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Life Expectancy and Life Years Lost After HIV Diagnosis in Puerto Rico, 2000-2020

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ABSTRACT

Background: In 2019, the Global Burden of Disease estimated that HIV/AIDS was globally the second top cause for disability-adjusted life years in individuals 25–49 years of age and the ninth most common cause for young individuals between the ages of 10-24. The objective of this study was to estimate the average life expectancy and life years lost (LYL) in individuals diagnosed with HIV in Puerto Rico from 2000-2020 and to evaluate the relationship between LYL and demographic factors. Methods: The epidemiological design was a retrospective cohort study of 11,524 people diagnosed with HIV who received services under the Eligible Metropolitan Area (EMA) of San Juan, Puerto Rico. The population among this cohort was described using socioeconomic characteristics with frequencies and proportions by category. We estimated the LYL by matching the expected residual lifetime for someone diagnosed with the disease with the life expectancy of the general population at that specific age as the null model. Results: LYL is greater with earlier HIV onset and is also influenced by level of poverty, type of insurance, and documented mode of transmission of HIV. The average life expectancy (number of years alive remaining after diagnosis) across all ages of an HIV-diagnosed individual is between 12 and 14 years. We found greater LYL in HIV patients with lower income status across age groups; in those without insurance, significantly in ages of 40-49 years; as well as with perinatal transmission versus other modes of transmission, and intravenous drug use versus heterosexual contact. No distinction was found between males versus females. Conclusion: This study reaffirms the importance of prevention and demographic aspects such as age, poverty level, insurance type, and factors related to lifestyle (transmission modes) to develop better prevention strategies to reduce the LYL as a consequence of HIV.

Keywords: Life Years Lost, HIV/AIDS, Life Expectancy, Puerto Rico, AIDS: Acquired Immunodeficiency Syndrome, ART: Antiretroviral Therapy, AYLL: Average Years of Life Lost, EMA: Eligible Metropolitan Area, HIV: Human Immunodeficiency Virus, LGB:

Lesbian, Gay and Bisexual, MSM: men who have sex with men, IDU: intravenous drug use, LYL: Life Years Lost, PR: Puerto Rico.

INTRODUCTION

The Global Burden of Disease estimated that HIV/AIDS was the eleventh most common cause of disability-adjusted life years globally in 2019–the second top cause for individuals 25–49 years of age, and the ninth most common cause for young individuals between the ages of 10-24 [1]. The Human Immunodeficiency Virus (HIV) is considered a chronic disease [2]. Since the introduction of antiretroviral therapy (ART), the prognosis of people living with HIV has improved. Still, there is no cure for HIV infection, despite the diagnosis and multiple alternatives for treatment and increasing life span. One method of evaluating a condition's impact on the health of individuals is to assess whether it results in a reduced lifespan. However, calculating the life expectancy of individuals who acquire the condition at different times in their lives is not straightforward, and comparison using analyses based on life expectancy is likely limited. Recently researchers described a method of estimating the impact of a disease considering the age of onset of the condition ([3], [4]), and others implemented these algorithms in an R package for easy use [5]. A few recent examples of how this method has been used to evaluate the life years lost (LYL) can be found in cancer [6], epilepsy [7], and mental illness [8]. Life years lost (LYL) of an individual is based on the age of onset of the evaluated condition, and average years of life lost (AYLL) estimates the average time across all ages individuals would be expected to live if they did not die prematurely compared to a base population without the condition or the general population ([9], [10]).

LYL has been infrequently estimated for HIV/AIDS, as noted in one study [11], which measured LYL among a population in Iran and found HIV/AIDS patients had 46 fewer years of life expectancy at age 20 than the general population. Another study [12] used the USA population-based National HIV Surveillance System data to estimate life expectancy and average years of life lost (LYL) from all 50 states and Washington, D.C., diagnosed with HIV infection during 2008-2011. This study did not include individuals living in Puerto Rico. Life expectancy after HIV diagnosis was determined using the life table method, and estimates were compared with life expectancy in the general population. Life expectancy and LYL were also estimated for subgroups by age, sex, and race/ethnicity. The overall life expectancy after HIV diagnosis in the United States increased by 3.43 years from 25.4 in 2008 to 28.9 in 2011. As noted by the authors, this was likely related to advancements in treatment and the potential impact on life expectancy following HIV diagnosis. Improvements were observed irrespective of sex, race/ethnicity, transmission category, and stage of disease at diagnosis, though the extent of improvement varied by different characteristics. Based on the life expectancy of the general population in 2010, the LYL for individuals diagnosed with HIV was 12.8 years for males and 16.5 years for females across all ages. In this study, at ages 20, 40, 60, and 80 years, males diagnosed with an HIV infection in 2010 had AYLL of 17.6, 14.1, 10.4, and 6.2 years respectively. Females diagnosed with HIV infection in 2010 at ages 20, 40, 60, and 80 years had AYLL of 24.5, 18.3, 12.1, and 7.3 years, respectively. Despite these improvements in life expectancy among people diagnosed with an HIV infection during 2008–2011, disparities by sex and race/ethnicity persisted in this study. The disparity in average LYL across all ages by race/ethnicity was still present, with blacks having 13.3 average life years lost and whites 13.4 average life years lost compared with 14.7 average life years lost for Hispanics/Latinos.

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LYL is also relevant to risk factors such as poverty level and mode of transmission. Higher poverty levels have been associated with lower life expectancy (which would amount to greater LYL) for each age, gender, and racial/ethnic group [13]. Risk factors, including different modes of transmission, have also been associated with differences in life expectancy. In a 2016 study [12], in each year from 2008-2010, the longest life expectancy by transmission mode among males was observed among men who have sex with men (MSM, 32.30 in 2011), followed by those with infection attributed to male-to-male sexual contact (MSM) *and* IDU (26.31 in 2011), heterosexual contact (23.45 in 2011), and lastly intravenous drug use (IDU) (21.36 in 2011). Specifically, in 2011, life expectancy of MSM (32.30, 95% CI 32.22–32.39) was 12.06 years (60%) higher than that of males with infection attributed to IDU (20.24, 95% CI 20.0–20.48). MSM consistently had greater life expectancy than persons with HIV infection attributed to any other transmission category with on average over 10 more years of life expectancy compared to persons with HIV infection attributed to IDU, who in turn had lower life expectancy than those in any other transmission category, which was also consistent with earlier findings. Another study in 2016 [14] compared life expectancy of persons with HIV in 1996-1997, 2008, and 2011, and considered various risk factors, including modes of transmission. Life expectancy at age 20 for HIV-infected individuals increased to 47.1 years in 2008 and 53.1 years by 2011, narrowing the gap to 11.8 years (8.9-14.8 years) in 2011. Race differences do not appear to show much difference in life expectancies in this study from 2008-2011; life expectancies at age 20 for HIV-infected individuals ranged from a low of 45.8 years for blacks and 46.0 years for those with a history of injection drug use to a high of 52.2 years for Hispanics. HIV-infected individuals who initiated antiretroviral therapy with CD4 ≥500 cells per microliter had a life expectancy at age 20 of 54.5 years in 2008-2011, narrowing the gap relative to HIV-uninfected individuals to 7.9 years (5.1-10.6 years). The gap narrowed further in subgroups with no history of hepatitis B or C infection, smoking, drug/alcohol abuse, or any of these risk factors, though did not yet reach zero at that point, even without considering comorbidities and effect on quality of life. Thus, life expectancy can vary with mode of transmission, among other risk factors, which consequently should be included in the analysis evaluating the burden of HIV in terms of life years lost.

The measurement of life years lost has the important advantage of allowing the breakdown of excess mortality into specific causes of death considering the age of diagnosis, which is critical in examining the magnitude of each cause and implementing focused public health programs. Life years lost have rarely been estimated for HIV in general, and the association between LYL after HIV diagnosis and sociodemographic variables has yet to be evaluated for the Puerto Rican population. We previously characterized and estimated LYL in the Puerto Rico HIV/AIDS population [15]. The objective of the present study is to estimate life years lost in people diagnosed with HIV in Puerto Rico from 2000-2020 with a specifically documented date of onset of HIV and date of death and to evaluate associations with sociodemographic variables. We evaluated whether patients with HIV with certain sociodemographic risk factors have a reduced lifespan by calculating the life expectancy and life years lost (LYL).

METHODS

Study Design and Participants

The epidemiological design used in this study was a retrospective cohort study. The population under study includes people who were diagnosed with HIV, who received services under the Eligible Metropolitan Area (EMA) of San Juan, Puerto Rico, during the period from 2000 to 2020,

and who had a documented date of onset of HIV and date of death. The first part of the study describes sociodemographic characteristics of gender, poverty level (%), mode of transmission, type of health insurance, and age of HIV diagnosis of the individuals included in this study. Posterior to describing the population, we estimated the probability of survival in people diagnosed with HIV, comparing with the general survivorship curves for Puerto Rico to estimate the LYL [16].

The information on the patients for this research was obtained from the electronic medical records of people diagnosed with HIV belonging to the eligible metropolitan area (EMA) of San Juan, Puerto Rico, from 2000 to 2020. All information and data were kept strictly confidential, encoded with identification numbers, and stored only with those identification numbers. Access to coded or encrypted storage was physically limited to authorized personnel only via an access code. The San Juan Bautista School of Medicine IRB (EMSJBIRB-17-2022) approved the study.

Data Analysis

The population with HIV was described using frequencies and proportions by category. Out of 24,143 patient records associated with a diagnosis of HIV and/or AIDS, the initial survey size for this study was 11,524 unique patients with a date of HIV diagnosis, and as information for some of the variables was missing, the sample size by analysis varies. In each case, the sample size is noted. We included only those who were diagnosed with HIV and who had a date of death specified in order to be able calculate the life expectancy, i.e., the average number of years between date of HIV diagnosis and death. Furthermore, we culled through the data to exclude any patients who appeared to be duplicates or had incomplete or clearly incorrect information. We estimated the relative impact of HIV on individuals' mean estimated life expectancy as a consequence of being diagnosed at a given age and the expected number of years to live. Our null model for life expectancy is the survivorship curve of the 1999-2001 demographic survey for Puerto Rico [16]. Evaluation of other survivorship curves (of other demographic surveys) shows only small differences and has minimal impact on the primary interpretation of the results. For analysis of the impact of the number of "Life Years Lost: LYL" as a consequence of a disorder, we applied a method proposed by Andersen (2017) [3, 4] and Erlangsen et al. (2017) [17].

This method considers the challenges of evaluating life span for age-specific mortality rates (for details, see Andersen 2013 [4]; Andersen 2017 [3]; Plana-Ripoll et al. 2020 [5]). Consequently, this approach has the advantage of measuring the LYL at the "onset" of a specific disorder and comparing the average of these individuals with the general population (null model). The assumption is that an individual that would not have contracted HIV would have had the same life span as the null model (general population). For our study, the onset is the year a patient is diagnosed with HIV. Consequently, the LYL is an estimate of the average mean number of years patients with the specific age of onset will lose. To see how the method has been used in other research, see reference [5].

All analyses were done in R (version 4.2.2, R Core Team 2020) and Excel (version 16.72 Microsoft 2023); the "lilies" R package was used to estimate LYL, and our null distribution of life span is the general population [18]. Data wrangling and basic demographic and visualization were done using the set of packages in "tidyverse" [19].

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Data were analyzed using a generalized linear model for association between life years lost and poverty level using a Gamma distribution, and between life years lost and insurance status, mode of transmission, and gender using a Gaussian distribution, with p values less than 0.05 considered significant. All patients with an HIV diagnosis and a date of death with data regarding these factors were analyzed in their respective categories. For poverty level, the percentage of the national poverty level represented by the patient's income, which considers household income and family size [20], was compared with the years of life lost using a gamma distribution model. For insurance status, the patient's status of being insured vs. uninsured, and having private vs. public insurance, were compared with respect to average years of life lost for each group. Transmission categories were similarly compared with respect to AYLL both by age group and overall. Finally, the LYL of males versus females were compared, both by age group and overall.

RESULTS

Population Characteristics

The data set used for the current study contains information on 1,090 patients who have a specific date of HIV diagnosis and a date of death indicated, which was obtained out of an initial data set of 24,143 patient records associated with a diagnosis of HIV and/or AIDS, belonging to the eligible metropolitan area (EMA) of San Juan, Puerto Rico, from 2000 to 2020.

The original data set included 18,729 unique individuals identified to potentially include in the analysis, of which 11,524 had a date of HIV diagnosis, and 3,624 had a date of AIDS diagnosis. Of these, 3,044 had both a date of HIV diagnosis and a date of AIDS diagnosis, 580 had only an AIDS diagnosis date but no date for HIV diagnosis, and 8,480 had an HIV but no AIDS diagnosis date. A total of 6,625 had neither an HIV nor an AIDS diagnosis date, and 15,105 had no AIDS diagnosis date, whether or not there was an HIV diagnosis date. The demographic analysis was focused on those who had an HIV diagnosis date (11,524). The average age at diagnosis for men with HIV was 36.8 years, while for women, it was 35.4 years. In this study, 92% of the individuals lived below the poverty level, with an average annual income of $4,483. Most individuals (74%) had an income at or below 50% of the poverty level. While 90% had public health insurance (63% had Medicaid, and the remainder had Medicare or other public insurance), 2% had "other" (unspecified) insurance, and 2% had no insurance. Individuals in this study with HIV, reported being infected through the following modes: 38.4% through heterosexual contact, 41.4% through the use of intravenous drugs, and 14.4% through homosexual contact. Only 2% reported both homosexual contact and intravenous drug use, while 7% reported transfusion, and 12% reported perinatal transmission. Table 1 presents the demographic information of the patients.

Table 1: Demographic characteristics of HIV patients in this study who received services under the Eligible Metropolitan Area (EMA) of San Juan, Puerto Rico, from 2000 to 2020.

Characteristic	N	Percent
Total	11,524	100.00
Vital Status	11,524	100.00
Alive	9,926	86.13
Dead	1,170	10.15
Unknown	428	3.71

Gender	11,524	100.00
Male	7,597	65.92
Female	3,879	33.66
Transgender	46	0.40
No answer	1	0.01
Unknown	1	0.01
Age (years) at diagnosis	11,524	100.00
0-9	336	2.92
10-19	327	2.84
20-29	2,666	23.13
30-49	3,605	31.28
40-49	2,918	25.32
50-59	1,261	10.94
≥ 60	411	3.57
% Poverty Level	11,524	100.00
≤ 50	7,430	64.47
≤ 100	9,371	81.32
> 100	1,633	14.17
"N/A"	520	4.51
Type of Medical Insurance	11,524	100.00
Public (Medicare/Medicaid/Other)	9,498	82.42
Medicaid	7,452	64.67
Private	1,117	9.69
Uninsured	694	6.02
"Other"	210	1.82
Mode of transmission	11,524	100.00
Heterosexual	4,983	43.24
Intravenous Drug Use (IDU)	2,561	22.22
Men Sex Men (MSM)	3,166	27.47
Perinatal	333	2.89
IDU & MSM	112	0.97
Blood transfusion	106	0.92
Other	46	0.40
Hemophilia	7	0.06
Not specified	210	1.82

LYL Results

The model assumes that the mean life expectancy of the general population of Puerto Ricans is 80.25 years old, which is the mean life expectancy (for males it is 76.7 years old and for females it is 83.6 years old.) The model also requires a maximum age, for which we used a *tau* of 80.25 years old which is the mean of life expectancy of males and females. Varying the maximum tau (80-99) produced insignificant changes in interpretations of the main results.

Impact on HIV Patients:

Of all patients who receive an HIV diagnosis and have date of death (n = 1,090) the expected LYL is 39.48 years for very young patients at age 0 (36.17-43.92), 31.67 at age 30 (30.73-32.56), and 14.34 at age 60 (13.77-14.42), and the average life expectancy across all ages (years alive remaining after the onset) of an HIV-diagnosed individual is between 12 and 14 years. (See

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Figure 1, below, red dots, with confidence intervals.) The life expectancy of individuals, irrespective of the age of onset, is many years less than that of the normal population. An individual who is diagnosed with HIV, at the age of 20, 30 and 50, has an expected mean lifespan of another 23, 19 and 9 years, respectively (Figure 1, black dots). Considering the whole population across all ages the average life expectancy is ± 40 years to live for an age-matched cohort (Figure 1, blue line).

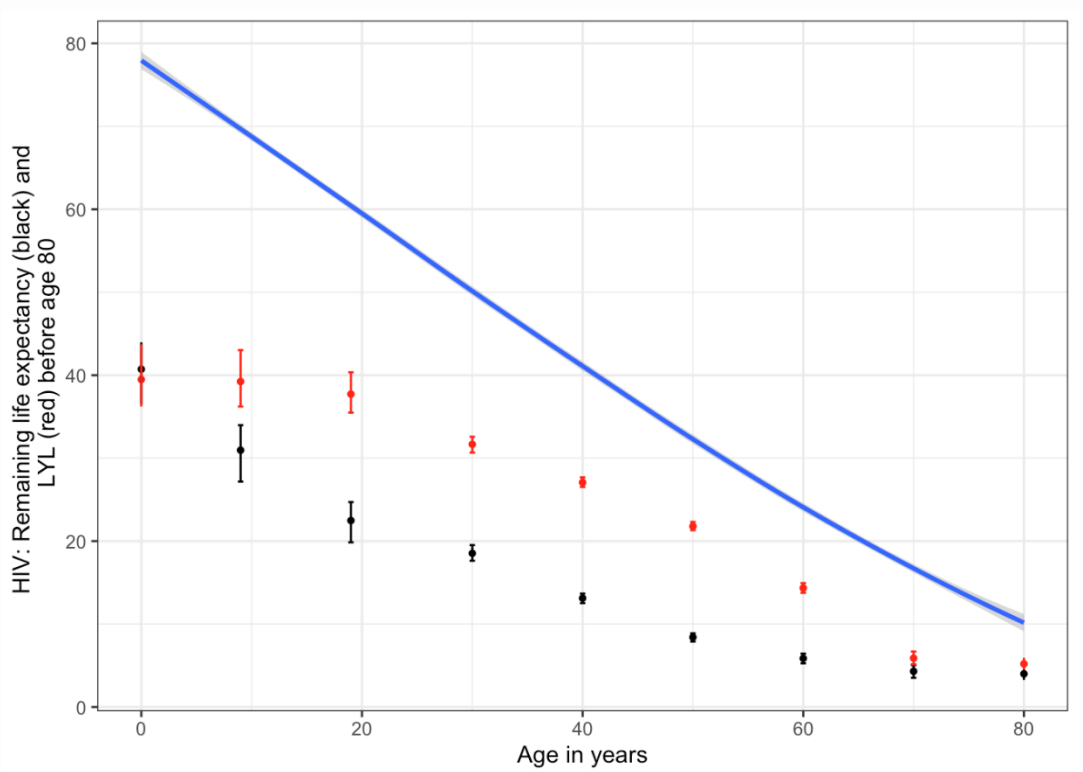


Figure 1: HIV: LYL and life expectancy of individuals diagnosed with HIV at a specific age. The blue line represents the mean life expectancy of individuals at a specific age for the general population of Puerto Rico (the null model). The black dots and confidence intervals represent the mean life expectancy of individuals who are diagnosed with HIV with onset at age X. The red dots and confidence intervals represent the mean LYL of an individual diagnosed with HIV with onset at age X. Note the grey area around the blue line, which represents the 95% confidence interval of the general population.

Poverty Level:

For patients diagnosed with HIV, a significant inverse association was found between the income-as measured by percentage of the poverty level—and LYL ($p < 0.001$), using a gamma distribution model for patients of all ages in this study (Figure 2). This association is also seen when evaluating patients among a specific range of ages at which they were diagnosed with HIV, specifically for those diagnosed at the age ranges of 20-29, 30-39, 40-49, 50-59, and 60-69. The strongest associations tended to be among those in the age ranges of 30-39, and 40-49, which also had the most data points. An individual diagnosed with HIV with <100% poverty level at the age of 35 and 45 has an expected mean lifespan of 51.2 ± 2.8 and 56.2 ± 2.5 years, respectively. The latter set of ranges excludes the extremes of age, which did not generate statistical significance; these ranges had a smaller sample size and may also be associated with

less accuracy regarding both LYL as a measure of impact on survival as well as current household income as a measure of socioeconomic status.

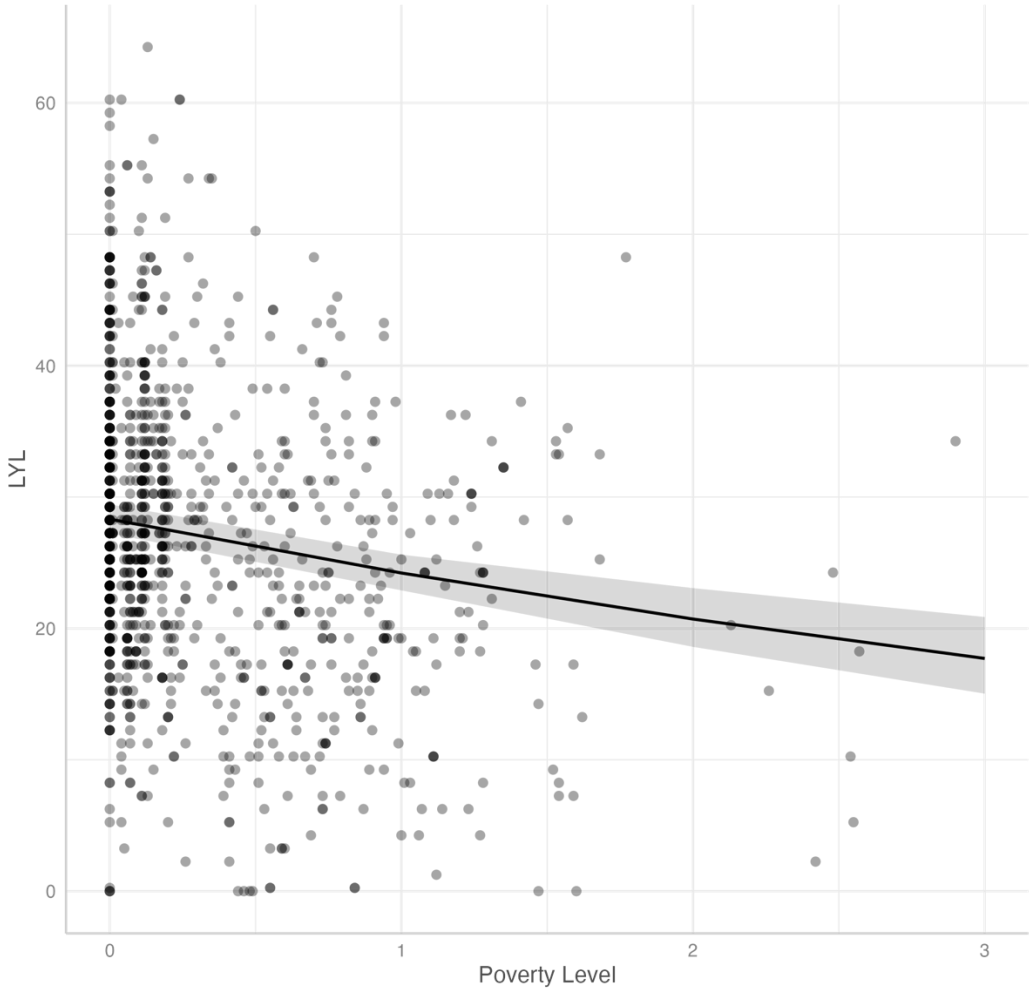


Figure 2: LYL versus poverty level of individuals diagnosed with HIV. The points represent individuals, and the line represents predicted values of LYL based on a gamma distribution model, including 95% confidence levels. The threshold for 100% the federal poverty limit is denoted with a bold vertical line. The x-axis excluded values larger than 3x the poverty level (only 1 data point.)

Mode of Transmission:

For all patients diagnosed with HIV, without stratifying by age, significantly greater LYL were found with perinatal transmission versus other modes of transmission, and greater LYL were found with IDU transmission versus with heterosexual contact. Other differences were observed within specific age groups. Specifically, in the age group 10-19, heterosexual transmission was associated with greater LYL compared with MSM and MSM & IDU categories. These three categories were the only transmission modes with greater than one patient in this age range. In the age range 40-49, heterosexual transmission carried greater LYL than IDU and transfusion modalities (Figure 3). However, as a general pattern LYL was generally very similar among transmission methods within a group age category.

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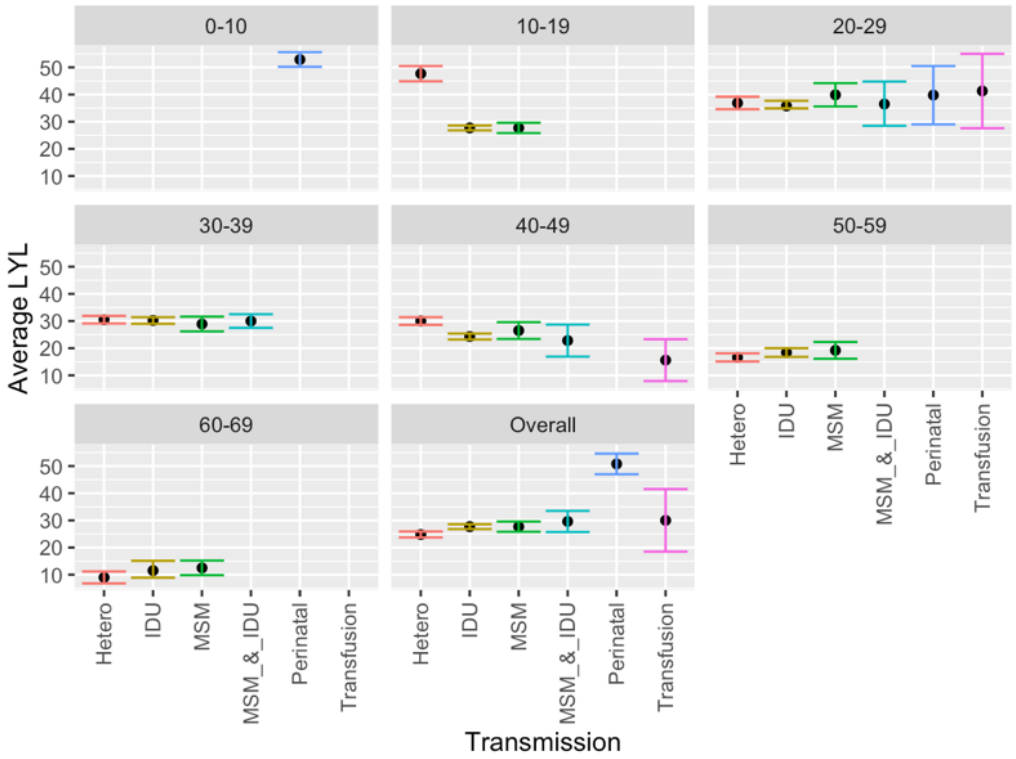


Figure 3: Average LYL by mode of transmission of individuals diagnosed with HIV, including 95% confidence levels, grouped by the age of first diagnosis.

Medical Insurance:

No significant difference was found between insurance categories for LYL among the entire group of HIV patients in this study. Although greater LYL were found in those with no insurance (30.9) versus those with insurance (26.9), the difference was not significant (p=0.08). In the age of onset in the range of 40-49, significantly greater LYL were found in those with no insurance versus with insurance (30.3 versus 24.2, respectively, p=0.02.) This trend was generally present in all age groups, but was only significant in the 40-49 age group, which included the greatest number of patients (n=326 with insurance, 9 without.). No significant difference in LYL was found between public versus private insurance in any age group, nor overall. There was also no difference between specific types of public insurance (e.g., Medicaid versus Medicare or other public insurance.)

Gender:

No association was found with gender, with approximately equal LYL found overall, and within all age groups between males and females. Overall, patients lost a total of 26.8 years (26.5 ± 0.8 for males, and 27.5 ± 1.2 for females.) Transgender patients and those who refused to answer the question of gender tended to have greater AYLL, but were few in number (n=3 and 1, respectively) so this did not produce significant difference in AYLL. In general, as we previously found for HIV/AIDS patients [15], number of life years lost decreased with increased age at HIV diagnosis.

Of note, our use of a Gaussian distribution for comparison of LYL is justified, as LYL values followed a normal distribution (Shapiro-Wilks's test of normality, p >0.05; Figure 4, below.)

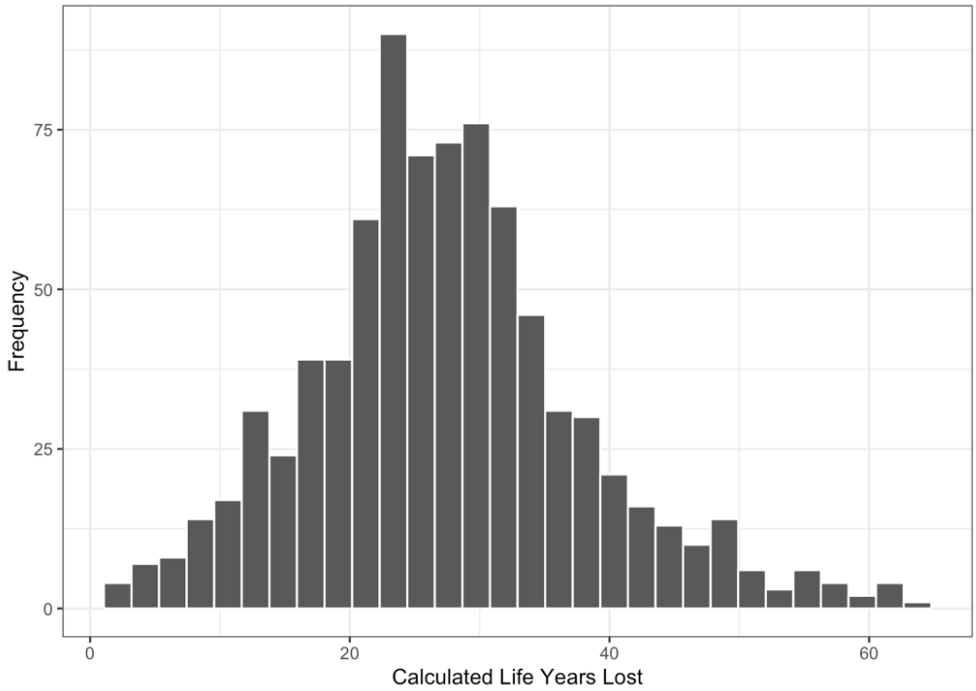


Figure 4: Distribution of LYL frequency by calculated frequency of number of life years lost.

DISCUSSION

One of the main findings of this study is that the number of Life Years Lost among HIV patients is associated with specific demographic factors. We have demonstrated in this study that LYL is dependent on the year of onset of the condition/diagnosis. A newborn diagnosed with HIV is expected to lose ± 40 years of life, while a 50-year-old is likely to lose closer to 20 years of life. As the age of onset or diagnosis of HIV increases, the LYL is reduced as expected. Individuals who are older when they are diagnosed with HIV have fewer LYL as they approach the natural average life expectancy of humans. This trend is consistent with other studies estimating LYL in the United States ([12], [21].) In our prior study [15], we also demonstrated that there is a greater number of life years lost in patients diagnosed with AIDS in this population compared to those diagnosed with HIV. This finding is also consistent with prior results in 2016 [12] indicating that those with late-stage disease at diagnosis (stage 3, i.e., AIDS) had a life expectancy that was, on average, 6.6 years lower than that for persons with HIV not classified as stage 3. This finding signal poorer outcomes with late diagnosis and more advanced disease. In 2021, approximately 5.9 million people did not know they were living with HIV, per UNAIDS data [22]. The life expectancy of individuals, irrespective of the age of onset, is many years less than the normal population. This situation underscores the importance of prevention, and it is important to consider demographic aspects such as gender, age, poverty level, and factors related to lifestyle to develop better prevention strategies.

Of note, it can be observed that our results from Puerto Rico demonstrate reduced life expectancy in HIV patients compared with results from the mainland U.S., for example from one study that estimated a 21-year-old would have another 54.9 years to live in 2000-2016 [23] versus approximately 22 years for a 20-year-old in our study. While there are differences in the timeframe, the earlier timeframe of the mainland U.S. study makes this a conservative

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comparison because the life expectancy was improving over time, so the difference would likely be greater for an equivalent period.

We demonstrated that certain modes of transmission are associated with greater LYL than others. Significantly greater AYLL were found with perinatal transmission versus other modes of transmission. This may be at least partly relatable to the significant association of younger age with greater LYL due to lower natural remaining life expectancy with greater age. It is difficult to parse out how much of the disparity is related to this versus other factors, if any. We found greater LYL with IDU transmission versus heterosexual contact for patients overall, which was robust enough to be significant for patients of all ages combined, despite not being significant among any individual age group (likely due to lower numbers and therefore reduced power) and being significantly lower compared to heterosexual transmission in ages 40-49. The greater years lost with IDU, which is associated with greater transmissibility, may be related to factors such as differences in risks of transmissibility of other diseases or infections with intravenous injection, and/or association with risky behaviors and other risk factors including lower socioeconomic status in the group of those who inject drugs. It is difficult to know how much the greater association with IDU compared heterosexual transmission across all ages but not within individual age groups is due to there being more overall data, versus whether, as may be the case with prenatal transmission, the lack of age stratification makes comparability problematic. Within the age group 10-19, heterosexual transmission was associated with greater AYLL compared with MSM and MSM & IDU categories, the only other categories with greater than one patient. It is difficult to know the reason for this association. This may be similar to the greater LYL in patients ages 40-49 with heterosexual transmission versus IDU. It is possible that earlier screening and diagnosis are related to a higher index of suspicion or concern in those individuals with the known risk factors of MSM and IDU versus those with heterosexual transmission, who may not have a reason to undergo testing until symptoms develop after the disease has further progressed. Diagnosis at later stages of progression may allow for less control of disease and greater LYL that result, which is consistent with our prior findings [15] that AIDS diagnoses are associated with greater LYL than HIV diagnoses. There is also room for error in knowledge of how the disease was transmitted when multiple modes of transmission are possible.

Greater LYL were found throughout all age groups in those with no insurance versus those with insurance, though the difference was only significant in the age range of 40-49. This age range had the greatest number of patients. It is also possible that other factors play a role, such as whether one's insurance status may be more likely related to other socioeconomic factors in the less extreme age groups, for instance, compared to the youngest ages when insurance may be through the parents, school, or other entity, or older ages when one is eligible for Medicare. No significant difference in LYL was found between public versus private insurance in any age group, nor overall, and the type of insurance did not make a difference. Such similarities in outcomes may have implications given differences in health care expenditures between public versus private health insurance sectors.

We also noted a significant association with poverty level, where poverty is associated with greater LYL. Despite resources such as Medicaid that exist to assist lower-income segments of the population, this signals that such programs are inadequate to alleviate the health outcome

inequity related to socioeconomic status and the various associated social determinants of health.

No trend nor association was found with male versus female gender. Transgender patients had generally greater LYL than males or females, but were few in this study (n=3) so, it is not surprising that this was not significant regardless of whether there is a real difference or not. Further, this number may potentially represent an underestimation, for example, if patients were categorized based on birth sex.

Our results are generally consistent with prior studies. Higher poverty levels have been associated with lower life expectancy generally in different age, gender, and racial/ethnic groups. [13] One study that examined socioeconomic, racial, and geographic disparities in HIV/AIDS mortality in the U.S. between 1987 and 2011 [24] found that mortality rose between 1987-1995 and then declined markedly between 1996-2011, yet socioeconomic and racial and geographic disparities in HIV/AIDS mortality increased in the latter period despite the steep mortality decline; those in the most-deprived group had 1.9 times higher HIV/AIDS mortality than those in the most affluent group in 1987, which increased to 2.9 in 1998 and 3.6 in 2009. Prior studies also found differences by transmission category, such as a 2016 study in the U.S. [14] that found MSM and heterosexuals reached significantly higher life expectancies compared with individuals with a history of IDU in 2008–2011 ($p = 0.004$ and $p = 0.011$, respectively), with no difference comparing MSM and heterosexuals ($p = 0.44$). Another U.S.-based study [12] found that among males, in each year from 2008 to 2010, MSM had the longest life expectancy, followed by males with infection attributed to male-to-male sexual contact *and* IDU, heterosexual contact, and finally IDU. These are consistent with our finding of IDU carrying greater LYL than heterosexual transmission. We did not find a significant difference between MSM versus combined MSM and IDU versus heterosexual, though it is difficult to know if this is due to insufficient power (small sample size) or differences in the study demographic, timeframe, and/or other factors.

Regarding gender differences, a 2020 U.S. study [23] found that in their cohort between 2000-2016 women had a greater difference in overall life expectancy by HIV status compared with men (12.1 years [95% CI, 10.0-14.3 years] vs 9.0 years [95% CI, 8.0-10.0 years]) but a smaller difference in years free of any comorbidity (12.7 years [95% CI, 10.4-15.1 years] vs 15.6 years [95% CI, 14.8-16.5 years]), with variation across individual comorbidities. We did not find any such differences between genders. The reason for this disparity compared to our study is unclear, though differences in population and location, as well as time frame, may play a role. Of note, as discussed earlier, this study [23] found that the life expectancy of adults with HIV infection was near that of the life expectancy of individuals without HIV infection, which differs from our results.

A limitation of the analysis in our study is that the sample sizes are unequal among ages. For example, few newborns and youth were diagnosed with HIV. Likewise, the number of individuals with onset of diagnosis of HIV at age 60 or above was small. The number of transgender individuals documented was also quite small. The small sample size in this category may have missed important associations. In addition, the deaths reported during the study period by the San Juan Eligible Metropolitan Area (EMA) were not matched with the Puerto Rico Demographic Registry. In addition, the data for the San Juan Eligible Metropolitan Area (EMA) does not include

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people who have been tested anonymously or people infected with HIV/AIDS who have not been tested, and this analysis also does not include individuals diagnosed with AIDS but who do not have a documented HIV diagnosis date. Our sample population only includes individuals who requested services through EMA.

Our study is currently limited in the ability of our estimated values for LYL to be compared with prior studies, given the lack of prior studies using the same time frames, methods, and populations, so such inter-study comparison would need to be made with caution. For example, the protocol in the 2016 U.S. study [12] does not include Puerto Rico and could produce different results due to the different population, access to care differences in the mainland United States versus Puerto Rico, and the time frame and methods. The 2016 study used data from 2008-2011, which is subsumed in but not identical to our population. Finally, their method involved subtracting from life table data from 2010, yielding different estimates from ours. Likewise, a 2010 United States study [21] did not include Puerto Rico and was performed with data from the timeframe between 1996-2005, which overlaps only partially with our timeframe. Estimates using more recent data may differ, with mortality potentially improved due to developments in treatment [12] that can help improve life expectancy, though still with co-morbidities [23, 24]. Timeframe differences may, therefore, make it more difficult to compare results. However, the stark differences in HIV mortality in the United States mainland [24] versus Puerto Rico may nonetheless be considered reflective of socioeconomic, racial, and geographic disparities [25]. When comparing the burden of disease on life expectancy across studies, caution is needed as methods may estimate different quantities; researchers should consider such differences concerning the purpose of the research and the type of available data when deciding among different methods to estimate YLL [9]. Future studies may also be performed that employ designs that minimize such discrepancies to allow accurate inter-study comparisons, including with our study results.

Additional limitations include restrictions in categorization, for instance, with the ability to classify the transmission mode. It may be difficult to determine with certainty the mode of transmission, particularly when more than one potential mode or risk factor exists. We combined MSM and IDU but did not include other combinations. Further, the combined MSM and IDU group subtracted from the number of individuals in the individual MSM and IDU groups because we did not include individuals in more than one overlapping group, although the number in this combined group was generally small. In conclusion, average years of life lost, in addition to survival and life expectancy, has been infrequently used to evaluate the impact of the HIV/AIDS epidemic, particularly in Puerto Rico, and can be used to compare risk factors. The number of life years lost (LYL) in HIV patients is related to age of onset as well as, notably, to insurance/no insurance status, poverty level, and transmission mode, but not male versus female gender. Our LYL estimations appear to indicate greater LYL in this Puerto Rico population compared with results from the mainland U.S. [23]. Our results may be considered within the broader context of socioeconomic, racial, and geographic disparities in HIV/AIDS mortality in the United States.

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Declarations

Conflict of interest: There are no conflicts of interest to declare.

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