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Erin Fennern

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**Association between BMI and quality of care
among patients with HIV, 2007-2010**

Erin Fennern

2015 MD/MPH Candidate

Oregon Health & Science University

ABSTRACT

Background: Obesity is a common medical condition that may be associated with disparities in healthcare quality.

Objective: Assess for differences in quality of care provided to HIV-infected patients by body mass index (BMI) category.

Design: Cross-sectional analyses of patients followed longitudinally. Data on 9 HIV quality indicators (QIs) were abstracted from patient medical records. BMIs were categorized as normal (18.5 to 24.9), overweight (25 to 29.9), stage 1 obese (30 to 34.9), stage 2 obese (35 to 39.9), and stage 3 obese (≥ 40).

Participants: 6,031 patients (10,896 total observations) age ≥ 18 years, engaged in care (i.e. ≥ 2 clinic visits per year) at 7 clinics in the HIV Research Network from years 2007 to 2010.

Main Measures: We used multivariate logistic regression to examine associations between BMI and receipt of each QI, and multivariate linear regression to examine the association between BMI and the mean percent of eligible QIs received.

Key Results: Patients received a mean of 65% of eligible QIs. Those with BMIs ≥ 40 received slightly less than normal weight patients (adjusted mean difference of -4%; 95% CI -6% to -2%). This group received slightly less screening for hepatitis C (HCV; aOR = 0.73, 95% CI 0.55 to 0.98), gonorrhea/Chlamydia (aOR = 0.76, 95% CI 0.60 to 0.96), and syphilis (aOR = 0.69, 95% CI 0.56 to 0.86), but more CD4 counts (aOR = 1.44, 95% CI 1.07 to 1.95), relative to normal weight patients.

Conclusions: The mean percent of eligible QIs received varied little in absolute differences across BMI categories. Providers prescribed anti-retroviral therapy (ART) regardless of BMI, but performed less HCV and sexually transmitted infection (STI) screening as BMI increased, suggesting prioritization of some QIs over others in high BMI patients.

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INTRODUCTION

Over the past 20 years, antiretroviral treatment (ART) has revolutionized HIV infection from a fatal diagnosis into – wherever ART is available – a treatable chronic disease¹. As with other chronic diseases, such as diabetes and heart disease, HIV has national guidelines aimed at promoting evidence-based management^{2,3}. Moreover, there is emerging consensus regarding indicators for measuring the quality of HIV care delivered²⁻⁶.

Quality of Care in the HIV Population

In 2004, the Institute of Medicine reviewed guidelines for improving the quality of care provided to HIV-infected individuals⁷. They recommended examining *process measures* of quality, which focus on the actions of providers. In addition, the committee recommended measuring the quality of care provided to historically vulnerable populations. To that end, there is now a strong body of research examining the quality of care received by certain HIV-infected patient sub-populations – such as those categorized by age⁸, substance use status^{9,10}, race¹¹, gender¹¹, insurance status¹², and others¹³⁻¹⁵. To date, however, there are no studies examining the quality of HIV care provided to patients according to their weight status.

Obesity Bias

Previous studies of HIV-unknown patient populations suggest that health care professionals may harbor conscious and/or unconscious assumptions regarding obese patients. A study of US primary care physicians' attitudes showed that more than 50% of physicians viewed obese patients as awkward, unattractive, and noncompliant^{16,17}. This work has been replicated in sub-specialty settings¹⁸, and among nurses and physician assistants¹⁹, demonstrating potential biases that may affect the quality of health care received by obese patients in these settings.

Though potential provider bias toward obese patients is well-studied and may be common, evidence regarding whether or how these attitudes affect health care quality is mixed.

Several studies found an increase in the provision of lipid screening and hemoglobin A1c testing for obese patients, suggesting that providers may triage certain process measures based on perceived risk^{20,21}. Unfortunately, other studies have demonstrated decreased provision of pap smears and mammography for obese patients²²⁻²⁴, which is not in accordance with existing recommendations.

Aims

With regard to the HIV-positive patient population, little is known about the quality of care received by obese versus normal weight patients. The objective of this analysis was to assess the association between patient body mass index (BMI) – a well-validated marker of weight status – and receipt of HIV quality of care indicators using a large multisite U.S. cohort. We hypothesized that the quality of HIV care might be lower for obese patients, compared to those of normal weight.

METHODS

Study Design and Participants

We conducted a series of cross-sectional analyses using the EMR data of HIV-infected adults enrolled in the HIV Research Network (HIVRN) from 2007 to 2010. Each cross-sectional data point represents one calendar year. In all, 6,031 patients contributed to a total of 10,896 data points, meaning that any one patient could contribute up to four data points to the study.

The HIVRN is a national consortium of 21 public and private clinics that provides care to HIV-infected individuals in the United States. The dataset is well-described elsewhere^{11,13,25}. Briefly, these sites provide both primary and specialty care to children and adults; 15 sites treat adults, six treat children, and eight of the 21 have academic affiliations.

For this analysis, electronic medical record (EMR) data was gathered from seven of the 15 adult sites. These sites were selected based on their capacity to conduct manual chart reviews of quality indicators for data validation. Only adult patients (those at least 18 years old) actively engaged in care (≥ 2 clinic visits per calendar year) were included. Underweight patients (BMI <18.5) were excluded from the data set, due to the study's intended focus on overweight patients.

Measures

We extracted EMR data on nine quality indicators (QIs) from multiple domains of care (Table 1): therapeutic (receipt of ART; receipt of *Pneumocystis jirovecii* & *Mycobacterium avium complex* prophylaxis, when eligible), monitoring (measurement of CD4 counts), screening (lipids, HCV, syphilis, gonorrhea/Chlamydia), and prevention (receipt of pneumococcal vaccination). These QIs were taken from the HIV/AIDS Bureau of the Health Resources and Services Administration's (HRSA) list of HIV clinical performance measures⁵, a set of core indicators for which there is national consensus for use in monitoring of HIV prevention, treatment, and comprehensive care²⁻⁴.

The primary outcome measure was the percent of eligible QIs each patient received. For example, if a person was eligible to receive six of the nine QIs in a given calendar year, and they received only four, the summary score for that patient was 66.6% ($4/6 \times 100$). The secondary outcome measures were receipt of each specific QI, measured dichotomously (yes/no if the QI was received).

The main independent variable was patient BMI, calculated for each patient data point in each calendar year (i.e. treated as a time-dependent variable). BMI was categorized as normal (18.5 to 24.9), overweight (25 to 29.9), stage 1 obese (30 to 34.9), stage 2 obese (35 to 39.9), and stage 3 obese (≥ 40), in accordance with NIH guidelines.

Covariates

Covariates included self-identified gender (female, male, trans-gender), race/ethnicity (White, Black, Hispanic, Other), primary HIV risk behavior (men who have sex with men (MSM), injection drug use (IDU), heterosexual, other), number of HIV primary care visits in a given calendar year, and age. Both the number of annual HIV primary care visits and patient age were time-dependent; the other covariates were fixed.

Patient characteristics are described overall and by patient BMI (Table 2) using ANOVA to assess for significant differences. Each covariate was significant in bivariate analyses, but these were also chosen *a priori* based on demonstrated importance in the literature.

Regression Models

We used multivariate linear regression to examine the association between patient BMI and the mean percent of eligible QIs received. This model was chosen over a logistic model for ease of interpretability; the linear model provides an estimate of absolute differences, which is preferable to the odds ratios generated by the logistic model. The normal assumption of the linear model was adequately satisfied, as determined using a Q-Q plot and histogram of the residuals,

as well as tests for skewness and kurtosis. Additionally, a logistic model (using binomial error distribution) was run as a sensitivity analysis. The findings in the logistic model were nearly identical to the linear model but, again, the latter was chosen for ease of interpretation.

To examine the associations between BMI and the binomially-distributed receipt of each specific QI, we utilized logistic regression.

All models – both linear and logistic – utilized a generalized estimating equation approach to account for correlation among repeated measures of the same patient over multiple calendar years. Additionally, all models adjusted for gender, race/ethnicity, age, primary HIV risk behavior, and number of primary care visits in a given calendar year.

STATA/SE version 12.0 (StataCorp, College Station, Texas) was used to perform all statistical analyses.

RESULTS

Descriptive Statistics

A total of 10,896 observations were generated by the 6,031 patients in our data set. The majority were male (70.6%) and nearly half were black (48.7%). The mean age was 46.1 years (SD 10.2 years). 74% of observations came from patients in the normal and overweight categories (Table 2).

Among obese patients, 15% of observations were from stage 1, 6% from stage 2, and 5% from stage 3. Relative to normal weight patients, obese patients were more frequently female and black, and more likely to report heterosexual contact as their primary HIV risk behavior. In addition, patients with stage 3 obesity were younger than those of normal weight (average age of 43.7 years vs 45.7 for normal weight patients). The average number of annual primary care visits for stage 3 obese patients was 6.5 visits per year, slightly higher than normal weight patients' average of 6.2 visits per year (Table 2).

The unadjusted mean percentage of all eligible QIs received was notable for its high value of 65.7%, as well as a very narrow range of difference (65.82% to 64.32%) across BMI categories. The unadjusted percentages for receipt of each QI were similarly notable for narrow ranges of absolute differences across BMI categories – with as high as a 9% difference for syphilis screening across BMI categories. The low percentage of patients who received both the Pneumococcal vaccination (37.6% overall) and screening for G/C (25.73% overall) contrasts with the very high percentage of patients who received CD4 counts (84.56% overall), ART (91.89% overall), MAC prophylaxis (81.57% overall), and PCP prophylaxis (89.87% overall; Table 3).

Multivariate Regression Analysis

The adjusted linear regression model indicated that overall there was a significant association between the mean percent of all eligible QIs received and patient BMI ($p = 0.004$). Compared to those of normal weight, patients with stage 3 obesity (BMI >40) received an estimated mean 4% fewer QIs (-4%; 95% CI of -6% to -2%). No other differences between BMI categories were statistically significant (Table 4).

The adjusted logistic regression models for receipt of specific QIs are notable for the following: Patients with stage 3 obesity had a lower odds of receiving both HCV screening (adjusted odds ratio [aOR] = 0.73, 95% CI 0.55 to 0.98) and sexually transmitted infection (STI) screening for both G/C (aOR = 0.76, 95% CI 0.60 to 0.96) and syphilis (aOR = 0.69, 95% CI 0.56 to 0.86), compared to normal weight patients. However, stage 3 obese patients had higher odds of receiving ≥ 2 CD4 counts than normal weight patients (aOR = 1.44, 95% CI 1.07 to 1.95). There were no significant differences in receipt of STI screening or HCV screening in other elevated BMI categories relative to those patients with normal BMIs. Receipt of ART, lipid screening, pneumococcal vaccination, PCP and MAC prophylaxis were comparable across all BMI categories (Table 4).

Notably, the unadjusted upward trend (as BMI category increased) seen for the percentage receiving G/C screening was inverted following multivariate regression analysis. In order to determine what was driving the unadjusted increase in G/C testing for obese patients, we did a stepwise analysis and found that gender was the primary variable driving down the odds of screening for patients with a BMI >40 in our multivariate model, with women, who more likely to have a BMI >40 compared with men, accounting for most of the disparity in GC testing.

DISCUSSION

Overall Quality of Care for Obese Patients

In our analysis, we found that obese and normal weight HIV-infected patients received a generally comparable overall proportion of eligible recommended QIs. A small– but statistically significant – estimated decrease in the mean receipt of eligible QIs was found for stage 3 obese (BMI >40) patients, relative to normal weight patients.

More substantial differences in care were found with regard to receipt of specific QIs. Namely, patients with stage 3 obesity had lower odds of receiving recommended STI screenings (for both gonorrhea/Chlamydia and syphilis), but higher odds of receiving CD4 count monitoring, compared to patients with a normal BMI. This suggests that HIV providers may prioritize some QIs over others in the management of patients with a high BMI. Importantly, patients received ART regardless of BMI. The overall measure of HIV care quality was high – consistent with prior studies^{3,13,26,27}.

STI Screening

With regard to differences in STI screening, it's important to note that patients in this dataset with stage 3 obesity primarily reported heterosexual contact as their HIV risk behavior and were disproportionately female and reported heterosexual contact as their primary risk behavior, relative to patients with normal BMIs. While we adjusted for these variables in our regression model, that adjustment serves to account for the impact that patient primary risk behavior and gender may have on receipt of the recommended screening QIs in our study – it does not adjust for patient risk of having either STI. Clinical suspicion for sexually transmitted infection in the stage 3 obese patient group should be equal to that for normal weight patients. Given that the odds of screening for gonorrhea/Chlamydia and syphilis were decreased by 24%

and 31%, respectively, for patients with stage 3 obesity relative to normal weight patients, there is good reason for concern.

The gap in STI screening was observed despite statistical adjustments for age, race, gender, primary HIV risk behavior, and number of HIV clinic visits in the analytic models – in fact, the differences by BMI category for gonorrhea/Chlamydia screening was seen only after these adjustments were made.

One might argue that the logistics of screening could account for these differences. Although syphilis is tested for using a blood test, gonorrhea/Chlamydia requires either a cervical swab (which may disproportionately deter obese patients) or collection of a urine sample following two full hours without voiding. The difficulty of acquiring a sample for gonorrhea/Chlamydia may account in part for the low overall receipt of this screening test and the differences between BMI categories. On the other hand, the comparative ease of conducting a Rapid Plasma Reagan (RPR) blood test for syphilis does not support that argument. Moreover, in the context of our finding of undifferentiated odds and high overall receipt of lipid screening (which is a 9-to-12-hour fasting blood test), these STI screening differences are unlikely to be due to the difficulty of conducting the test.

There are several additional theories, however, that may account for this difference in care. It may be that these patients require management of a greater number of medical problems, and therefore STI screening competes with more urgent medical needs. Alternatively, it may be that patients were offered STI testing, and obese patients disproportionately refused. Lastly, it may simply be that providers disproportionately skip a discussion and recommendation of STI testing to their obese patients because of an inaccurate perception that these patients are at a lower risk. Unfortunately, our data set does not allow us to gain insight into these areas.

Looking more widely at the general medicine patient population, no published studies examining differences in STI screening rates in normal weight versus obese patients were able to be identified using a Medline search. Several studies, however, have identified sizable and statistically significant decreases in the odds of cervical cancer screening among obese patient populations^{22-24,35,36}. Taken together with the current findings, these studies may lend support to the hypothesis that the decreased odds of STI screening – which is clinically related to cervical cancer screening – may indicate that providers assume that obese patients are at lower risk of contracting STIs.

Alternatively, providers may be limiting STI screening to patients who report being sexually active, as endorsed by HRSA guidelines for established patients. Our data set did not include information about specific patient sexual behaviors (only sexual orientation), nor details about patient-provider discussions of STI risk. In short, additional studies are needed to elucidate the source of these STI screening differences.

HCV Screening

The finding of decreased odds of HCV screening among stage 3 obese patients also merits further discussion and investigation. Many of the possible explanations for the STI screening differences might also apply to this finding. More specifically, providers may have a lower clinical suspicion for HCV screening in patients without a history of IDU risk behavior, which was decreased in obese patients and may have led to decreased HCV testing in this group, even after adjusting for HIV risk behavior. Alternatively, it may be that obese patients disproportionately refuse screening, as a second stigmatizing condition.

CD4 Counts

The finding of significantly increased odds of receiving recommended CD4 counts for obese patients is another area with many unanswered questions. One would think that if

providers suspected a need for greater CD4 monitoring in patients with obesity, that they would also request more frequent visits – but the mean number of HIV clinic visits was comparable across BMI categories. One would also expect to see differences in receipt of ART and/or prophylaxis, as CD4 count values directly impact patient eligibility for these QIs, but this was not observed. It may be that patient BMI correlates with differences in patient adherence to CD4 blood tests, however this was not seen (as mentioned previously) for lipid testing. Given that other primary HIV care QIs (ART therapy, MAC and PCP prophylaxis) showed no significant differences across BMI categories, this is a particularly difficult finding to assess. Additional studies are needed to further explore – and validate – this finding.

Finally, the findings of this study contrast with a similar study of data from the medical records of general medicine patients at several Veterans Health Administration (VHA) outpatient clinics. That study found large absolute and statistically significant *increases* in the odds of provision of several primary care and preventive services – including increased odds of pneumococcal vaccination, but no differences seen for cervical cancer screening – for class 3 obese veteran patients relative to their normal weight counterparts³⁷. This study differed from the current study in that there are large differences in the health care systems of the VHA compared with clinics participating in the HIVRN, thus limiting direct comparison of findings. Nonetheless, the comparison does serve to highlight the disparities experienced by HIV-infected patients in this study population, and it illustrates the possibility for improvement of STI screening within the HIVRN.

Limitations

Our study should be interpreted in light of several limitations. First, this study utilized data from 7 of the 14 adult outpatient HIV clinics within the HIVRN. This sample is not nationally representative, and may not be generalizable to all HIV care sites; although patient

demographics in the current study are consistent with national HIV epidemiologic trends. Our findings may differ at clinics where providers have less experience with HIV and/or a different patient demographic. Additionally, in patients who did not receive the recommended QIs, we are unable to determine whether patient refusal occurred or whether providers failed to recommend eligible care. Moreover, we did not have access to patient information regarding education and other measures of socioeconomic status known to be correlated with the quality of care received. Finally, it is important to highlight that the serial cross-sectional study design limits our ability to make inferences about causation.

FUTURE DIRECTIONS

While the differences in overall quality of care provided to patients by BMI category were not dramatic in absolute terms, the differences in the provision of individual QIs suggests that care is provided differently to patients based on their BMI. The finding of decreased STI screening in patients with stage 3 obesity points to a need for further studies of the outpatient HIV-positive patient population to examine potential confounders affecting this finding - such as the possibility of increased medical complexity of patients with obesity, and of differences in obese patient refusal or adherence to recommended care.

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Table 1. HIV Quality of Care Indicators

Quality Indicators (QIs)	Eligibility Criteria	“Passing” Criteria
ART Therapy	First CD4 < 350	Prescribed during CY
MAC Prophylaxis	First CD4 < 50	Prescribed during CY
PCP Prophylaxis	First CD4 <200	Prescribed during CY
Lipid Screening	On ART	Tested during CY
CD4 Counts	All	≥ 2 counts three or more months apart during CY
Syphilis Screening	All	RPR during CY
Chlamydia Screening	All	Tested during CY
Gonorrhea Screening	All	Tested during CY
HCV Screening	All	Tested during CY
Pneumococcal Vaccination	All	Vaccinated ever

Table 2. Patient Characteristics, Overall and by BMI Category

	Overall (10,896 data points)	BMI 18.5 - 24.9 (4,394 data points)	BMI 25.0 - 29.9 (3,698 data points)	BMI 30.0 - 34.9 (1,613 data points)	BMI 35.0 - 39.9 (655 data points)	BMI ≥40.0 (536 data points)	ANOVA P-values
Mean Age in Years (SD)	46.1 (10.2)	45.6 (10.8)	46.6 (9.8)	46.9 (9.4)	46.8 (9.8)	43.7 (9.3)	< 0.001
Gender (%)							
Female	28.7	22.8	25.8	36.3	46.9	52.5	< 0.001
Male	70.6	76.7	73.1	63.2	52.1	46.6	
Trans	0.7	0.5	1.1	0.4	1.1	0.9	
Race (%)							
White	21.8	25.6	23.0	16.3	13.7	10.6	< 0.001
Black	48.7	46.7	45.8	51.8	56.3	63.3	
Hispanic	27.7	25.2	29.4	31.0	28.7	25.6	
Other	1.8	2.5	1.8	0.9	1.4	0.6	
1° HIV Risk Behavior (%)							
MSM	36.4	42.1	38.4	27.0	22.3	21.7	< 0.001
IDU	20.7	21.5	20.9	20.7	21.6	12.6	
Heterosexual	38.2	31.7	36.4	47.3	50.4	60.9	
Other	4.7	4.7	4.3	5.0	5.8	4.8	
Mean # HIV PCP Visits per Year (SD)	6.4 (4.3)	6.2 (4.3)	6.5 (4.3)	6.5 (4.0)	6.5 (3.9)	6.5 (4.1)	0.03

Table 3: Unadjusted Proportion of Patients Receiving each QI and Mean Proportion of All Eligible QIs Received, by Patient BMI

	BMI 18.5 - 24.9 (4,394 data points)	BMI 25.0 - 29.9 (3,698 data points)	BMI 30.0 - 34.9 (1,613 data points)	BMI 35.0 - 39.9 (655 data points)	BMI ≥40.0 (536 data points)	Overall (10,896)
Received ≥2 CD4 Counts	82.96%	85.85%	85.01%	84.72%	86.60%	84.56%
Received ART Therapy	91.85	91.64	92.50	93.27	90.23	91.89
Received PCP Prophylaxis	91.55	87.90	87.76	88.57	92.86	89.87
Received MAC Prophylaxis	83.06	77.34	82.61	82.76		81.57
Received Syphilis Screening	69.64	69.33	66.58	63.66	60.45	68.27
Received GC/CT Screening	24.58	25.74	27.03	27.79	28.73	25.73
Received Lipid Screening	76.42	80.09	81.94	81.66	81.84	79.04
Received HCV Screening	68.99	66.78	69.20	69.47	68.11	68.26
Received Pneumococcal Vaccination	38.31	37.70	34.81	37.01	40.64	37.60
Overall % Eligible QIs Received	65.66	65.82	65.82	65.80	64.32	65.68

Table 4: Adjusted* Associations Between BMI Category and Receipt of each QI and Mean Percent QIs Received, if Eligible

	BMI 18.5 - 24.9 (4,394 data points)	BMI 25.0 - 29.9 (3,698 data points)	BMI 30.0 - 34.9 (1,613 data points)	BMI 35.0 - 39.9 (655 data points)	BMI ≥40.0 (536 data points)
Mean QIs Received (adjusted absolute difference, 95% CI)	(reference)	-1% (-2% to 0%)	-1% (-2%, 0%)	-2% (-3%, 0%)	-4% (-6%, -2%)
≥2 CD4 Counts (aOR, 95% CI)	1.00 (ref)	1.20 (1.04, 1.37)	1.12 (0.93, 1.35)	1.08 (0.83, 1.42)	1.44 (1.07, 1.95)
ART Therapy (aOR, 95% CI)	1.00 (ref)	0.90 (0.72, 1.12)	1.08 (0.80, 1.46)	1.23 (0.80, 1.90)	0.80 (0.50, 1.30)
PCP Prophylaxis (aOR, 95% CI)	1.00 (ref)	0.65 (0.46, 0.92)	0.63 (0.39, 1.02)	0.79 (0.41, 1.53)	1.45 (0.40, 5.22)
MAC Prophylaxis (aOR, 95% CI)	1.00 (ref)	0.76 (0.41, 1.40)	0.81 (0.34, 1.88)	**1.65 (0.51, 5.34)	
Syphilis Screening (aOR, 95% CI)	1.00 (ref)	0.99 (0.89, 1.10)	0.92 (0.80, 1.05)	0.84 (0.69, 1.02)	0.69 (0.56, 0.86)
GC/CT Screening (aOR, 95% CI)	1.00 (ref)	1.05 (0.93, 1.18)	1.00 (0.85, 1.17)	0.85 (0.68, 1.08)	0.76 (0.60, 0.96)
Lipid Screening (aOR, 95% CI)	1.00 (ref)	1.10 (1.06, 1.37)	1.24 (1.03, 1.48)	1.21 (0.92, 1.59)	1.24 (0.93, 1.66)
HCV Screening (aOR, 95% CI)	1.00 (ref)	0.90 (0.77, 1.04)	0.94 (0.77, 1.15)	0.86 (0.65, 1.13)	0.73 (0.53, 1.01)
Pneumococcal Vaccination (aOR, 95% CI)	1.00 (ref)	0.96 (0.82, 1.13)	0.78 (0.63, 0.96)	0.90 (0.66, 1.23)	0.91 (0.65, 1.26)

* All models adjusted for gender, race/ethnicity, age, primary HIV risk behavior, and number of primary care visits in a year

** combined for small values