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MAJOR ARTICLE

# Benchmarking HIV Quality Measures in the US OPERA HIV Cohort

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***Background.*** Quality measures are effective tools to improve patient outreach, retention in care, adherence, and outcomes. This study benchmarks National Quality Forum–endorsed HIV quality measures in a US clinical cohort.

***Methods.*** This observational study utilized prospectively captured data from the Observational Pharmaco-Epidemiology Research and Analysis (OPERA) database over 2014–2016 to assess quality measure achievement among patients with HIV in terms of *medical visit frequency* (#2079), *medical visit gaps* (#2080), *viral suppression* (#2082), and *antiretroviral therapy* (ART) *prescriptions* (#2083). The proportion of patients meeting each measure was calculated. Generalized estimating equations assessed trends in measure achievement.

***Results.*** The OPERA sample included 23 059–42 285 patients with similar demographics and characteristics across measurement periods. Overall, 62%–66% of patients met the visit frequency measure (#2079), 81%–85% had no gaps between visits (#2080), 71%–73% achieved viral suppression (#2082), and 92%–94% were prescribed ART (#2083). The adjusted odds of achieving viral suppression and being prescribed ART increased over time by 3% and 19%, respectively, despite a significant decline in patient engagement (16% for #2079, 25% for #2080). Patients <30 years of age were significantly less likely to meet all measures than older patients ($P < .0001$), with particularly low levels of engagement. Measure achievement also varied by gender, ethnicity, region, and select clinical characteristics.

***Conclusions.*** Despite gains in the rate of ART prescription and viral suppression, there remains room for improvement in the care of patients with HIV. Strategies for quality improvement may be more effective if tailored by age group.

**Keywords.** antiretroviral therapy; benchmarking; National Quality Forum; retention in care; quality measures.

Quality improvement is an essential component in HIV care models, but effective implementation requires a set of common and consistent measures to accompany an evaluation strategy, which can assess process and outcomes as they relate to the goals of care. The Health Resources and Services Administration, in conjunction with the National Quality Forum (NQF) and other organizations, developed and endorsed a standardized set of HIV quality indicators beginning in 2008 [1–4]. These indicators, used to evaluate provider and practice adherence to HIV care standards, are an integral part of the National HIV/AIDS Strategy (NHAS) [3, 5].

A central goal of the NHAS strategy is for 90% of people with HIV (PWH) to know their diagnosis, 90% to be retained in care, and 80% of those with a diagnosis to be virologically suppressed by 2020 [5]. Additionally, although they differ slightly, the NHAS strategy is to align US policy with the United Nations AIDS (UNAIDS) initiatives, commonly referred to as the 90-90-90 target [5, 6]. The UNAIDS goals, also to be achieved by 2020, are for 90% of all PWH to know their HIV status, 90% of all people with diagnosed HIV infection to receive sustained antiretroviral therapy (ART), and 90% of all people receiving ART to be virologically suppressed [6]. However, achieving these targets requires a standardized monitoring and evaluation framework and availability of these data in the public domain.

Measures endorsed by the NQF are used by hospitals, health care systems, and government agencies for public reporting and quality improvement [7, 8]. Select measures are currently used to assess HIV care in federal programs, such as the Merit-based Incentive Payment System, the Ryan White HIV/AIDS Program, and the Medicaid Adult Core Set. However, though US health care providers are often required to calculate and submit HIV-specific quality measure achievement results related to their clinical practice, these measures are not consistently required across payer types or practices, and as such, limited benchmarking data are available [1, 9, 10].

Providing a point of reference or benchmark on 4 of the NQF-endorsed HIV quality measures, specifically those characterizing retention/engagement in care, ART prescription, and

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viral suppression, may enhance identification of populations that will benefit from quality improvement programs, especially when such benchmarking characterizes variability in measure achievement by select demographic and clinical characteristics. Benchmarking these measures using a large, geographically diverse cohort of HIV patients from a real-world setting in the United States may also help to assess progress nationally toward both the NHAS and UNAIDS targets.

## METHODS

### Study Design and Population

This observational analysis of a US clinical cohort utilized prospectively captured electronic health record (EHR) data from the Observational Pharmaco-Epidemiology Research & Analysis (OPERA) database and included data from 85 clinics across 54 cities (Figure 1). OPERA-participating physicians and ancillary health care providers have documented the care of over 77 108 PWH (16.2% women), representing 8% of all PWH linked to care in the United States. Forty-six percent of the cohort was diagnosed with HIV on or after 2010, 22% before 2000. One-third of patients were followed for at least 5 years, 13% for 10 or more years. Eighty-nine percent were ART experienced at their last follow-up.

The OPERA database is refreshed from each clinic's individual EHR daily. Proprietary algorithms are used to sort, classify, and aggregate the data pulled from each system. The process includes automated classification of clinical terms into common clinical terms with review by trained medical staff. The patient health data gathered, classified, and aggregated include medical and social history, visit dates, vital signs, lab orders and results, medications, problems and diagnoses, and procedures. Through their membership in OPERA, medical practices meet the Centers for Medicare & Medicaid Services EHR Incentive Program for Integration with a Specialized Registry.

PWH who were seen at least once at an OPERA-participating clinic between January 1, 2013, and December 31, 2016, were included in the study. Diagnosis of HIV-1 was confirmed with evidence of a positive HIV-1 Western Blot, enzyme-linked immunosorbent assay, or viral load test.

### Study End Points

#### *NQF-Endorsed Quality Measures*

Four NQF-endorsed measures were included as primary outcomes (Table 1). Two measures were used as markers of engagement and/or retention: measure #2079 *HIV medical visit frequency* and measure #2080 *no gaps in HIV visits* measure. The latter measure was inverted from the original NQF-endorsed *gap in HIV medical visits* measure so that all measures would consistently correlate higher performance rates with the targeted positive treatment and outcomes. The #2082 *HIV viral load suppression* and #2083 *prescription of ART* measures assessed the proportion of patients with an HIV viral load <200 copies/mL or with ≥1 prescription for any ART during the measurement period, respectively. The measurement periods for all measures were each of the full calendar years within the

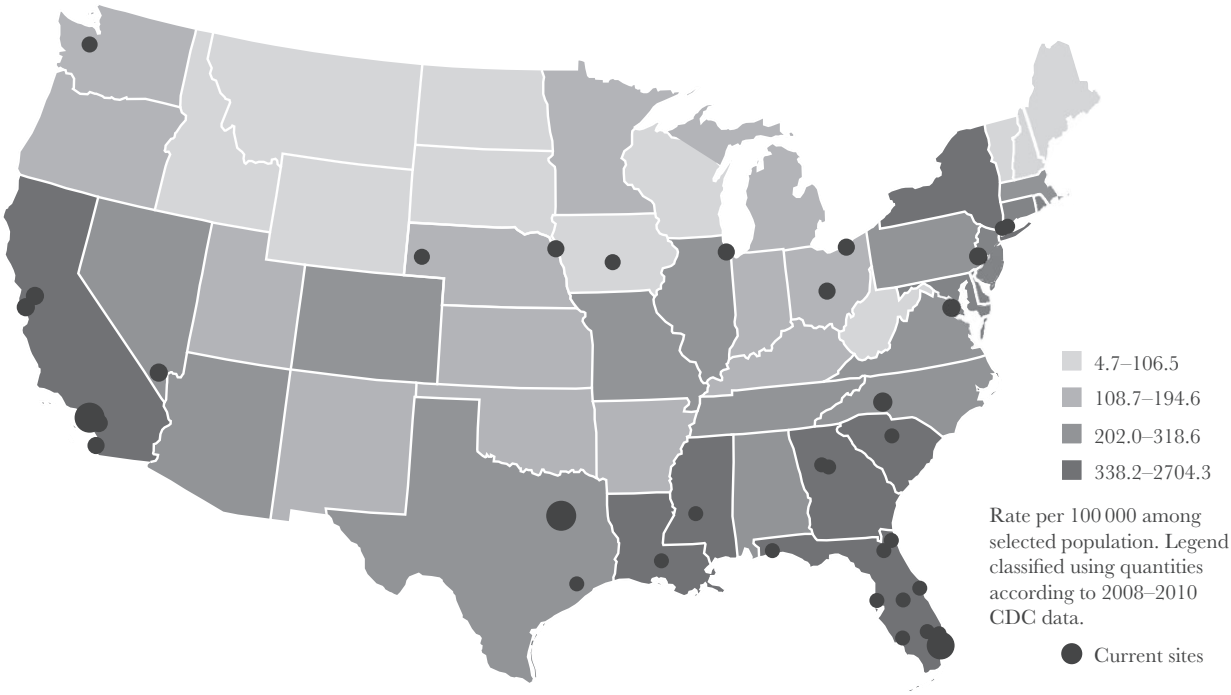


**Figure 1.** HIV-infected population[a] and OPERA clinic locations in the United States. [a]HIV-infection based on CDC 2008–2010 data. Abbreviations: CDC, Center for Disease Control and Prevention; OPERA, Observational Pharmaco-Epidemiology Research and Analysis.

**Table 1. NQF-Endorsed Quality Measures**

| NQF-Endorsed Quality Measure | Measure Description |
|---|---|
| #2079 *HIV medical visit frequency* | Percentage of patients with HIV with ≥1 medical visit in each 6-month period of the 24-month measurement period (minimum of 60 days between visits), used to gauge engagement or retention of care. |
| #2080 *no gaps in HIV visits* | Percentage of patients with HIV who had a medical visit in both the first and last 6 months of the 12-month measurement period, also used to gauge engagement or retention of care. This measure was inverted from the original NQF-endorsed *gap in HIV medical visits* measure. |
| #2082 *HIV viral load suppression* | Percentage of patients with an HIV viral load <200 copies/mL at their last HIV viral load test during the measurement period. |
| #2083 *prescription of ART* | Percentage of patients with HIV with ≥1 prescription for ART at any point during the measurement period. |

Abbreviations: ART, antiretroviral therapy; NQF, National Quality Forum.

study (ie, 2014, 2015, and 2016), except for the #2079 *HIV medical visit frequency* measure, where a 24-month measurement period was required.

#### *Patient Characteristics*

Unless otherwise specified, all patient demographics and clinical characteristics were captured as of January 1 of each measurement year. AIDS-defining events (ADEs) were defined according to the 1993 Centers for Disease Control and Prevention AIDS case definition [11]. The Veterans Aging Cohort Study (VACS) mortality index scores were determined by summing pre-assigned points for age, $CD4^+$ count, HIV-1 RNA, hemoglobin, platelets, aspartate and alanine transaminase, creatinine, and viral hepatitis C infection [12] and were only calculated for patients with test results for all score components in the 12 months before each measurement period. Comorbidities were based on documented diagnoses (either code-based or extracted as per text strings with logic applied to exclude rule-out diagnoses). The only exception was renal impairment and chronic kidney disease, which were based on estimated glomerular filtration rates.

#### Statistical Analysis

The proportion of patients meeting the criteria for each measure was calculated for each measurement period (2014, 2015, and 2016). For NQF measure #2079 (*HIV medical visit frequency*), where a 24-month evaluation period was required, the displayed calendar year was the period in which the last 12 months were measured. Measure achievement ratios were not standardized to account for changes in OPERA demographics. Patient characteristics were summarized using medians and interquartile ranges for continuous data and percentages for categorical data. Patient characteristics were presented in aggregate at the population level for each measure and contrasted at the measure level by criteria achievement (met vs not met) using the Pearson chi-square test or Fisher exact test for categorical variables and Wilcoxon rank-sum test for continuous variables. The Sidak correction was applied to account for multiple comparisons between groups. Generalized estimating equations were used to fit 4 repeated-measures logistic regression models to assess trends in measure achievement over time while controlling for changes in demographics and HIV-specific clinical characteristics (adjusted analyses).

OPERA complies with all Health Insurance Portability and Accountability Act and Health Information Technology for Economic and Clinical Health requirements and receives annual institutional review board approval by Advarra, including a waiver of informed consent and authorization for use of protected health information.

## RESULTS

#### Description of the OPERA Population

Through 2016, there were 75 579 patients with HIV in the OPERA database, representing ~8% of patients with HIV diagnosed and linked to care in the United States. The number of patients for each measurement period ranged from 23 059 patients for the #2079 *HIV medical visit frequency* measure in 2014 to 42 285 patients for the #2082 *HIV viral load suppression* and #2083 *prescription of ART* measures in 2016 (Table 2).

The median age across 2014–2016 was 45 years; 15%–18% of patients were <30 years of age, 46%–51% were 30–49 years of age, and 35%–37% were ≥50 years of age. Although median age was constant across the measuring period, the proportions of patients <30 and ≥50 years of age significantly increased over time ($P < .0001$).

Overall, 83% of patients were male and 45%–49% were classified as men who have sex with men (MSM). Over 2014–2016, 35%–40% of patients were African American and 24%–25% were Hispanic or Latino. There was a moderate increase in the proportion of African American patients over time (Table 2). Over half of patients (54%–56%) resided in the Southern United States (Table 2). The proportion of patients residing in the Northeast, South, and Midwest increased over time, and there was a corresponding decrease in those residing in the West ($P < .0001$).

Viral load and VACS score remained consistent across the measurement periods, whereas $CD4^+$ cell count increased over 2014–2016 ($P < .0001$). Across the measurement periods, the proportion of patients who had a history of syphilis, diabetes mellitus, mild renal impairment, and moderate/severe chronic kidney disease increased ($P < .0001$) whereas ADE,

**Table 2. Demographics and Clinical Characteristics of the OPERA Study Population**

| | Measurement **P**eriod | | | |
|---|---|---|---|---|
| | 2014 | 2015 | 2016 | |
| Demographics | (n = 34 657) | (n = 37 187) | (n = 42 285) | *P* Value for Trend[a] |
| Age | | | | **<.0001** |
| <30 **y, No. (%)** | 5051 (14.6) | 6020 (16.2) | 7421 (17.5) | |
| 30–49 **y, No. (%)** | 17 581 (50.7) | 17 852 (48.0) | 19 433 (46.0) | |
| ≥50 **y, No. (%)** | 12 025 (34.7) | 13 315 (35.8) | 15 431 (36.5) | |
| Median (IQR)**, y** | 45.1 (35.1–52.1) | 45.1 (34.1–53.1) | 45.1 (33.1–53.1) | **.0003** |
| Gender**, No. (%)** | | | | .9537 |
| Male | 28 847 (83.2) | 30 914 (83.1) | 35 187 (83.2) | |
| Female | 5800 (16.7) | 6254 (16.8) | 7069 (16.7) | |
| Race**, No. (%)** | | | | **<.0001** |
| African American | 12 183 (35.2) | 13 726 (36.9) | 16 735 (39.6) | |
| Not African American | 20 741 (59.8) | 21 850 (58.8) | 23 757 (56.2) | |
| Unknown | 1733 (5.0) | 1611 (4.3) | 1793 (4.2) | |
| Ethnicity**, No. (%)** | | | | **<.0001** |
| Hispanic/Latino | 8539 (24.6) | 9287 (25.0) | 10 302 (24.4) | |
| Not Hispanic/Latino | 24 743 (71.4) | 26 693 (71.8) | 30 586 (72.3) | |
| Unknown | 1375 (4.0) | 1207 (3.2) | 1397 (3.3) | |
| Region**, No. (%)** | | | | **<.0001** |
| South | 18 875 (54.5) | 20 239 (54.4) | 23 862 (56.4) | |
| West | 12 515 (36.1) | 13 090 (35.2) | 13 579 (32.1) | |
| Northeast | 2982 (8.6) | 3373 (9.1) | 4136 (9.8) | |
| Midwest | 285 (0.8) | 484 (1.3) | 708 (1.7) | |
| Payer**, No. (%)** | | | | |
| Commercial | 7768 (22.4) | 9410 (25.3) | 11 712 (27.7) | **<.0001** |
| Medicaid | 7044 (20.3) | 7667 (20.6) | 7730 (18.3) | **<.0001** |
| Medicare | 3531 (10.2) | 3772 (10.1) | 4068 (9.6) | .0071 |
| Ryan White | 7304 (21.1) | 7640 (20.5) | 7616 (18.0) | **<.0001** |
| Other payer | 98 (0.3) | 139 (0.4) | 113 (0.3) | .5830 |
| No Payer Information | 11 733 (33.9) | 11 743 (31.6) | 13 918 (32.9) | .0154 |
| Risk of infection**, No. (%)** | | | | **<.0001** |
| MSM | 16 855 (48.6) | 17 267 (46.4) | 19 164 (45.3) | |
| Not MSM | 17 802 (51.4) | 19 920 (53.6) | 23 121 (54.7) | |
| History of syphilis**, No. (%)** | 7918 (22.8) | 8999 (24.2) | 10 343 (24.5) | **<.0001** |
| History of ADE**, No. (%)** | 6240 (18.0) | 6289 (16.9) | 6472 (15.3) | **<.0001** |
| Viral load | | | | **<.0001** |
| Median (IQR)**, copies/mL** | 19.0 (19.0–88.0) | 19.0 (19.0–40.0) | 19.0 (19.0–35.0) | |
| $CD4^+$ count | | | | **<.0001** |
| Median (IQR)**, cells/μL** | 564.0 (386.0–770.0) | 578.0 (390.0–786.0) | 592.0 (403.0–810.0) | |
| Common comorbidities | | | | |
| Hyperlipidemia | 11 039 (31.9) | 11 753 (31.6) | 12 706 (30.0) | **<.0001** |
| Hypertension | 8905 (25.7) | 9915 (26.7) | 10 996 (26.0) | .4188 |
| Mild renal impairment[b] | 6159 (17.8) | 7296 (19.6) | 8753 (20.7) | **<.0001** |
| Anxiety disorders | 5924 (17.1) | 6611 (17.8) | 7330 (17.3) | .4551 |
| Depression | 3630 (10.5) | 3896 (10.5) | 4251 (10.1) | .0482 |
| Diabetes mellitus | 2660 (7.7) | 3088 (8.3) | 3569 (8.4) | **.0002** |
| Chronic **h**epatitis C | 2365 (6.8) | 2391 (6.4) | 2348 (5.6) | **<.0001** |
| Moderate/**s**evere CKD[b] | 799 (2.3) | 1047 (2.8) | 1394 (3.3) | **<.0001** |
| VACS score | | | | |
| Median (IQR) | 13.0 (6.0–24.0) | 13.0 (6.0–25.0) | 13.0 (6.0–24.0) | .1816 |

Abbreviations: ADE, AIDS-defining event; CD4, cluster of differentiation 4; CKD-EPI, chronic kidney disease epidemiology collaboration; eGFR, estimate glomerular filtrate rate; IQR, interquartile range; MSM, men who have sex with men; OPERA, Observational Pharmaco-Epidemiology Research and Analysis; VACS, Veterans Aging Cohort Study.

[a]Sidak correction was applied (adjusted $\alpha < .001$) to adjust for multiple comparisons, and statistically significant results are bolded.

[b]Renal status is based on the last 2 consecutive CKD-EPI calculated eGFR results before the start of the calendar year.

hyperlipidemia, and chronic hepatitis C significantly decreased ($P < .0001$).

#### Patients Meeting NQF-Endorsed Measures

Figure 2 depicts the percentage of patients who met the criteria for each quality measure. Patient engagement diminished over 2014–2016, as evidenced by decreases in the percentage of patients with visits at least every 6 months over both a 12-month (#2080 *no gaps in HIV visits*) and a 24-month (#2079 *HIV medical visit frequency*) period. In contrast, there were modest increases in the proportion of patients meeting the #2082 *HIV viral load suppression* measure or the #2083 *prescription of ART* measure.

The unadjusted trends (Figure 2) varied by age group, with younger patients being significantly less likely to meet each of the NQF measures. Although levels of engagement in patients <30 years of age was largely unchanged across performance years (~50% measure #2079, ~76% #2080), the proportion of patients prescribed ART increased from 85.1% to 91.0% and the proportion achieving viral suppression increased from 57.8% to 64.5%. Levels of engagement/retention were highest among patients ≥50 years of age (~73% measure #2079, ~87% #2080), although still below the 90% NHAS target. Moreover, levels of engagement/retention in this population appeared to decrease over time in the unadjusted analysis. Despite decreasing levels of engagement across performance years, the proportion of patients ≥50 years of age prescribed ART increased from 94.4% to 95.1% and the proportion achieving viral suppression increased from 78.4% to 79.4%. Measure achievement also varied by gender, ethnicity, census region, and risk of infection.

There were significant differences in the distribution of key covariates in the underlying OPERA population across performance years (Table 2). As rates of measure achievement varied notably by age, gender, ethnicity, census region, risk of infection, and several other clinical characteristics, no conclusion could be drawn regarding trends in measure achievement in the unadjusted analysis.

Figure 3 presents adjusted odds ratios for measure achievement by select demographic and clinical characteristics. Similar to the unadjusted analyses, patients <30 years of age were significantly less likely to achieve each of the 4 quality measures compared with patients 30–49 years of age, whereas patients ≥50 years of age were significantly more likely to meet all measure criteria vs patients 30–49 years of age (both $P < .0001$). In addition, female (vs male), MSM (vs not MSM), and Northeastern US (vs Southern US) patients were significantly more likely to meet all measures (all $P < .0001$). Hispanic/Latino patients were significantly more likely to meet all measure criteria compared with non-Hispanic/Latino patients ($P < .0001$), except for the #2083 *prescription of ART* measure, which was not significant ($P = .93$). Patients with a history of ADE had lower odds of meeting the #2080 *no gaps in HIV visits* measure; however, they were significantly more likely to achieve the #2079 *HIV medical visit frequency*, #2082 *HIV viral load suppression*, and #2083 *prescription of ART* measures ($P \leq .0001$). Compared with non–African American patients, African American patients had greater odds of meeting the #2079 *HIV medical visit frequency*, #2080 *no gaps*

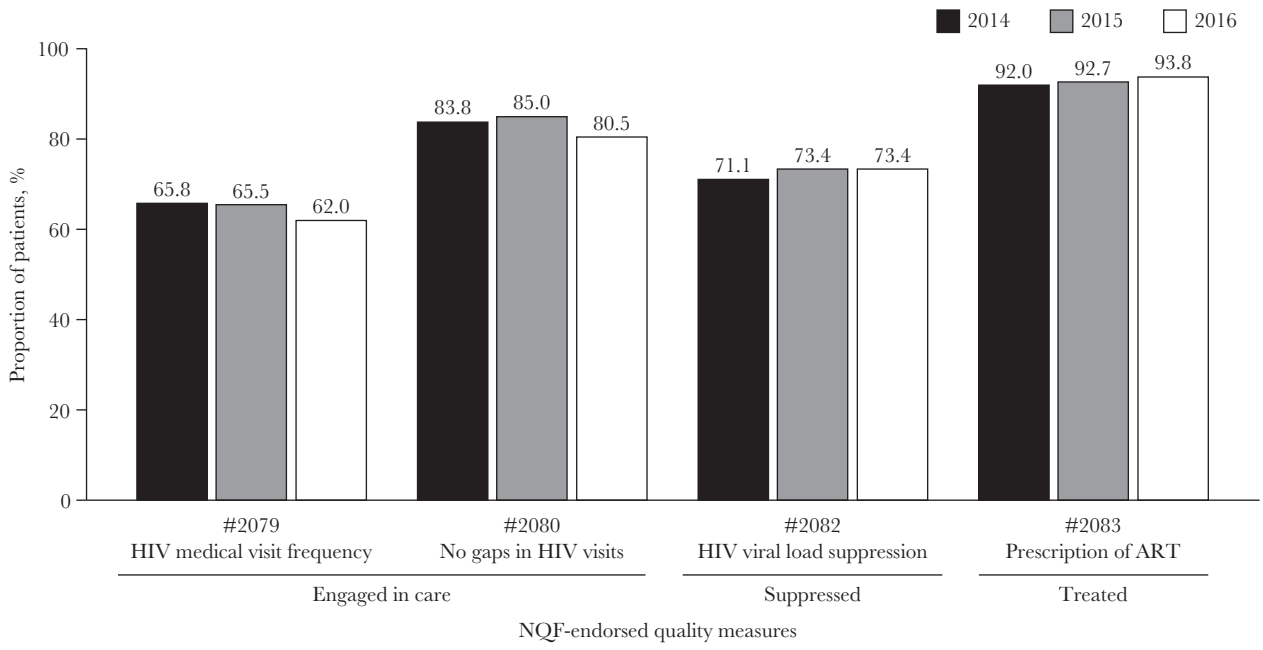


**Figure 2.** Unadjusted proportion of patients meeting NQF-endorsed quality measures by measure and measurement period. Abbreviations: ART, antiretroviral therapy; NQF, National Quality Forum.

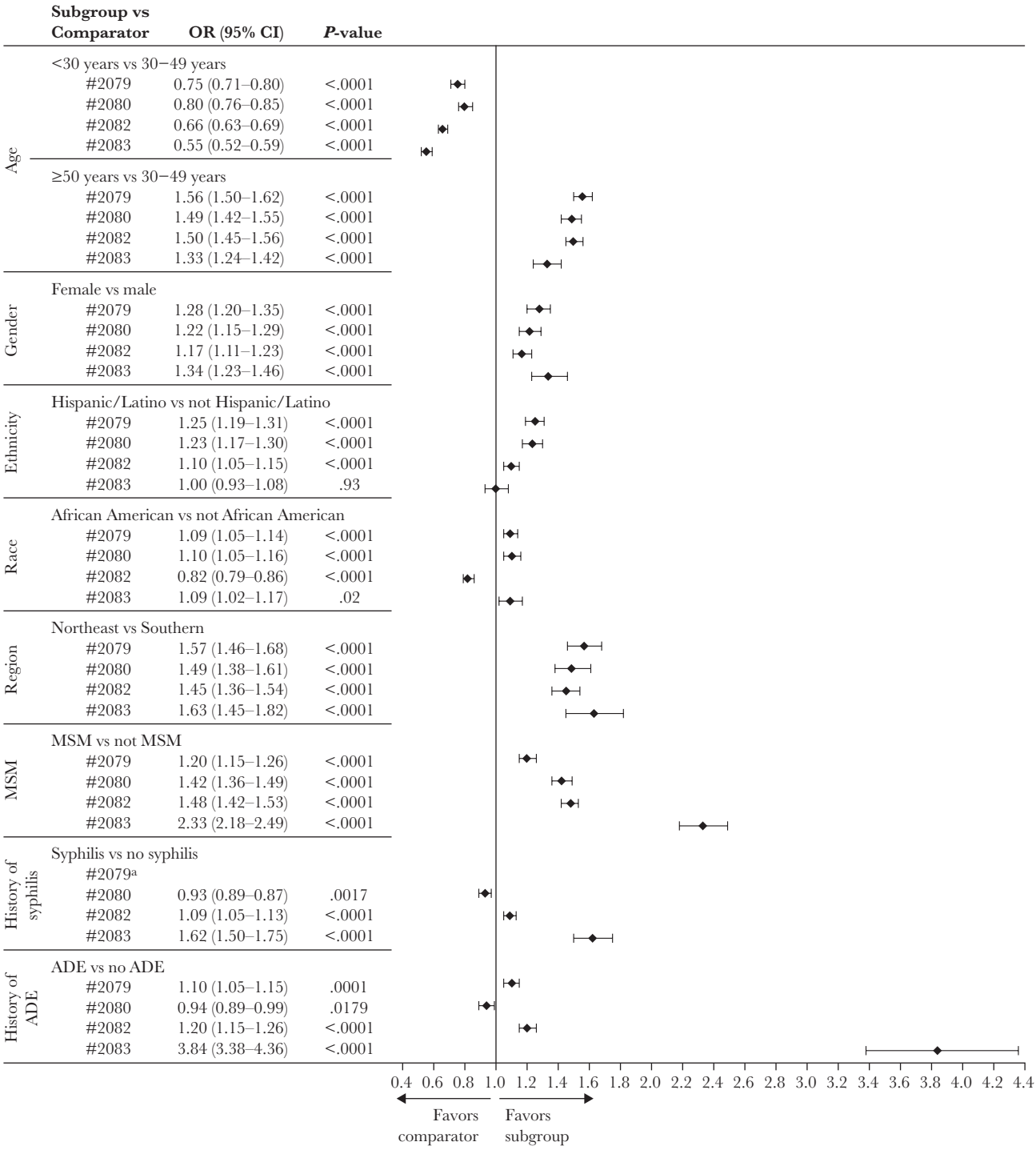


**Figure 3.** Adjusted odds ratios for NQF-endorsed quality measures by select demographics over 2014–2016 (GEE model). [a]The history of the syphilis covariate was removed from the #2079 *HIV medical visit frequency* quality measure model, as it neither improved model fit nor was significant. NQF-endorsed measure definitions: #2079 *HIV medical visit frequency*, #2080 *no gaps in HIV visits*; #2082 *HIV viral load suppression*; #2083 *prescription of ART*. Abbreviations: ADE, AIDS-defining event; ART, antiretroviral therapy; CI, confidence interval; GEE, generalized estimating equations; MSM, men who have sex with men; NQF, National Quality Forum; OR, odds ratio.

*in HIV visits*, and #2083 *prescription of ART* measures (all $P \leq .02$); however, they were significantly less likely to achieve the #2082 *HIV viral load suppression* measure ($P < .0001$).

Table 3 presents both the unadjusted and adjusted odds of measure achievement associated with each measurement year. The adjusted odds of meeting #2079 *HIV medical visit frequency* and #2080 *no gaps in HIV visits* measures decreased by 25% and 17% per calendar year, respectively (both $P < .0001$). Conversely, the adjusted odds of meeting measures #2082 *HIV viral load suppression* and #2083 *prescription of ART* were increased by 3%

**Table 3. Odds Ratios for NFQ-Endorsed Measures Over 2014–2016**

| | Unadjusted Per Calendar Year | Adjusted[a] Per Calendar Year |
|---|---|---|
| NFQ-Endorsed Quality Measure | Odds Ratio (95% CI) | Odds Ratio (95% CI) |
| #2079 *HIV medical visit frequency* | 0.77 (0.76–0.78) | 0.75 (0.74–0.77)[b] |
| #2080 *no gaps in HIV visits* | 0.84 (0.82–0.86) | 0.83 (0.81–0.85)[b] |
| #2082 *HIV viral load suppression* | 1.03 (1.02–1.05) | 1.03 (1.02–1.05)[b] |
| #2083 *prescription of ART* | 1.18 (1.15–1.20) | 1.19 (1.16–1.22)[b] |

Abbreviations: ART, antiretroviral therapy; CI, confidence interval; NQF, National Quality Forum.

[a]Adjusted for changes in demographics and HIV-specific clinical characteristics.

[b]$P < .0001$.

and 19% per calendar year, respectively (both $P < .0001$). These data suggest that even after adjusting for changes in the underlying OPERA population, there was an increase in the odds of meeting the ART prescription measure despite decreases in the engagement/retention measures. Moreover, comparatively large increases in the odds of meeting the ART prescription measure (19%) did not translate to the same magnitude of increase in achievement of viral suppression (3%).

## DISCUSSION

This study provides important real-world data on rates of measure achievement for 4 NQF-endorsed HIV-specific quality measures over 2014–2016 in a large, geographically diverse cohort of PWH in the United States. These data not only establish trends in measure achievement for engagement and retention in care, ART prescription, and viral suppression over time, but also demonstrate the variability in measure achievement across a wide array of demographic and clinical characteristics. This type of benchmarking is critical for helping payers, providers, and state governments identify areas to improve patient care, facilitate achievement of NHAS and UNAIDS targets, and develop future impactful measures.

In this analysis, only the #2083 *prescription of ART* measure reached the 90% NHAS and UNAIDS threshold across all measurement periods, with the adjusted odds of meeting this measure increasing by 19% over 2014–2016. Despite improvement in ART prescription measure achievement, the proportion of virally suppressed patients continues to fall short of the NHAS 80% (UNAIDS 90%) target (73% in 2016), with the odds of achieving this measure increasing by only 3% between 2014 and 2016. It is important to note that the ART prescription measure only assesses whether a patient was prescribed ART during a measurement period [8]. It does not evaluate complete regimens or consider multiple prescriptions over time; therefore, it does not measure treatment adherence. In addition to early linkage and retention in care, adherence to ART is essential for both achieving and maintaining virologic suppression [13–15]. Poor adherence or nonadherence to ART in PWH has been widely associated with higher morbidity and mortality, increased risk of HIV transmission, and ART drug resistance [16]. Despite the negative outcomes associated with suboptimal adherence, adherence rates continue to be low, ranging from 27% to 80% across different populations [17, 18], still generally below the threshold targeted (80%–95%) to achieve viral suppression [17–20].

These study findings are similar to those reported by Bradley et al. in a 2016 study that used data from the Medical Monitoring Project (MMP) to assess trends in ART prescription and viral suppression [21]. The authors concluded that rates of ART prescription rose significantly ($P < .01$), from 89% in 2009 to 94% in 2013, slightly higher than the 92%–94% (2014–2016) we report in the current study. Rates of viral suppression in the MMP-based study rose from 72% in 2009 to 80% in 2013, higher than the 71%–73% viral suppression rate observed in the current study. Differences in the rate of viral suppression between the studies may be an artifact of population selection, as patients with any encounter during a performance year are included in the NQF performance measure even if that encounter occurs toward the end of the year. In contrast, the Bradley study restricted eligibility to those with an encounter in the first 4 months of the year evaluated, allowing time for newly diagnosed patients prescribed ART to achieve suppression.

Rates of retention observed in the current study are similar to those reported by Rebeiro and colleagues in a 2016 study. The authors used data from the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD) to evaluate geographic variation in retention among patients who had been successfully linked to and established in care [22]. Retention rates, which rose significantly ($P < .01$) during the course of the study (2000–2010), were highest in the Midwest (87%) and lowest in the West (72%). Retention rates in the current study, using a comparable retention definition (NQF #2080), ranged from 80% to 85%. In contrast to the NA-ACCORD study, the odds of meeting this retention metric in the current study decreased significantly ($P < .0001$). The decreasing levels of care engagement observed in our study may be an artifact of increasing ART prescription, as better drugs translate into guidelines that recommend starting treatment early with less frequent monitoring. Given the potency of newer, firstline

therapies, many providers are seeing patients more frequently. Accordingly, the decrease observed in patient engagement between 2014 and 2016 in the current study may be the product of changes in practice patterns and the NQF measure requirement that patients be seen once every 6 months.

Although the definition of retention remains in flux, early engagement in care after diagnosis and subsequent retention in care remain critical elements of the HIV care continuum and have been associated with increased viral suppression and reduced viral load burden in PWH [23–26]. This study highlights a clear opportunity for improvement in achieving various HIV quality care measures, particularly for viral suppression. Although the odds of achieving viral suppression increased significantly between 2014 and 2016, only 73% of patients met the measure, despite ART prescription rates above both NHAS and UNAIDS targets.

In this analysis, measure achievement varied by key patient characteristics, including age, gender, race, and ethnicity. The most notable variation was observed in different age groups, whereby older patients (≥50 years of age) had the greatest levels of achievement across all measures and measurement periods evaluated. Younger patients (<30 years of age) had the lowest levels of measure achievement and were significantly less likely to meet each of the 4 measures compared with patients 30–49 years of age. This finding is in line with previous studies, where the proportions of patients meeting HIV quality care measures of ART adherence and care retention were also lower in younger vs older patients [10, 27, 28]. Keeping younger people engaged in care is of concern, especially among patients <30 years of age; this study showed that only half of younger patients met the visit frequency measure, and a quarter had a gap in their visit schedule. In addition, although ART prescription in younger patients rose above the 90% threshold for the first time in 2016, levels of viral suppression remained low, at 65%. This may be indicative of an overall lack of engagement with care for younger PWH. Younger PWH have been reported to have lower performance than older adults in all steps of the cascade of care, resulting in <6% maintaining viral suppression [29]. Moreover, younger people in the United States continue to represent an active population for HIV, with people 13–24 years of age representing 21% of new HIV diagnoses in 2016 [30]. Therefore, effective interventions tailored for younger PWH are needed to successfully engage them in the cascade of HIV care programs [29].

Our study is not without limitations, and results should therefore be interpreted with caution. Like other observational analyses, this study may be subject to potential information and confounding bias due to missing data and unknown confounders that were not included in the EHR data. Additionally, although the OPERA database includes complete patient health records managed in EHR systems, several issues confronting population-level assessments need to be highlighted. These include the effects of differential medical care by practice size and specialty, the academic and research orientation of the health care practitioner, gender- and ethnic-based attitudes, and geographical regional health care practices. As data are collected at the point of care, they are also subject to the record-keeping practices of each health care provider and the standards of each clinic or organization. Patients may also consult multiple physician practices for various conditions, which might result in incomplete case ascertainment. To mitigate information bias, OPERA employs a host of quality assurance processes, most notably the use of proprietary algorithms to sort, classify, and aggregate patient diagnoses and procedures from all major coding systems, in addition to text-based natural language processing. This process includes automated classification of clinical terms that are reviewed by trained medical staff. Finally, data are collected for the medical management of patients and are not directly intended for research purposes. Key strengths of the study include the large sample size and a geographically diverse cohort of PWH, which expands the current knowledge gained from smaller, geographically centered studies of HIV quality care measures. Although this study identified various areas for improvement across the evaluated measures, further research is required to investigate the underlying reasons for these identified gaps in HIV care.

## CONCLUSIONS

This real-world evaluation of 4 NQF-endorsed measures of HIV quality care demonstrates that improvement is needed in the care of PWH, with care engagement and viral suppression levels continuing to fall short of both NHAS and UNAIDS targets. Strategies for quality improvement may be more effective if tailored by age group.


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