Title

Association Between Community Health Center Usage and Emergency Department Utilization among California’s HIV-Infected Medicaid Beneficiaries, 2009

Author

Chow, Jeremy Yan-Shun

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requirements for the degree Master of Science in Clinical Research

by

Jeremy Yan-Shun Chow

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ABSTRACT OF THE THESIS

Association Between Community Health Center Usage and Emergency Department Utilization among California's HIV-Infected Medicaid Beneficiaries, 2009

by

Jeremy Yan-Shun Chow
Master of Science in Clinical Research
University of California, Los Angeles, 2016
Professor Marc Adam Suchard, Chair

Importance: Community Health Centers (CHC) are important sites of care for people living with HIV (PLWH) and play an increasing role in their care under the Affordable Care Act. Little is known about the relationship between CHC usage and emergency department (ED) utilization in this population.

Objective: To determine the association between CHC usage and ED utilization

Design: Retrospective, cross-sectional study of diagnosed PLWH enrolled in California's Medicaid program in 2008 and 2009. Zero-inflated Poisson models were used to estimate the odds of being an ED user and the number of ED visits in 2009. We controlled for demographics (age, gender, race, urban residence, income, education), service characteristics (managed care enrollment, provider HIV experience), and medical characteristics (mental health, substance abuse, tobacco, medical comorbidity, antiretroviral therapy).

Setting: Emergency department

Participants: We included 6284 adult, full-term 2008-2009 beneficiaries with strong evidence of HIV diagnosis and excluded pregnant and dual-eligible beneficiaries.

Exposures: CHC users were patients who had ≥1 CHC outpatient claim in 2008. Non-CHC users had outpatient claims only at non-CHCs. Those with no outpatient usage had no 2008 outpatient claims.

Main Outcomes and Measures: Number of ED claims on separate days per beneficiary in 2009

Results: CHC users averaged significantly greater numbers of ED visits than non-CHC users and those with no outpatient usage (1.91, 1.58, and 1.70, respectively; *P*=0.022). CHC users had higher odds of being ED users (OR=1.16; 95%CI 1.04-1.30). Controlling for demographic and service characteristics did not alter this result (OR=1.16; 95%CI 1.03-1.31). The difference was mitigated once medical characteristics were included (OR=1.09; 95%CI 0.96-1.25). The association between CHC status and number of ED visits, conditional on using the ED at all, was not significant in the bivariate (rate ratio (RR)= 1.12; 95%CI 0.97-1.28) or multivariate models (RR=1.01; 95%CI 0.87-1.17). The overall differences in mean ED visits observed between CHC and non-CHC groups were reduced to insignificance (1.77; 95% CI 1.60-1.93 vs 1.68; 95%CI 1.53-1.84) after adjusting for demographic, service, and medical characteristics.

Conclusions and Relevance: CHC users had higher ED utilization than non-CHC users, but the disparity was largely driven by differences in medical characteristics.

The thesis of Jeremy Yan-Shun Chow is approved.

Warren S. Comulada

Elliot M. Landaw

Arleen Leibowitz

Marc Adam Suchard, Committee Chair

University of California, Los Angeles

2016

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CHAPTER 1: MANUSCRIPT

ABSTRACT

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INTRODUCTION

Federally Qualified Health Centers (FQHC) and Rural Health Clinics (RHC) are safety net health centers that provide primary care services to medically underserved communities. FQHCs were first established in 1991 under the Omnibus Budget Reconciliation Act of 1990. RHCs were established by the Rural Health Clinic Service Act of 1977 to address the supply of existing physicians serving Medicare beneficiaries in rural areas[1]. Since then, FQHCs and RHCs (which will be referred to jointly as community health centers (CHC) hereafter) have grown in number, and the federal budget to support these health centers increased. The Affordable Care Act (ACA) allocated $11 billion to fund CHCs over a period of five years to help meet the anticipated increased health care demand following the ACA's insurance expansion[2]. From the beginning, CHCs have played an important part in the provision of health services to people living with HIV (PLWH) since HIV disproportionately affects lower income communities. In 2009, there were 427,797 encounters in CHCs representing 94,972 patients with HIV/AIDS[3]. In addition, since an AIDS diagnosis confers disability status many PLWH received health coverage through Medicaid, and in turn, CHCs became a prominent source of care for these patients. In 2009, it was estimated that 40.3% of PLWH in the US receiving outpatient care had Medicaid coverage[4].

Given the continued expansion of CHCs, it is important to assess how successful CHCs are in keeping populations healthy and decreasing utilization of emergency services. This issue has important economic implications as spending on emergency care has been estimated to make up 5-6% of national health expenditures, but could be as high as 10%.[5]. The issue of emergency department (ED) utilization is especially relevant to PLWH because in a nationally representative sample, they have been found to have higher ED visit rates with higher numbers of diagnostic and screening tests, longer duration of stay, and higher likelihood of being admitted compared to non-HIV-infected patients[6].

Comparisons of ED utilization among CHC and non-CHC users who are HIV-infected are lacking. However, a recent study done among dual-eligible Medicare and Medicaid beneficiaries (not limited to HIV) from 2008-2010 showed that ED utilization and hospitalizations were higher among CHC users across all racial groups[7]. A similar study in Colorado showed that Medicaid beneficiaries who used CHCs had higher rates of ED utilization, but their odds of ED utilization were actually lower when adjusted for age, sex, rural residence, and disability status[8]. An older study from 1992 had similar findings[9], as did an ecological study that found that the presence of CHCs in a county was associated with decreased rates of hospitalization for ambulatory care sensitive conditions[10].

This study seeks to determine the association between CHC usage in 2008 and ED utilization for HIV-infected beneficiaries enrolled in California's Medicaid program (also known as Medi-Cal) in 2009. We hypothesized that patients receiving care at CHCs would have higher ED utilization, even after accounting for known risk factors. Studying this question in the Medicaid population is particularly relevant because public insurance has been found to be associated with increased ED utilization[11,12]. In addition, using 2009 data provides an important reference point for future studies of the Medicaid and CHC programs under the ACA. Finally, this study provides a unique opportunity to test this hypothesis while accounting for substance abuse disorders, which have been found to be important predictors of increased ED utilization[13,14]. After 2008, substance abuse diagnoses were redacted from the Medicaid claims database due to concerns for patient privacy; thus omitted variable bias might limit the conclusions from more recent data.

METHODS

Overview and Study Cohort:

We conducted a retrospective cross-sectional study of beneficiaries enrolled in California's Medicaid program using data obtained through a confidential data use agreement with the Centers for Medicare and Medicaid Services (CMS). HIV diagnosis was defined by a previously developed and validated algorithm[15] designed to capture those with strong evidence of HIV diagnosis. The sample included only beneficiaries who were enrolled for the entire 24 months of 2008 and 2009 since some of our variables, including service and medical characteristics, were abstracted from the year prior (2008) to the ED utilization to minimize the potential bias of reverse causality. Pregnant and dual-eligible Medicare and Medicaid patients were excluded. The result is a cohort of 6284 non-pregnant, full-year 2008 and 2009 Medicaid beneficiaries with HIV diagnoses.

Measures:

Outcome Measure: Emergency Department Utilization

The number of ED visits was defined as the total number of claims on separate days associated with an ED for each beneficiary from January 1 to December 31, 2009.

Covariates

Community Health Center Status

Beneficiaries were divided into three groups by CHC status: CHC users, non-CHC users, and those with no outpatient use. CHC users were defined as those who had any outpatient (evaluation/management) claims at a FQHC, FQHC look-alike, or RHC during 2008. Non-CHC users had at least one outpatient claim, of which none was at a CHC. Those who had zero outpatient claims for 2008 were placed in a "no outpatient use" group.

Demographics

Age, gender, and race were included in the model. Race was reported by CMS and was stratified into the following categories: white (reference group), African American, Hispanic, Asian/Pacific Islander, and other/unknown. Rural vs urban residence was determined by the ZIP code of residence, using the Rural-Urban Commuting Area codes. These were further dichotomized into rural and urban according to the University of Washington schema (Categorization C)[16]. Neighborhood socioeconomic status (SES) and education level were represented by the median income[17] and the percentage of high school and college graduates in the ZIP code of residence, respectively, as reported in the American Community Surveys[18].

Service Characteristics

Enrollment in a Medi-Cal managed care plan for any part of 2008 was included to account for any differences in care between managed care and non-managed care beneficiaries. Provider HIV volume was ascertained by determining the number of unique beneficiaries with HIV (ICD-9 codes 042 or v08) in any diagnosis field in 2008 for each provider across Medi-Cal and Medicare databases. To assess access to HIV expertise, each patient was associated with the provider they visited who had the most HIV patients. Access to provider experience was then stratified into three groups: <5 (including zero), 5-49, and ≥50 patients.

Medical Characteristics

Mental health and substance abuse diagnoses were defined using the ICD-9 codes designed by the Clinical Classifications Software for ICD-9-CM (CCS)[19], while tobacco usage was determined by tobacco-related diagnosis codes. Medical comorbidities were determined using standard ICD-9 codes for the comorbidities that comprise the Charlson Comorbidity Index[20]. AIDS was excluded in order to capture the effect of comorbidities aside from HIV. Because 71.3% of the subjects did not have any comorbidities, the variable was dichotomized to reflect the presence or absence of any Charlson comorbidity. Antiretroviral therapy (ART) usage was based on the presence of any ART claims in 2008.

All comorbidities and diagnoses were counted only if they appeared on ≥1 inpatient or ED claim, or ≥2 outpatient claims.

Statistical analysis:

Zero-inflated Poisson regression (ZIPR)[21] was used to model the impact of community health center status on the number of ED visits. A ZIPR model was used because >50% of 2009 beneficiaries had zero ED visits. Its appropriateness was confirmed by the Vuong statistic[22] (z=19.07, p<0.0001). A bivariate model was first used to estimate the association between CHC usage and ED utilization (Model A). Then demographic (age, sex, race, income, education) and service characteristics (managed care, provider HIV experience) were added to form a multivariable model (Model B). Finally, medical characteristics (mental health, substance abuse, tobacco, medical comorbidity, ART usage) were added to create a final multivariable model (Model C). This sequential approach was undertaken to better understand the contributions of these groups of covariates on the CHC association found in Model A. The ZIPR model allowed us to model two aspects of ED utilization. The zero-inflation (logistic) portion models the odds of being in the "zero state" (i.e. an ED non-user). The inverse of the odds ratios (OR) is presented, reflecting the odds of being an ED user. The conditional count (Poisson) portion models the number of annual ED visits among potential ED users and associations are presented as rate ratios (RR). Predictive margins were calculated for our model to determine the combined association of CHC usage on ED utilization. All analyses were conducted with Stata version 13.1 (StataCorp), using a two-tailed .05 level of significance and robust standard errors. The first diagnosis code associated with each 2009 ED visit was abstracted and the top ten diagnoses were tabulated.

RESULTS

Patient characteristics:

The characteristics of the 6,284 HIV-infected Medi-Cal beneficiaries are shown in Table 1. More than 40% of beneficiaries were seen in CHCs in 2008. CHC users had a median of 6 CHC visits in 2008 (interquartile range 3-11). ED utilization was similar for the three groups overall, with >50% of each group having zero 2009 ED visits, though the mean number of ED visits was highest among CHC users compared to non-CHC users and those with no outpatient usage (1.91, 1.58, and 1.70 visits respectively, P=0.022). The study population had a mean age of 47.0 years, was mostly men (66.6%), and comprised a large minority population (33.1% African American, 20.7% Hispanic, 10.9% other/unknown). CHC and non-CHC users lived in neighborhoods with similar percentages of high school and college graduates. Several notable differences were found among the three groups. Among demographics, CHC users were slightly older and more likely to be male. They were more likely to reside in rural areas and neighborhoods with lower income. Their service characteristics were also notably different. CHC patients were more likely to have access to providers with ≥50 HIV-infected patients, and were much less likely to have been enrolled in managed care in 2008. Regarding medical characteristics, CHC users were more likely to have mental health and substance abuse diagnoses. Both CHC and non-CHC users were significantly more likely to have medical comorbidities than those with no outpatient usage, but CHC users were less likely to be on ART compared to non-CHC users.

Odds of being an ED user:

In the bivariate model (A), CHC users had significantly higher odds of being an ED user compared to non-CHC users (OR=1.16; 95%CI 1.04-1.30) (Table 2). This relationship remained significant when demographic and service characteristics were adjusted for (B), but was mitigated when medical characteristics were added into the model (C) (OR 1.09; 95%CI 0.96-1.25). Several other demographic characteristics were found to be significant in the full model (C). Older patients (50-59 years old (OR 0.73; 95%CI 0.55-0.97) and ≥60 years old (OR 0.51; 95%CI 0.36-0.71)), males (OR 0.73; 95%CI 0.64-0.83), and Asian/Pacific Islanders (OR 0.64; 95%CI 0.41-0.98) had lower odds of being ED users, while African Americans (OR 1.19; 95%CI 1.03-1.37) and those with higher percentages of high school graduates in their ZIP code (OR 1.011; 95%CI 1.003-1.019) had higher odds. Service characteristics were not significant predictors. Among the medical characteristics, mental health (OR 1.20; 95%CI 1.05-1.36), substance abuse (OR 2.00; 95%CI 1.69-2.36), tobacco (OR 1.68; 95%CI 1.14-2.47), and medical comorbidities (OR 1.66; 95%CI 1.47-1.88) were all associated with higher odds of being an ED user, while ART usage was associated with lower odds (OR 0.73; 95%CI 0.61-0.87).

Annual rate of ED visits:

Although CHC users had greater numbers of ED visits, given that they had any, this difference was not significant in the bivariate model (A) (RR 1.12; 95%CI 0.97-1.28); the association was even weaker in the full model (C) (RR 1.01; 95%CI 0.87-1.17) (Table 3). Few demographic characteristics were associated with the rate of ED visits, but Asian/Pacific Islanders had fewer ED visits (RR 0.62; 95%CI 0.40-0.92), while urban residents had more ED visits (RR 1.47; 95%CI 1.14-1.90). Regarding service characteristics, managed care enrollees (RR 0.84; 95%CI 0.71-0.99) and patients whose providers treated ≥50 HIV patients (RR 0.72; 95%CI 0.54-0.96) had fewer ED visits. Finally, all of the medical characteristics (mental health (RR 1.43; 95%CI 1.27-1.61), substance abuse (RR 1.58; 95%CI 1.38-1.81), tobacco (RR 2.12; 95%CI 1.40-3.20), and medical comorbidities (RR 1.51; 95%CI 1.35-1.69)) were associated with increased rates of ED visits, except ART usage.

Adjusted mean annual ED visits and top ED diagnoses:

The differences in mean ED visits observed between CHC and non-CHC groups (p=0.006) were reduced to insignificance after adjusting for demographic, service, and medical characteristics (1.77; 95% CI 1.60-1.93 vs 1.68; 95%CI 1.53-1.84) (Figure 1).

The top ED diagnoses found in this study population included chest pain, not otherwise specified (n=504); pre-operative exam, unspecified (n=311); and abdominal exam, unspecified site (n=288). HIV disease ranked at number 4 (n=274); the remaining diagnostic codes can be seen in Table 4.

DISCUSSION

Our study shows that, on average, CHC users do visit the ED more than non-CHC users. The primary factor underlying this difference lies in CHC users' higher odds of being ED users. CHC status did not significantly affect the number of ED visits, conditional on using the ED at all. However, once the demographic, service, and medical characteristics were adjusted for, the difference in any ED use was no longer statistically significant. Our data show that the medical characteristics of CHC patients drive their ED utilization. This suggests that it is the mental health, substance abuse, tobacco use, and medical comorbidities of patients that receive care in CHCs, rather than the characteristics of the CHC setting (and the potential differences such as quality of care, access to specialists, or wait times) itself that are responsible for the increased ED utilization among CHC patients.

Other studies of Medicaid beneficiaries' use of EDs have shown mixed results. Some have documented increased[7] ED utilization among CHC patients, while others have shown decreased ED use[8]. However, these studies included patients with heterogeneous diagnoses and medical needs. Our study examined HIV-infected Medicaid beneficiaries, who have higher rates of ED utilization than others[6,11]. In addition, the aforementioned studies[7,8] did not account for the medical characteristics of the patients, which were some of the strongest predictors of ED use in our study. Furthermore, the finding that medical characteristics were significant predictors in *both* parts of the model, emphasizes that these are important drivers of overall ED utilization, consistent with the findings of prior analyses that have emphasized the association between mental health[23,24] and substance abuse[11,25] and ED utilization in

PLWH. This study is the first to show the important role of tobacco and medical comorbidities in this setting.

Consistent with prior studies, we found that younger age[26] and female gender[11,26] were associated with increased ED utilization. Interestingly, we found that the higher the percentage of high school graduates in one's ZIP code, the higher the odds of being an ED user. However, the odds ratio was very close to unity and therefore of little practical impact. The second part of the model also identified some notable associations. Higher ZIP code income was associated with decreased rate of ED utilization, while urban residence was associated with a higher rate of ED utilization, possibly due to access and proximity to EDs in urban areas. Managed care was associated with a decreased rate, as managed care enrollees likely have improved access to a coordinated network of care. Finally, those with providers with more HIV experience also had lower rates of ED utilization, which is reassuring and emphasizes the importance of the provider's HIV experience in achieving optimal outcomes.

Our study has some limitations. While we have tried to adjust for all the factors with important impacts on ED utilization, we had to use ZIP code-level data for income and education because patient level measures were not available in this administrative data. Nevertheless, ZIP code data is frequently used in other studies[24,27] to adjust for the neighborhood where the beneficiary resides. Other types of clinical data such as HIV viral load and CD4 counts were also not available as our data were not linked to medical records. Finally, our population only includes HIV-infected Medicaid beneficiaries, and excludes dual-eligible Medicare-Medicaid patients. Generalizations should not be extended to populations not studied here, including undocumented immigrants, who may have different utilization patterns.

With the implementation of the ACA and the large increase in federal funding for CHCs, it is increasingly crucial to understand the health care utilization and costs incurred by CHC patients. In the 2014 California Health Interview Survey (CHIS), a representative survey of all 58 counties in California, 16.8% of participants reported an ED visit in the last year[28], whereas close to 50% of our study participants had at least one ED visit, emphasizing the high ED utilization of our study group compared to the general population. Moreover, our data emphasize the large role that CHCs play in caring for HIV-infected Medicaid beneficiaries– close to 40% of our study population received care at a CHC. In contrast, a nationwide study found that about 14% of 2009 Medicaid beneficiaries received care from a CHC[29]. The confluence of these contextual factors makes this a timely study that provides another piece of important data on the outcomes of CHCs in California. Further study of this topic is warranted because the ACA's Medicaid Expansion and Heath Insurance Exchanges have given many previously uninsured PLWH access to care from private providers and CHCs outside of Ryan White sites. Indeed, the proportion of Californians using CHCs increased by 71.3% between 2005 and 2014 [29]. Our study sets an important baseline for examining changes that the ACA has delivered.

Conclusions:

To conclude, our study found that, on average, CHC users had 0.33 more visits per year than non-CHC users, but this difference was mitigated once medical characteristics were accounted for. Although this unadjusted difference seems small, the average cost of an ED visit was $1233 in 2008[30], thus efforts to decrease ED visits at the payer(Medicaid) and clinic (CHC) level could lead to substantial savings on a population wide level. Our study suggests that successful outpatient management of mental health, substance abuse, tobacco, and chronic medical conditions, may be the keys to decreasing ED utilization in this population.

Table 1: Characteristics of Study Subjects, Stratified by Community Health Center Status (n=6284)					
Characteristics	**Non-CHC n=3446 n(%)**	**CHC n=2516 n(%)**	**No outpatient use n=322 n(%)**	**Overall n=6284 n(%)**	***P* value[1]**
Outcome:					
Number of ED visits: mean(SD)	1.58 (4.41)	1.91 (4.74)	1.70 (4.12)	1.72 (4.53)	0.022
median (range)	0 (0-151)	0 (0-129)	0 (0-45)	0 (0-151)	<0.001
0	1919 (55.7%)	1296 (51.5%)	177 (55.0%)	3392 (54.0%)	0.025
1-5	1292 (37.5%)	999 (39.7%)	118 (36.7%)	2409 (38.3%)	
6-9	134 (3.9%)	126 (5.0%)	16 (5.0%)	276 (4.4%)	
≥10	101 (2.9%)	95 (3.8%)	11 (3.4%)	207 (3.3%)	
Demographics:					
Mean Age (SD)	46.8 (9.6)	47.5 (9.1)	45.1 (9.3)	47.0 (9.4)	<0.001
18-29	191 (5.5%)	111 (4.4%)	18 (5.6%)	320 (5.1%)	<0.001
30-39	456 (13.2%)	310 (12.3%)	63 (19.6%)	829 (13.2%)	
40-49	1396 (40.5%)	995 (39.6%)	143 (44.4%)	2534 (40.3%)	
50-59	1127 (32.7%)	908 (36.1%)	75 (23.3%)	2110 (33.6%)	
≥60	276 (8.0%)	192 (7.6%)	23 (7.1%)	491 (7.8%)	
Gender					0.001
Female	1218 (35.4%)	770 (30.6%)	113 (35.1%)	2101 (33.4%)	
Male	2228 (64.7%)	1746 (69.4%)	209 (64.9%)	4183 (66.6%)	
Race					
White	1233 (35.8%)	885 (35.2%)	102 (31.7%)	2220 (35.3%)	0.691
African American	1129 (32.8%)	843 (33.5%)	108 (33.5%)	2080 (33.1%)	
Hispanic	719 (20.9%)	507 (20.2%)	76 (23.6%)	1302 (20.7%)	
Other/unknown[2]	365 (10.6%)	281 (11.2%)	36 (11.2%)	682 (10.9%)	
Rural residence	60 (1.7%)	177 (7.0%)	10 (3.1%)	247 (3.9%)	<0.001
Urban residence	3386 (98.3%)	2339 (93.0%)	312 (96.9%)	6037 (96.1%)	
Mean ZIP code income (SD)	$49413 (1802)	$47619 (1972)	$48525 (1877)	$48649 (1877)	0.001
Mean % HS graduates in ZIP code (SD)	76.2 (13.9)	76.9 (13.1)	76.5 (13.1)	76.5 (13.5)	0.107
Mean % college graduates in ZIP code (SD)	26.6 (16.4)	28.9 (17.9)	27.9 (17.7)	27.6 (17.1)	<0.001
Service characteristics:					
Enrolled in managed care	1039 (30.2%)	93 (3.7%)	95 (29.5%)	1227 (19.5%)	<0.001
Provider HIV experience					<0.001
<5 patients	453 (13.2%)	82 (3.3%)	322 (100%)	857 (13.6%)	
5-49 patients	1313 (38.1%)	517 (20.6%)	N/A	1830 (29.1%)	
≥50 patients	1680 (48.8%)	1917 (76.2%)	N/A	3597 (57.2%)	
Medical characteristics:					
Any mental health diagnosis	743 (21.6%)	848 (33.7%)	52 (16.2%)	1643 (26.2%)	<0.001
Any substance abuse diagnosis	391 (11.4%)	437 (17.4%)	34 (10.6%)	862 (13.7%)	<0.001
Tobacco	66 (1.9%)	57 (2.3%)	4 (1.2%)	127 (2.0%)	0.428
Any medical comorbidity	1125 (32.7%)	834 (33.2%)	41 (12.7%)	2000 (31.8%)	<0.001
On ART	3185 (92.4%)	2250 (89.4%)	284 (88.2%)	5719 (91.0%)	<0.001

[1]*P* values from comparisons on continuous variables using ANOVA (or Kruskal-Wallis tests for skewed distributions) and categorical variables using Chi-squared tests

[2]Asian/Pacific Islander and other/unknown were combined because CMS prohibits publication of patient numbers <11

Abbreviations: CHC: community health center, ED: emergency department, HS: high school, ART: antiretroviral therapy

Table 2. Relationship Between Predictors and Odds of Being an ED User in 2009[1] (n=6284)						
	Bivariate model (A)		**Multivariable model with demographics & service characteristics (B)**		**Full multivariable model (C)**	
Characteristic	**OR (95%CI)**	***P* value**	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**
CHC status						
Non-CHC	ref		ref		ref	
CHC	1.16 (1.04-1.30)	0.006	1.16 (1.03-1.31)	0.015	1.09 (0.96-1.25)	0.193
No outpatient use	1.02 (0.80-1.29)	0.891	0.86 (0.64-1.16)	0.323	0.94 (0.68-1.29)	0.699
Demographics:						
Age (years)						
18-29			ref		ref	
30-39			1.02 (0.77-1.35)	0.910	0.99 (0.73-1.34)	0.931
40-49			0.89 (0.69-1.15)	0.360	0.83 (0.63-1.10)	0.194
50-59			0.81 (0.63-1.05)	0.118	0.73 (0.55-0.97)	0.028
≥60			0.56 (0.41-0.76)	<0.001	0.51 (0.36-0.71)	<0.001
Gender						
Female			ref		ref	
Male			0.70 (0.62-0.79)	<0.001	0.73 (0.64-0.83)	<0.001
Race						
White			ref		ref	
African American			1.23 (1.08-1.41)	0.002	1.19 (1.03-1.37)	0.021
Hispanic			0.84 (0.71-0.99)	0.034	0.86 (0.71-1.03)	0.101
Asian/Pacific Islander			0.56 (0.38-0.83)	0.004	0.64 (0.41-0.98)	0.042
Other/unknown			1.05 (0.85-1.29)	0.669	1.04 (0.83-1.30)	0.749
Urban residence			0.87 (0.63-1.19)	0.388	0.79 (0.56-1.12)	0.183
ZIP code income (per $10000)			0.97 (0.94-1.01)	0.177	0.98 (0.94-1.03)	0.472
% HS graduates in ZIP code			1.012 (1.004-1.019)	0.001	1.011 (1.003-1.019)	0.005
% College graduates in ZIP code			0.996 (0.990-1.001)	0.141	0.995 (0.989-1.002)	0.145
Service characteristics:						
Enrolled in managed care			1.045 (0.890-1.228)	0.590	1.06 (0.90-1.26)	0.481
Provider HIV experience						
<5 patients			ref		ref	
5-49 patients			0.78 (0.63-0.96)	0.021	0.81 (0.64-1.01)	0.065
≥50 patients			0.92 (0.75-1.14)	0.459	0.95 (0.76-1.19)	0.662
Medical characteristics:						
Any mental health diagnosis					1.20 (1.05-1.36)	0.007
Any substance abuse diagnosis					2.00 (1.69-2.36)	<0.001
Tobacco					1.68 (1.14-2.47)	0.008
Any medical comorbidity					1.66 (1.47-1.88)	<0.001
On ART					0.73 (0.61-0.87)	<0.001
Model constant	0.84 (0.79-0.91)	<0.001	0.85 (0.44-1.65)	0.627	1.01 (0.48-2.10)	0.984

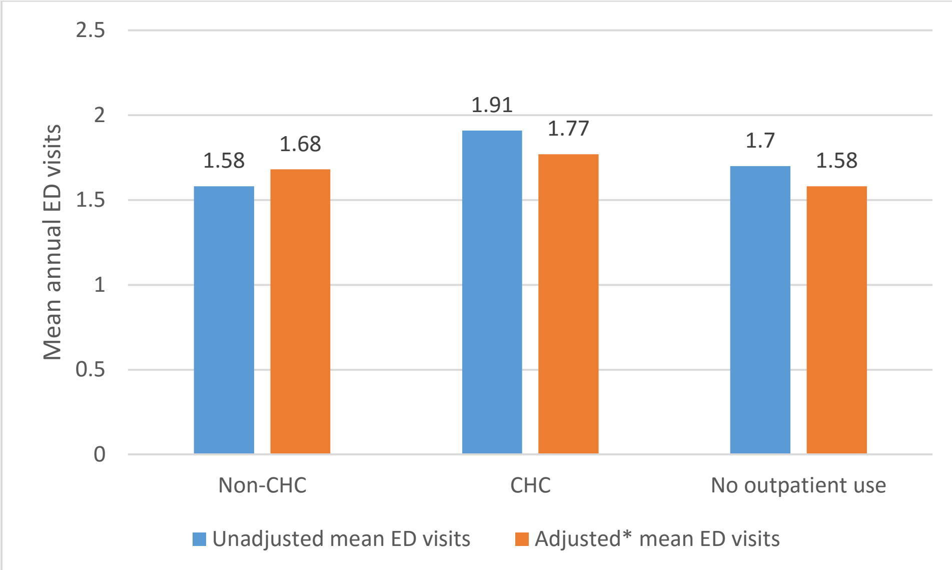
[1]Based on logistic portion of zero-inflated Poisson models

Table 3. Relationship Between Predictors and Number of ED Visits in 2009[1] (n=6284)						
	Bivariate model (A)		**Multivariable model with demographics & service characteristics (B)**		**Full multivariable model (C)**	
Characteristic	**RR (95%CI)**	***P* value**	**RR (95% CI)**	***P* value**	**RR (95% CI)**	***P* value**
CHC status:						
Non-CHC	ref		ref		ref	
CHC	1.12 (0.97-1.28)	0.113	1.12 (0.97-1.29)	0.131	1.01 (0.87-1.17)	0.893
No outpatient use	1.07 (0.81-1.41)	0.629	0.88 (0.58-1.33)	0.536	0.97 (0.67-1.39)	0.856
Demographics:						
Age (years)						
18-29			ref		ref	
30-39			1.10 (0.81-1.49)	0.550	1.05 (0.78-1.43)	0.736
40-49			1.03 (0.80-1.31)	0.838	0.99 (0.77-1.27)	0.910
50-59			0.95 (0.73-1.23)	0.679	0.85 (0.65-1.12)	0.247
≥60			0.88 (0.65-1.18)	0.404	0.80 (0.59-1.10)	0.168
Gender						
Female			ref		ref	
Male			0.91 (0.79-1.04)	0.176	0.94 (0.82-1.07)	0.350
Race						
White			ref		ref	
African American			1.12 (0.97-1.30)	0.130	1.12 (0.98-1.29)	0.104
Hispanic			0.92 (0.70-1.20)	0.531	0.99 (0.76-1.28)	0.914
Asian/Pacific Islander			0.59 (0.40-0.89)	0.012	0.62 (0.40-0.94)	0.025
Other/unknown			1.02 (0.82-1.28)	0.844	1.11 (0.88-1.40)	0.381
Urban residence			1.56 (1.21-2.00)	0.001	1.47 (1.14-1.90)	0.003
ZIP code income (per $10000)			0.96 (0.90-1.02)	0.184	0.96 (0.91-1.02)	0.161
% HS graduates in ZIP code			1.004 (0.997-1.011)	0.296	1.006 (0.998-1.013)	0.129
% College graduates in ZIP code			1.000 (0.993-1.007)	0.993	0.998 (0.992-1.005)	0.559
Service characteristics:						
Enrolled in managed care			0.79 (0.66-0.95)	0.012	0.84 (0.71-0.99)	0.034
Provider HIV experience						
<5 patients			ref		ref	
5-49 patients			0.81 (0.59-1.12)	0.206	0.80 (0.60-1.07)	0.130
≥50 patients			0.74 (0.53-1.05)	0.088	0.72 (0.54-0.96)	0.025
Medical characteristics:						
Any mental health diagnosis					1.43 (1.27-1.61)	<0.001
Any substance abuse diagnosis					1.58 (1.38-1.81)	<0.001
Tobacco					2.12 (1.40-3.20)	<0.001
Any medical comorbidity					1.51 (1.35-1.69)	<0.001
On ART					0.85 (0.71-1.02)	0.077
Model constant	3.45 (3.13-3.80)	<0.001	2.77 (1.37-5.57)	0.004	2.01 (0.99-4.09)	0.054

[1]Based on Poisson portion of zero-inflated Poisson models

Abbreviations: RR: rate ratio, CI: confidence interval, CHC: Community Health Center, HS: high school, ART: antiretroviral therapy

Figure 1: Mean Number of Annual ED Visits, by CHC Status



*Adjusted for age, gender, race, urban residence, ZIP code income, percent high school and college graduates in ZIP code, managed care, provider HIV volume, mental health diagnoses, substance abuse, tobacco use, medical comorbidities, and being on ART.

Table 4. Top ED Diagnosis Codes

	ICD-9 code	n	Description
1	78650	504	Chest pain NOS
2	V7284	311	Preop exam unspecified
3	78900	288	Abdominal pain unspecified site
4	042	274	Human Immunodeficiency Virus disease
5	486	245	Pneumonia, organism NOS
6	7840	235	Headache
7	78605	235	Shortness of breath
8	7862	169	Cough
9	78659	164	Chest pain NEC
10	7295	154	Pain in limb

Abbreviations: ICD-9: International Classification of Diseases, Ninth Revision, NOS: Not otherwise specified; NEC: Not elsewhere classified

CHAPTER 2: STATISTICAL APPENDIX

Selection of regression models:

Because our outcome of interest was number of ED visits, which occur in nonnegative, integer-valued responses, it was natural to choose a count model. One of the most basic count models uses the Poisson distribution to model the data (naïve Poisson). However, this model has a key assumption that the conditional sample variance is equal to the mean[31]. In many data sets, this assumption is violated because there is overdispersion, in which the conditional sample variance is greater than the mean. In such cases, it is often necessary to use a different model. A likelihood-ratio test of α (which is a variance parameter to account for overdispersion) = 0 can be performed, and if this test is significant, it can be concluded that there is overdispersion. In these cases, a negative binomial model can be used in lieu of the Poisson model. In this dataset, the likelihood ratio test of $\alpha=0$ was significant ($p<0.001$), signifying that the negative binomial model is a better fit for this data.

A related aspect to overdispersion that needs to be taken into consideration is the possibility of zero inflation, i.e. if there are excess zeros beyond what can be explained by a Poisson or negative binomial distribution (those who have zero ED visits in this study). Since 54% of participants in this study had zero ED visits, it is likely that there are excess zeros. The distribution of ED visits in our study population can be seen in Figure 2. This distribution can be accounted for by using a modified Poisson model known as a zero-inflated Poisson regression (ZIPR) model. Zero-inflated models allow zero counts to come from two processes. A zero can come from an individual who does not use the ED for medical care, i.e. an individual in a "zero" state. A zero can also come from an individual who may visit the ED but did not do so during the data collection period. This process is generated from a Poisson distribution conditional on not being in the zero state. In the ZIPR model, the odds of being in the zero state modeled with a logistic (or probit) regression model, and the rates/counts of the outcome observations are modeled with a Poisson distribution for observations not classified in the zero state[21,32]. To formally test for excess zeros, one can use the Vuong test, which compares the ZIPR model with the naïve Poisson model. In this study, this test was performed and was highly significant ($z=19.07$, $p<0.0001$), suggesting the need for the ZIPR model instead of the naïve Poisson model. Finally, a similar zero-inflated negative binomial (ZINB) exists, which also models the odds of having zero outcomes using a logistic (or probit) regression model, but models the rate of the outcome using a negative binomial model. A similar test of $\alpha=0$ can be used to test for overdispersion to determine whether the ZIPR or ZINB model is preferred. In this study, although this likelihood ratio test was significant ($p<0.0001$), the final model used was the ZIPR model because the ZINB model had a number of covariates (data not shown) with very extreme estimates and standard errors, suggesting a poor fit. A comparison of all four models can be seen in Table 5. Ultimately, ZIPR seems to be the best model for the data in this study. Regardless, it is reassuring that direction and significance of the model estimates were fairly consistent despite the different models that were used, which suggests that the model estimates are robust. A possible exception are the ORs that appear to differ between the ZIPR and ZINB models and may reflect difficulties in model fit for the ZINB model.

Finally, an alternative way that excess zeros are often accounted for is by using a two-part model[33]. This model consists of a logit or probit model for the probability that an individual has an outcome (an ED visit in this case) and typically ordinary least squares regression (including any number of different distributions) applied only to the subsample with nonzero outcomes (i.e. ≥1 ED visit). Often the OLS portion is log-transformed to account for right skew, which is often present in health utilization data. One of the main assumptions of this model is conditional mean independence. In other words, conditional on ED visits being ≥1, the unobservable determinants of its log have zero mean[33]. This assumption usually requires that unobservable factors that influence the positive level of ED visits must be independent of those governing the probability of having any ED visits. Unfortunately, this assumption is often difficult to examine, as in our case of ED utilization. One's decision to go to the ED or not may be dictated by the same factors (for example an ongoing illness) that drive the intensity of ED visits (i.e. number of visits) given he/she utilizes the ED. The other drawback to the two-part model is that transformations are often necessary to appropriately model the nonzero values and call for re-transformation in order to interpret the model; re-transformation is not always straightforward. For these reasons, we favored the ZIPR model. To further demonstrate the robustness of this model, we performed two sensitivity analyses. In the first, we removed the two patients with the most extreme numbers of ED visits (129 and 151 visits), and in the second, we removed those who had the top 1% of ED visits (≥18). In both cases, the qualitative results of our analysis are unchanged (data not shown) with almost identical RR and OR estimates for the CHC variable, affirming the robustness of our model.

Propensity score:

Unlike a true experimental design, analyses of nonexperimental data or observational data often have to rely on alternate methods for estimating treatment effects. It is often not possible, practical, or ethical to complete studies of programs or treatments in a true experimental manner with randomization and controls, so several quasi-experimental methods have been developed to help estimate treatment effects in these contexts. One of the more commonly used methods involves creating a propensity score. Though there are various propensity score-based methods, they all share in common the creation of a propensity score, which is a way of estimating a subject's propensity or likelihood of being in the treatment or intervention group. This requires one to have variables that reliably predict a subject's likelihood or propensity of being in the treatment group. These multidimensional covariates that affect one's treatment group assignment can thus be reduced to a one-dimensional score known as a propensity score. Once the propensity score is created, it can be used to match those in the treatment and non-treatment groups based on propensity score, separate them into strata, or weight them based on propensity score. Through these methods, the treatment effect can be estimated, allowing researchers to move toward a more causal inference[34].

Because of the aforementioned reasons, propensity scoring could potentially be a useful technique to better identify treatment effect in our study. However, there have not been other studies of HIV-infected CHC-users; thus it is not known which characteristics truly distinguish CHC users from non-CHC users. It is not clear whether the current covariates actually predict one's propensity to use a CHC. The propensity score would thus be based purely on hypothesis. Furthermore, variables which would likely be most predictive of one's CHC status—distance from a CHC, for example—were not available. Because of these limitations, it was decided that a propensity score would not be the most beneficial in this application.

Moreover, the ultimate purpose of creating a propensity score is to allow us to adjust for how likely one is to be a CHC user. Further explorations of our dataset were performed to determine whether there was a concern some participants may not be "true" CHC users and to explore whether propensity scoring is conceptually necessary in this dataset. First, it could be argued that patients who only visited a CHC once during a year may have incidentally used a CHC, and were otherwise non-CHC users for the remainder of the year. This exploration revealed that 91.2% of CHC users had more than one CHC visit (Figure 3) and are true, regular CHC users. Alternatively, one can also examine the proportion of each subject's outpatient visits that took place at a CHC ("CHC proportion"). Though CHCs are places of comprehensive primary care, they often do not offer specialty services, which need to be referred to other providers outside of the center. In light of this, if we define a “true” CHC user as one who uses a CHC for at least 50% of their outpatient visits, we find similar results: 82.4% (n=2073) of CHC users are “true” CHC users. Figure 4 shows the distribution of participants by their CHC proportion. These exploratory analyses show that the vast majority of those that we have designated as CHC users are those who regularly use CHC services. This underscores the relevance of our definition of CHC status. From clinical and policy perspectives, it is easier to interpret the findings with the straightforward definition of CHC use that we have used. When a patient is seen in the clinic or when CHC users are considered in policy decisions, it is much more complicated to use propensity scoring to determine who are true CHC users.

Figure 2. Distribution of ED Visits among Participants in 2009 (n=6284)

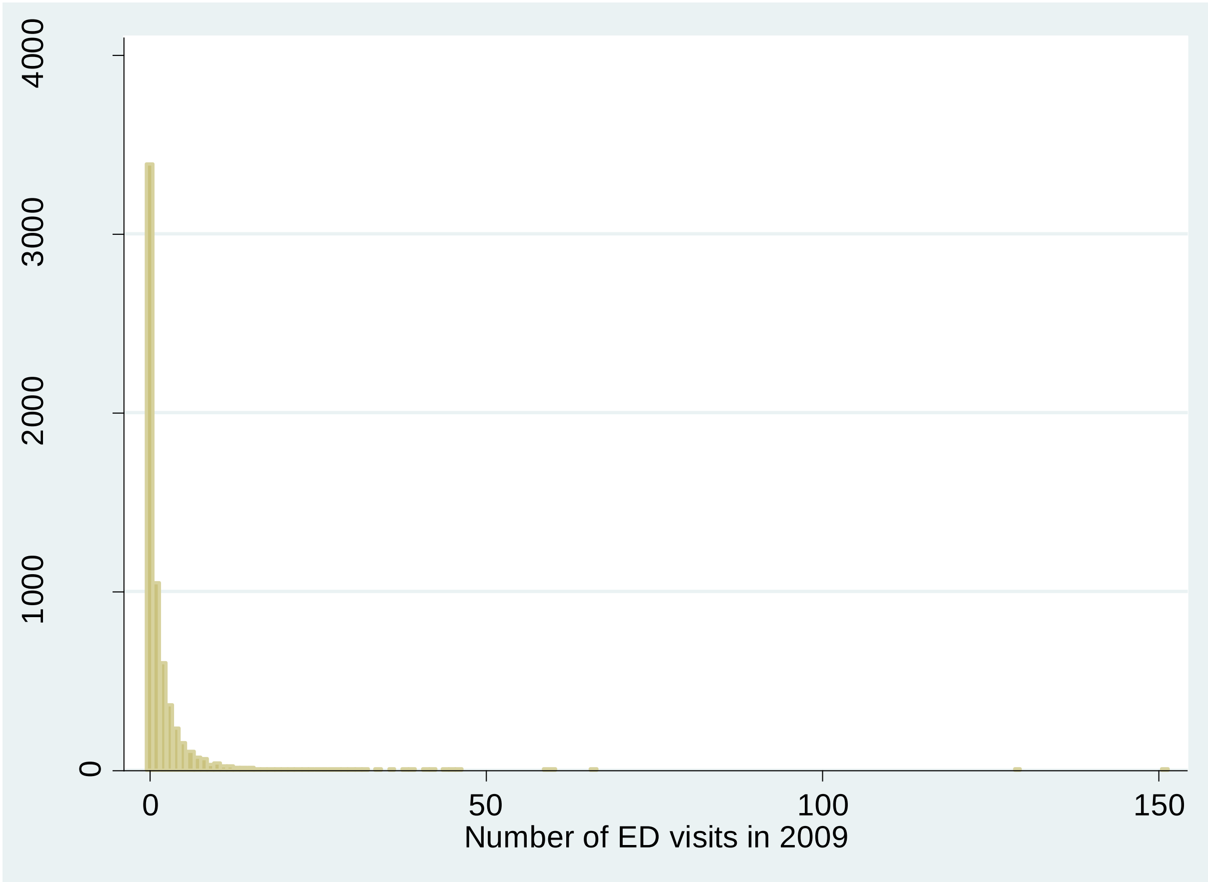


Table 5. Association Between CHC status and ED Visits in HIV-infected Medi-Cal Beneficiaries, 2009

	Model 1 Naïve Poisson		Model 2 Naïve Negative Binomial		**Model 3 Zero-Inflated Poisson**				Model 4 Zero-Inflated Negative Binomial			
CHC status:	RR (95% CI)	p-value	RR (95% CI)	p-value	OR (95% CI)	p-value	RR (95% CI)	p-value	OR (95% CI)	p-value	RR (95% CI)	p-value
Non-CHC	ref		ref		ref		ref		ref		ref	
CHC	1.05 (0.92-1.21)	0.462	1.11 (0.99-1.25)	0.062	1.09 (0.96-1.25)	0.193	1.01 (0.87-1.17)	0.893	0.89 (0.39-2.02)	0.780	1.13 (0.97-1.31)	0.126
No outpatient usage	0.93 (0.65-1.34)	0.708	0.96 (0.74-1.25)	0.775	0.94 (0.68-1.29)	0.699	0.97 (0.67-1.39)	0.856	1.16 (0.16-8.26)	0.883	0.96 (0.69-1.34)	0.815

Model also controls for age, gender, race, urban residence, ZIP code income, percent high school and college graduates in ZIP code, managed care, provider HIV volume, mental health diagnoses, substance abuse, tobacco use, medical comorbidities, and being on ART.
All models were performed with robust standard errors
Abbreviations: RR: Rate ratio, OR: Odds ratio, CI: Confidence interval

Figure 3: Distribution of Number of CHC Visits among CHC Users in 2008 (n=2516)

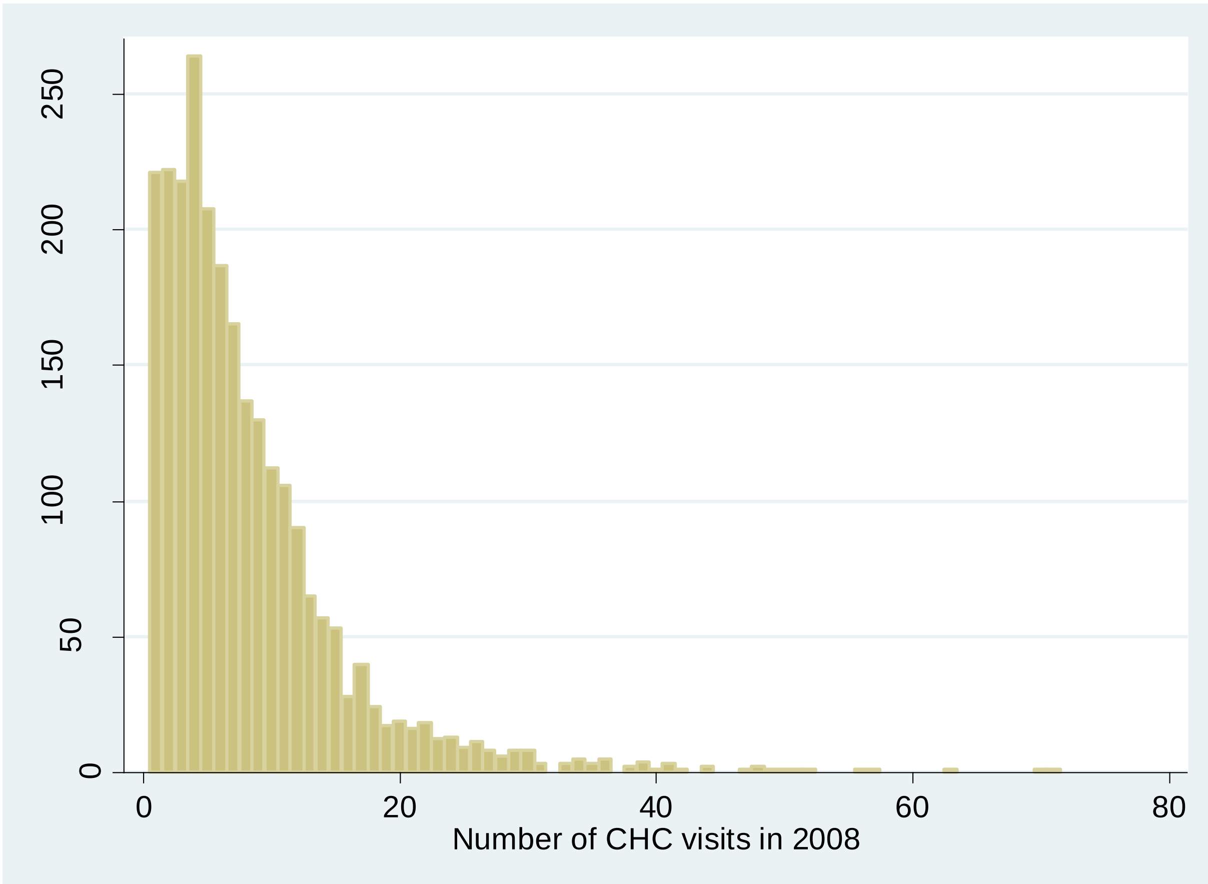
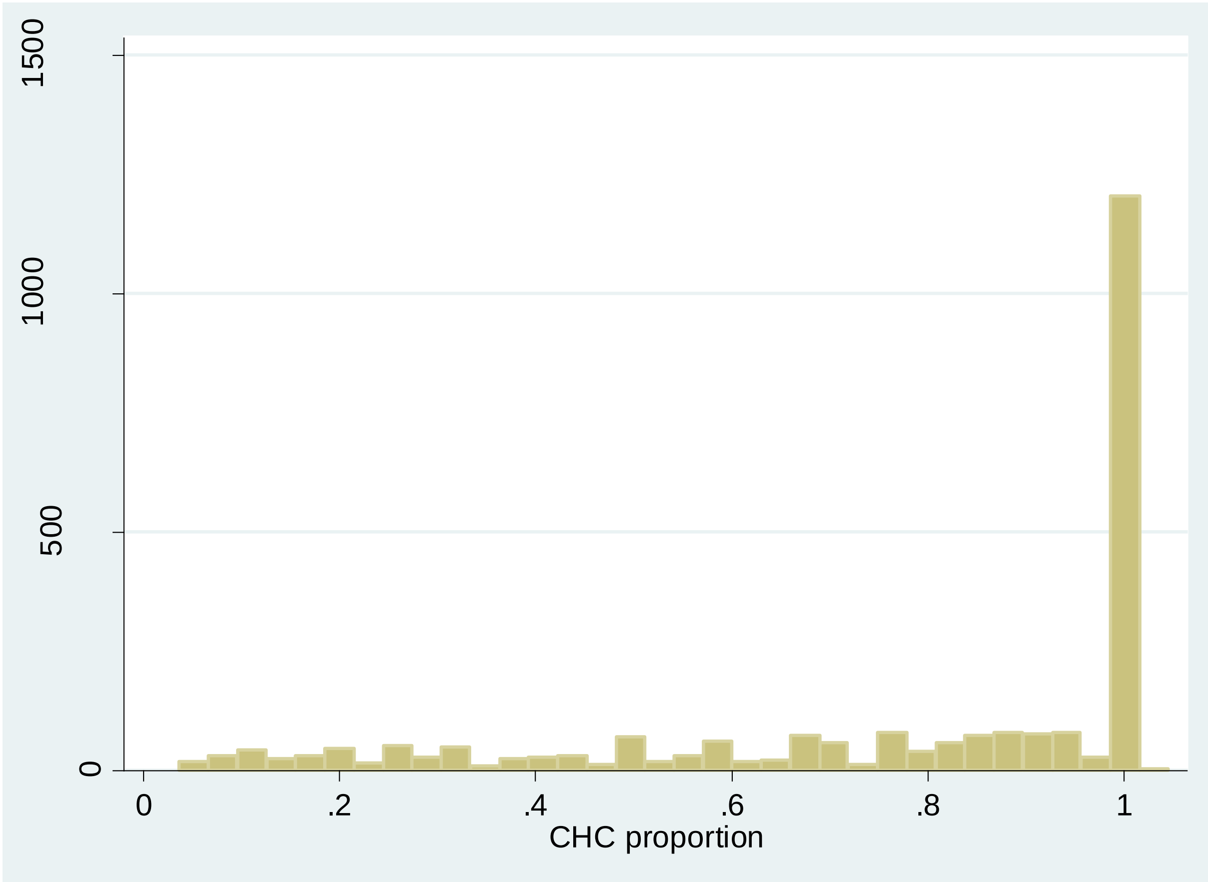


Figure 4. Proportion of Visits at CHCs among CHC Users in 2008 (n=2516)



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