Incidence of non-AIDS defining comorbidities among young adults with perinatally acquired HIV in North America

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Objective: The aim of this study is to describe the incidence of diabetes mellitus type 2 (T2DM), hypercholesterolemia, hypertriglyceridemia, hypertension, and chronic kidney disease (CKD) from 2000 to 2019 among North American adults with perinatally acquired HIV (PHIV) aged 18–30 years.

Design: Description of outcomes based on electronic health records for a cohort of 375 young adults with PHIV enrolled in routine HIV care at clinics contributing data to the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD).

Methods: We estimated overall, sex, and race-stratified cumulative incidences using Turnbull estimation, and incidence rates using quasi-Poisson regression. T2DM was defined as glycosylated hemoglobin more than 6.5% or based on clinical diagnosis and medication use. Hypercholesterolemia was based on medication use or total cholesterol at least 200 mg/dl. Hypertriglyceridemia was based on medication use or fasting triglyceride at least 150 mg/dl or nonfasting at least 200 mg/dl. Hypertension was based on clinical diagnosis. CKD was defined as estimated glomerular filtration rates less than 90 ml/mi|1.73 m^2 for at least 3 months.

Results: Cumulative incidence by age 30 and incidence rates from age 18 to 30 (per 100 person-years) were T2DM: 19%, 2.9; hypercholesterolemia: 40%, 4.6; hypertriglyceridemia: 50%, 5.6; hypertension: 22%, 2.0; and CKD: 25%, 3.3. Non-Black women had the highest incidence of hypercholesterolemia and hypertriglyceridemia, Black adults had the highest hypertension incidence, and Black men had the highest CKD incidence.

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Conclusion: There was a high incidence of five chronic comorbidities among people with PHIV. Earlier screening at younger ages might be considered for this unique population to strengthen prevention strategies and initiate treatment in a timely way.

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Keywords: chronic kidney disease, comorbidities, diabetes, dyslipidemia, HIV, hypertension, perinatally acquired, young adult, youth

Introduction

As survival improves among people with HIV (PWH) in North America, the prevalence of non-AIDS defining comorbidities (NADC) continues to increase, such as chronic kidney disease (CKD), cardiovascular disease (CVD), and their risk factors including dyslipidemia, hypertension, and diabetes mellitus Type 2 (T2DM) [1]. The risk may be driven by a combination of factors, such as HIV infection affecting inflammation pathways or pubertal development, toxicities associated with suboptimal antiretroviral therapy (ART), and long-term ART exposure that increases the risk of resistance and persistent viremia [2,3]. People with perinatally acquired HIV (PHIV) may be at risk of earlier onset of NADC compared with people with nonperinatally acquired HIV, given that people with PHIV may experience decades-longer chronic HIV infection and lifetime ART exposure [3]. Young adults with PHIV have a higher prevalence of early cardiovascular dysfunction than young adults with nonperinatally acquired HIV potentially mediated by a longer duration of chronic HIV infection [3]. Chronic HIV infection also adversely affects blood pressure via several hypertension pathways, such as the increased activity of the renin-angiotensin-aldosterone system (RAAS) [4], and this may occur at earlier ages among adults with PHIV than adults with nonperinatally acquired HIV. There are known metabolic complications to some antiretroviral medications that are known among PWH that may be amplified in children and adolescents with PHIV, such as dyslipidemia with protease inhibitors [5], and kidney complications with tenofovir disoproxil fumarate [6].

Although the incidence of PHIV in North America has remained low, the number of people with PHIV has substantially increased because of improved survival and more children and adolescents with PHIV are aging into early adulthood and beyond. Canada reports only a handful of infants born with PHIV every year, due to high rates of ART use among pregnant women with HIV that prevent mother-to-child transmission and effective management of exposed infants [7]. In 2021, the United States (US) has achieved the overall incidence elimination target for HIV perinatal transmission of less than 1 per 100 000 live births, yet the number of people with PHIV increased by 14% (a total of 12 355 persons) from 2010 to 2019 [8]. As the number of people with PHIV increases, the burden of NADCs among persons with PHIV remains unknown [9].

Leveraging data from a large HIV cohort collaboration, the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD), this study describes the overall and sex- and race-specific incidence of T2DM, dyslipidemia (i.e., hypercholesterolemia, hypertriglyceridemia), hypertension, and CKD among young adults aged 18–30 years with PHIV who enrolled in continuity HIV care in North America from 2000 to 2019. Characterizing the incidence of NADCs in early adulthood may help understand the natural history of these comorbidities in this special population and inform clinical guidelines.

Materials and methods

Study population

The study population consisted of people with PHIV in the NA-ACCORD, a collaboration of cohorts of adults with HIV aged 18 years and older in the United States and Canada [10]. Participating cohorts provide individual-level sociodemographic, laboratory, medication, and outcome data using a standardized format to the Data Management Core (University of Washington, Seattle), where data are harmonized, quality checked for completeness and accuracy of the data. They are then transferred to the Epidemiology/Biostatistics Core (Johns Hopkins University, Baltimore, USA) for additional quality controls, such as comparison of the data transmitted during the current year vs. the prior year due to drifts in electronic health record data and exploratory data analysis [10]. Ascertainment of perinatal acquisition of HIV was determined based on a thorough review of clinical records based on the protocols of each participating cohort and harmonized by the Data Management Core and Epidemiology/Biostatistics Core. The study was approved by institutional review boards at the Johns Hopkins School of Medicine and locally at each cohort.

We studied all PWH who acquired HIV perinatally [10] in 14 clinical cohorts that contributed data to the

NA-ACCORD for at least one month of follow-up from January 1, 2000, to December 31, 2019. Follow-up time was restricted based on outcome-specific observational windows defined by the NA-ACCORD as the period in the cohort where outcome ascertainment is likely based on cohort-specific data collection procedures [11].

Outcomes

There were five outcomes of interest: T2DM, hypercholesterolemia, hypertriglyceridemia, hypertension, and CKD. These conditions were chosen based on earlier studies suggesting early onset of these outcomes among children and adolescents living with HIV [2,12]. These NADCs are not widely expected to occur at younger ages in the general population, so we selected case definitions with the highest sensitivity compared with other studies that evaluated these NADCs at older ages and provided sensitivity analyses that considered more specific definitions.

We defined T2DM as having glycosylated hemoglobin levels (HbA1c) more than 6.5%, use of medication specific to T2DM, or use of T2DM-related medication and having a clinical diagnosis of T2DM [13]. We defined hypercholesterolemia as reporting use of lipid-lowering medications or having total cholesterol at least 200 mg/dl, in accordance with the National Cholesterol Education Program Adult Treatment Panel III Guidelines (NCEP-ATP III) [14]. We defined hypertriglyceridemia as reporting use of lipid-lowering medications or having fasting triglyceride value at least 150 mg/dl, in accordance of NCEP-ATP III Guidelines, or nonfasting triglyceride value at least 200 mg/dl [15]. We defined hypertension as having a clinical diagnosis of hypertension regardless of treatment, as hypertension may not always be treated at this young age [16]. We defined CKD as having estimated glomerular filtration rates (eGFR), calculated using the 2021 Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [17], less than 90 ml/min|1.73 m^2 for at least 3 months [18]. This cutoff has previously been used for individuals under age 30 without known CKD for screening purposes [19]. For sensitivity analyses, we alternatively considered the following: a higher cutoff of at least 240 mg/dl for hypercholesterolemia, which is used in the National Health Examination Survey (NHANES), a higher cutoff of at least 300 mg/dl for hypertriglyceridemia for both fasting and nonfasting tests, treated hypertension which includes both a clinical diagnosis and antihypertensive medication use, and CKD less than 60 ml/min|173 m^2 for at least 3 months.

Statistical analysis

We followed participants from the latest date among study enrollment, cohort open date, outcome observational window start date, and January 1, 2000, until the earliest date among the occurrence of the first outcome, cohort close date, outcome observational window close date, December 31, 2019, death date, the study participant's 30th birthday, or the date of loss to follow-up. We defined loss to follow-up as the start of the 18-month period without a $CD4^+$ cell count or viral load measurement [20]. We used age as the time scale, an approach that directly accounts for the strong association between age and incident NADCs [21].

Because many study participants had a prevalent NADC at study entry, we estimated cumulative incidence curves and their 95% confidence intervals (95% CIs) by age 30 using a hybrid Turnbull estimation approach combining expectation-maximization and modified iterative convex minorant (EMICM) algorithms [22], which extends the Kaplan–Meier approach by incorporating interval censoring for prevalent events. We stratified results by sex at birth and self-identified race and compared the curves visually to describe any potential differences in the cumulative incidence of NADCs across groups. Incidence rates and their 95% CI were calculated from age 18 to 30, overall, and by sex at birth and self-identified race using quasi-Poisson regression.

In addition to estimating overall incidence of NADCs, we reported incidence stratified by sex at birth and self-identified race, dichotomized into Black vs. non-Black [10].

We conducted the cumulative incidence analysis in SAS 9.4 (SAS Institute, Cary, North Carolina, USA), and conducted the incidence rate analysis and generated all figures using R 4.3.0 (R Foundation).

Results

There were 375 people aged 18–30 years with PHIV between 2000 and 2019 from 14 participating NA-ACCORD cohorts. The median year of enrollment was 2012 [interquartile range (IQR): 2010, 2015], median age of enrollment was 22 years (IQR: 19, 25), and median follow-up time was 3.0 years (IQR: 1.1, 5.5). Table 1 presents information on the study participants in the subsample for each outcome. Across all five outcomes, the median year and median age of enrollment was similar to the overall sample, but the follow-up time was about 1 year shorter, largely affected by the outcomes' observational windows. At study entry, 39% had undetectable viral load and median $CD4^+$ cell count was 412 cells/μl (IQR: 176, 675). At study entry, 54% were on protease inhibitor-containing therapies, while 39% were on integrase inhibitor-containing therapies. At study entry, 27% were ever smokers, and the median BMI was 23.6 (IQR: 20.7, 28.1). The numbers of prevalent cases at study entry of the NADCs under study were 5 (1%) for T2DM, 62 (18%) for hypercholesterolemia, 74 (21%) for hypertriglyceridemia, 19 (5%) for hypertension, and 9 (2%) for CKD.

Cumulative incidence curves for each NADC are presented in Fig. 1. By age 30, the cumulative incidence

Table 1. Descriptive statistics by overall sample and outcome subsample ($N = 375$).

	Overall	Diabetes mellitus Type 2	Hypercholesterolemia	Hypertriglyceridemia	Hypertension	Chronic kidney disease
Final sample[a]	375	359	358	357	358	358
Prevalent cases, *n* (%)[b]		5 (1%)	63 (18%)	75 (21%)	19 (5%)	9 (3%)
Sex at birth and self-identified race, *n* (%)[c]						
Nonblack male	77 (21%)	74 (21%)	74 (21%)	74 (21%)	74 (21%)	74 (21%)
Black male	92 (25%)	89 (25%)	89 (25%)	89 (25%)	89 (25%)	89 (25%)
Non-black female	89 (24%)	83 (23%)	82 (23%)	82 (23%)	82 (23%)	82 (23%)
Black female	117 (31%)	113 (32%)	113 (32%)	112 (31%)	113 (32%)	113 (32%)
Median (IQR) of follow-up time among incident and right-censored study participants [d,e]						
Age at study entry	21.6 (19.3, 24.8)	21.4 (19.3, 24.5)	21.6 (19.4, 24.7)	21.6 (19.5, 24.7)	21.5 (19.4, 24.6)	21.5 (19.4, 24.6)
Follow-up years	2.0 (0.8, 4.2)	1.9 (0.8, 4.0)	1.8 (0.8, 3.8)	1.7 (0.8, 3.6)	1.9 (0.8, 4.0)	1.9 (0.8, 4.0)
HIV-related characteristics at study entry[c,e]						
Undetectable viral load, *n* (%)	147 (39%)	143 (40%)	143 (40%)	144 (40%)	137 (39%)	142 (40%)
CD4$^+$, cells/μl, median (IQR)	412 (176, 675)	414 (176, 682)	412 (172, 675)	414 (176, 683)	405 (157, 675)	422 (176, 683)
Protease inhibitor use, *n* (%)	201 (54%)	194 (54%)	190 (53%)	193 (54%)	188 (54%)	195 (54%)
Integrase inhibitor use, *n* (%)	148 (39%)	141 (39%)	145 (41%)	143 (40%)	141 (40%)	141 (39%)
Other risk factors at study entry [c,e]						
BMI, median (IQR)	23.6 (20.7, 28.1)	23.6 (20.6, 28.3)	23.6 (20.7, 28.3)	23.6 (20.7, 28.4)	23.6 (20.6, 28.2)	23.6 (20.6, 28.3)
Ever observed smoking, *n* (%)	100 (27%)	96 (27%)	96 (27%)	96 (27%)	96 (27%)	96 (27%)

[a]The final sample differs by outcome because of differences in the outcome's specific observational windows.
[b]Proportions are based on the overall sample ($N = 375$).
[c]Proportions are based on the final sample of the outcome.
[d]The median year of study entry across all outcomes was 2012 (IQR: 2010, 2015).
[e]For overall sample, study entry was defined as the date of enrolment.

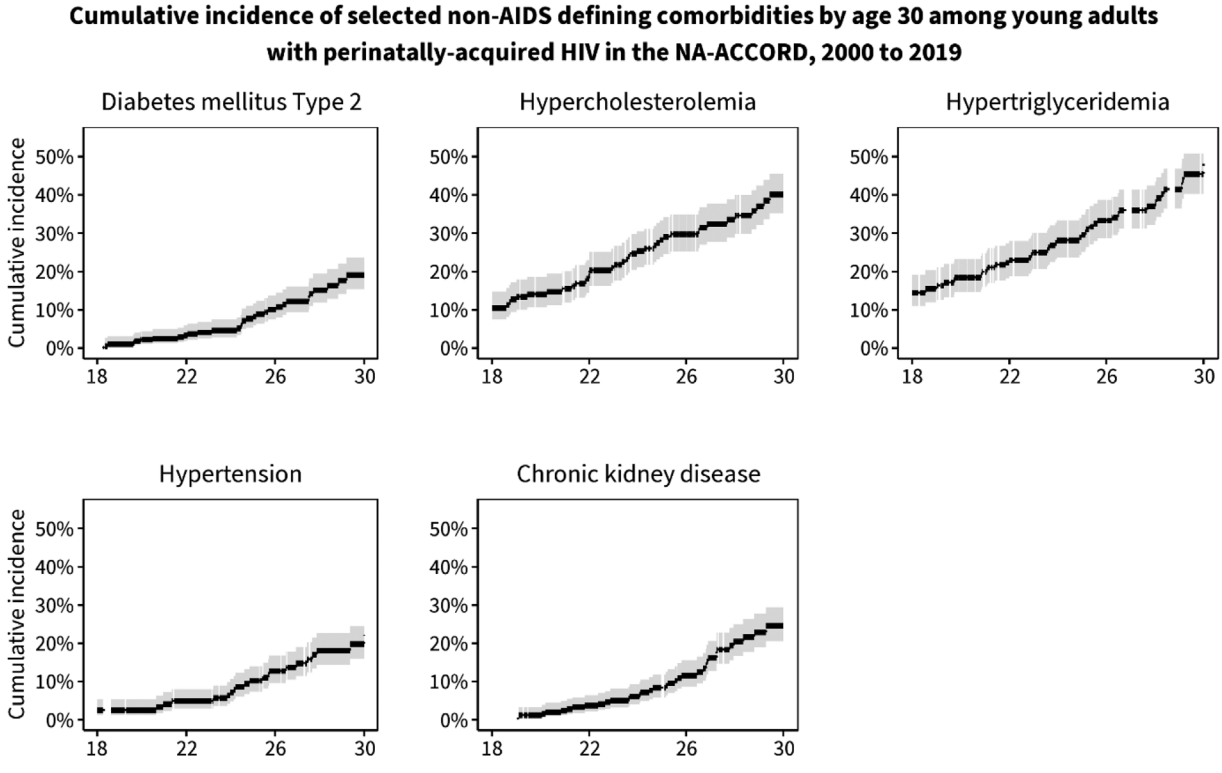

Fig. 1. Overall cumulative incidence curves of selected non-AIDS defining comorbidities by age 30 among young adults with perinatally acquired HIV in the NA-ACCORD, 2000–2019.

of T2DM was 19% (95% CI: 15–24), hypercholesterolemia 40% (95% CI: 35–46), hypertriglyceridemia 50% (95% CI: 44–55), hypertension 22% (95% CI: 18–27), and CKD 25% (95% CI: 20–29). Using the alternative cutoffs described above for sensitivity analyses (Supplementary Figure 1, http://links.lww.com/QAD/D155 and Supplementary Table 2, http://links.lww.com/QAD/D155), incidences were lower: hypercholesterolemia 22% (95% CI: 18–26), hypertriglyceridemia 25% (21–30), hypertension 10% (7–14), and CKD 4% (95% CI: 2–7).

Among PHIV age 18–30, from 2000 to 2019, the incidence rate was 2.9 per 100 person-years (95% CI: 2.0–4.1) for T2DM, 4.7 per 100 person-years (95% CI: 3.1–6.7) for hypercholesterolemia, 5.5 per 100 person-years (95% CI: 3.7–7.8) for hypertriglyceridemia, 2.0 per 100 person-years (95% CI: 1.3–3.0) for hypertension, and 3.3 per 100 person-years (95% CI: 2.2–4.8) for CKD (Table 2). Using the alternative cutoffs described above for sensitivity analyses (Supplementary Table 2, http://links.lww.com/QAD/D155), incidences were lower: 2.5 per 100 person-years (95% CI: 1.6–3.6) for hypercholesteremia, 2.6 per 100 person-years (95% CI: 1.6–3.8) for hypertriglyceridemia, 0.6 per 100 person-years (95% CI: 0.3–1.2) for hypertension, 0.4 per 100 person-years (95% CI: 0.2–0.8) for CKD.

Cumulative incidence curves and incidence rates for each outcome, stratified by sex at birth and self-identified race are presented in Supplementary Figure 2, http://links.lww.com/QAD/D155 and Table 2, http://links.lww.com/QAD/D155. For T2DM, the cumulative incidence and incidence rates were similar across all sex and race groups. Non-Black women had the highest cumulative incidence of hypercholesteremia, at 54% by age 30 (95% CI: 43–66) vs. 40% overall, and of hypertriglyceridemia, at 62% by age 30 (95% CI: 52–73) vs. 50% overall. Black men and women had the highest cumulative incidence of hypertension, with male incidence at 33% (95% CI: 24–44) and female incidence also at 33% (95% CI: 25–43) vs. 22% overall. Black men had the highest cumulative incidence of CKD at 37% (95% CI: 28–48) vs. 25% overall.

Discussion

We estimated the incidence of T2DM, dyslipidemia, hypertension, and CKD by age 30 among people with PHIV. The introduction of ART in the 1990 s prolonged the survival of people with PHIV into early adulthood in the 2010 s, and this study adds to the medical knowledge of NADCs among people with PHIV by showing that persons with PHIV are at high risk for the development of these conditions during early adulthood.

Our results suggest that by age 30, about one in five people with PHIV have T2DM, two in five have hypercholesterolemia, one in two have hypertriglyceridemia, one in four have hypertension, and one in four have CKD. We also found that about one in five have already developed hypercholesterolemia and hypertriglyceridemia before they transitioned into adult HIV care. Across sex at birth and self-identified race, non-Black women had the highest incidence of hypercholesterolemia and hypertriglyceridemia, Black adults with PHIV had the highest incidence of hypertension, and Black men had the highest incidence of CKD.

Across all outcomes, the incidence measures among young adults with PHIV were higher than has been reported among young adults in the general population and in some instances among PWH. Incidence remained higher than the general population even when the more specific case definitions were used in the sensitivity analysis. For T2DM, we observed an incidence rate among young adults with PHIV that was three to six times higher than what has been reported among young to middle-aged adults in the general population in North America [23,24] and PWH [25]. For hypertension, the cumulative incidence of hypertension among people with PHIV by age 30 was at least 50% higher than among the US general population [26]. There were no available

Table 2. Cumulative incidence by age 30 and incidence rate per 100 person-years from age 18 to 30 (95% CI) for selected non-AIDS defining comorbidities among young adults with perinatally acquired HIV in North America, 2000–2019, overall and by sex at birth and self-identified race.

	Diabetes mellitus Type 2	Hypercholesterolemia	Hypertriglyceridemia	Hypertension	Chronic kidney disease
Cumulative incidence by age 30					
Overall	19% (15%, 24%)	40% (35%, 46%)	50% (44%, 55%)	22% (18%, 27%)	25% (20%, 29%)
Non-Black male	8% (4%, 17%)	26% (17%, 37%)	46% (35%, 58%)	17% (10%, 28%)	24% (16%, 36%)
Black male	24% (16%, 34%)	46% (36%, 57%)	37% (28%, 48%)	33% (24%, 44%)	37% (28%, 48%)
Non-Black female	24% (16%, 34%)	54% (43%, 66%)	62% (52%, 73%)	4% (2%, 12%)	17% (10%, 27%)
Black female	21% (15%, 30%)	38% (29%, 47%)	48% (39%, 58%)	33% (25%, 43%)	23% (16%, 32%)
Incidence rate per 100 person-years from age 18 to 30					
Overall	2.9 (2.0, 4.1)	4.7 (3.1, 6.7)	5.5 (3.7, 7.8)	2.0 (1.3, 3.0)	3.3 (2.2, 4.8)
Non-Black male	1.7 (0.7, 4.3)	3.0 (1.3, 6.8)	7.5 (4.4, 12.8)	0.8 (0.2, 3.5)	3.5 (1.6, 7.6)
Black male	4.0 (2.1, 7.5)	5.7 (3.0, 10.8)	1.9 (0.6, 6.0)	3.4 (1.6, 7.2)	5.8 (3.1, 10.9)
Non-Black female	4.4 (2.4, 8.2)	8.8 (4.9, 15.8)	10.7 (6.3, 18.4)	1.0 (0.2, 4.0)	1.9 (0.7, 5.8)
Black female	2.1 (1.0, 4.3)	3.1 (1.5, 6.4)	3.7 (1.9, 7.0)	2.7 (1.3, 5.4)	2.5 (1.1, 5.3)

incidence measures of dyslipidemia in the general population, but the prevalence among those aged 18–34 years using NHANES data was 9.9% for hypercholesterolemia using a stricter definition of total cholesterol at least 240 mg/dl, and 12.4% for hypertriglyceridemia using a similar definition of triglyceride levels used in this study [27]. Using those definitions, the cumulative incidences by age 30 of hypercholesterolemia and hypertriglyceridemia were still much higher among people with PHIV. The prevalence of dyslipidemia in PWH is estimated to be between 20 and 80% [28], largely due to adverse metabolic effects of protease inhibitors and some nonnucleoside reverse transcriptase inhibitors [29,30] and is independent of obesity [31]. Similarly, no data on the incidence of CKD based on the eGFR less than 90 ml/min|1.73 m^2 was available, but the reported prevalence of CKD stages 1–4 in the US general population aged 18–64 years was 6% [32], much lower than observed among adults with PHIV despite our use of a stricter definition.

The differences in outcomes by sex and race in this study were similar to what has been reported in other studies. For example, there were no differences in hypertension prevalence among all US adult PWH [33]. The high CKD incidence of Black males with HIV has been reported by other studies looking at sex and race differences among all PWH aged 40 years and above [34,35]. It has previously been reported that females in the general US population aged 18–64 years had a higher prevalence of hypercholesterolemia but a lower prevalence of hypertriglyceridemia than males [27].

Since 2019, the AHA has recommended that atherosclerotic cardiovascular disease (ASCVD) risk assessment among PWH who are virally suppressed start at age 40, or at age 21 if there is a history of clinical ASCVD or untreated hyperlipidemia of low-density lipoprotein cholesterol of at least 190 mg/dl [36]. Our results suggest that screening should also be indicated at earlier ages for people with PHIV. Although PWH engaged in care may receive periodic laboratory screening and blood pressure measurements as part of their routine clinical visits, however, there are barriers including lower rates of engagement and retention in care and variability in appreciation of potential significance of comorbidities for young people by the patients and providers alike. Although our study population is limited to individuals retained in care, it is likely the results are similar or higher among individuals not retained in care. Therefore, screening modalities should extend beyond routine clinic visits, such as screening during re-engagement in care or through community-based voluntary screening. With early screening, clinicians may then recommend a range of behavioral and pharmacological interventions for prevention.

One pharmacologic preventive intervention recently recommended for PWH is daily statin use, which was shown to lower cardiovascular risk among PWH aged 40 years or older [37]. This recommendation highlights the importance of early screening for hyperlipidemia to prevent NADC complications. Although there is limited information on the benefits of statin use in individuals younger than 40, the high incidence of dyslipidemia before age 30 among adults with PHIV demonstrates the significance of potential benefits of NADC screening recommendations during early adulthood for adults with PHIV. Clinicians may also need to be cautious in using CVD risk prediction tools like Framingham, ASCVD or the HIV-specific Data Collection on Adverse Effects of Antiretroviral Drugs (D: A:D) for people with PHIV, as age is weighed substantially in the calculation of the risk score, and the CVD risk of people with PHIV may be underestimated [38]. The benefits of early statin initiation should also outweigh its risks, where the benefit of lowering cholesterol levels is less clear for younger people in the general population [39].

Our study has several strengths. First, the NA-ACCORD is a longitudinal HIV clinical cohort that has a very large number of people with PHIV who have aged into adulthood, providing a novel opportunity to estimate the incidence of these NADCs specific to this population. The distribution of our study population in terms of age, sex, and race reflect that of our target population of all people with PHIV in North America. The age and calendar year distribution of our study sample confirms the fact that the number of new diagnoses of PHIV peaked around the late 1980 s to early 1990 s [40], thus majority of people with PHIV in the early 2010 s would be in their early 20 s. The US CDC reports that among all people with PHIV, 54% are female, and 56% are Black [41]; these proportions mirror exactly the proportions in the study population. Second, this study estimated incidence, rarely reported for these conditions at early ages, and will contribute to understanding the natural history of these conditions in people living with PHIV. Third, this study accounted for prevalent cases at study entry in the estimation of cumulative incidence, which incorporated some information on the outcomes even before they were observed under follow-up.

This study has several limitations. First, study participants only had a median follow-up time of around three years, much less than the time span of 12 years in the analysis, so the study relied heavily on the assumption of non-informative censoring, and that there were no secular trends between 2000 and 2019 affecting the incidence of these outcomes. Second, despite a centralized data harmonization procedure for outcome ascertainment, there may still be differences in clinical assessment and data quality across cohorts. Finally, the study did not have available pediatric history data to explore other factors related to incident comorbidities, especially adherence to ART or switching therapies, obesity, and smoking. Future studies may consider collating both pediatric and adult

health and behavioral data to examine the associations of these factors on the development of these conditions. The study's results may extend to populations outside of North America, but future studies may also consider confirming our study's results in other regions.

In summary, we found a high incidence of five NADCs among a young adult population with PHIV in the age of ART. Timely treatment of these NADCs may mitigate downstream consequences, thus future clinical guidelines may consider lowering the age at which screening for these conditions is recommended for people with PHIV. We recommend clinicians who care for young adults with PHIV in adult care to consider their history of dyslipidemia during pediatric care, and consider screening for T2DM, dyslipidemia, hypertension, and CKD.

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Conflicts of interest

J.G. has received honoraria as ad hoc member of HIV National Advisory Boards to Merck, Gilead, and Viiv Healthcare. H.C. has received grant funding from NIH, AHRQ, and Viiv Healthcare. MK has received funding from Gilead and Viiv Healthcare. J.E. has served as ad hoc consultant to Merck, Viiv Healthcare, Gilead, and is an investigator on clinical trials supported by contracts to UNC Chapel Hill from Viiv Healthcare and Gilead. A.A. has previously served on the scientific advisory boards of Gilead and Merck, and as expert advisor for Viiv Healthcare.

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