 2.9]	0.81 [0.70 – 0.88]
Females				
Age 45				
HIV-uninfected	33.2 [32.0 – 35.0]	28.7 [27.3 – 29.8]	4.0 [3.4 – 5.1]	0.86 [0.83 – 0.88]
HIV-infected	29.6 [27.3 – 31.9]	26.4 [24.0 – 28.5]	2.7 [1.9 – 4.0]	0.89 [0.85 – 0.92]
Virally suppressed	31.6 [29.2 – 34.1]	28.1 [25.4 – 30.2]	3.1 [2.0 – 4.8]	0.89 [0.84 – 0.92]
Not virally suppressed	26.4 [23.1 – 29.1]	23.8 [20.8 – 26.6]	2.1 [1.3 – 3.5]	0.90 [0.85 – 0.93]
Age 65				
HIV-uninfected	16.4 [15.7 – 17.0]	12.3 [11.5 – 13.1]	3.4 [2.8 – 4.1]	0.75 [0.72 – 0.79]
HIV-infected	15.2 [13.9 – 16.4]	11.9 [10.5 – 13.1]	2.8 [1.9 – 4.1]	0.79 [0.70 – 0.83]
Virally suppressed	16.3 [14.9 – 17.9]	12.6 [10.7 – 14.2]	3.2 [1.9 – 5.0]	0.77 [0.67 – 0.85]
Not virally suppressed	13.4 [11.2 – 15.4]	10.9 [8.9 – 12.8]	2.0 [0.9 – 3.6]	0.81 [0.70 – 0.89]