AIDS and Behavior (2019) 23:459–474
https://doi.org/10.1007/s10461-018-2206-2

ORIGINAL PAPER

The Role of Religious Service Attendance, Psychosocial and Behavioral Determinants of Antiretroviral Therapy (ART) Adherence: Results from HPTN 063 Cohort Study

Yusuf Ransome[1,2] · Kenneth H. Mayer[3,4,5] · Kiyomi Tsuyuki[6] · Matthew J. Mimiaga[7] · Carlos E. Rodriguez-Diaz[8] · Kriengkrai Srithanaviboonchai[9] · Ruth K. Friedman[10] · Mohammed Limbada[11] · Steven A. Safren[12] · for the HIV Prevention Trials Network 063 Team

Published online: 28 June 2018

Abstract

Early and sustained antiretroviral therapy (ART) adherence can suppress the HIV virus in individuals and reduce onward transmission of HIV in the population. Religiosity has been associated with better HIV clinical outcomes. Data are from a longitudinal, observational study of 749 HIV-infected individuals from Brazil, Zambia, and Thailand (HPTN 063). Ordered logistic regression assessed whether religious service attendance was associated with ART adherence (self-reported and plasma HIV-RNA) and moderated the association between alcohol problems and ART adherence. In each country, > 80% of participants reported high self-reported ART adherence (good/very good/excellent). Religious service attendance exceeded 85% but was statistically unrelated to adherence. In combined-country models, ($p = 0.03$) as alcohol problems increased, the probability of high self-reported ART adherence, as well as viral-load, became weaker at higher compared to low service attendance frequency. Future studies should evaluate spirituality variables and replicate the moderation analyses between religious attendance and alcohol problems.

Keywords Religion · Antiretroviral therapy (ART) adherence · HPTN · Alcohol · HIV/AIDS

Resumen

La adherencia temprana y sostenida a la terapia antirretroviral (TAR) puede suprimir el virus del VIH en los individuos y reducir la transmisión del VIH en la población. La religiosidad se ha asociado con mejores resultados clínicos del VIH. Los datos provienen de un estudio observacional longitudinal de 749 individuos infectados con VIH de Brasil, Zambia y Tailandia (HPTN 063). La regresión logística ordenada evaluó si la asistencia al servicio religioso estaba asociada con la adherencia al TAR (autoreportado y el ARN del VIH en plasma) y moderaba la asociación entre los problemas del alcohol y la adherencia al TAR. En cada país, > 80% de los participantes reportaron un alto cumplimiento autoreportado de ART (bueno/muy bueno/excelente). La asistencia al servicio religioso excedió el 85%, pero estadísticamente no estuvo relacionada con la adherencia. En los modelos de países combinados, ($p = 0.03$) a medida que aumentaban los problemas de alcohol, la probabilidad de una alta adherencia autoreportada al TAR, así como la carga viral, se debilitó a una frecuencia de asistencia más alta en comparación con la baja. Los estudios futuros deberían evaluar las variables de espiritualidad y reproducir los análisis de moderación entre asistencia religiosa y problemas con el alcohol.

Introduction

More than 84% of the global population report being religiously involved [1]. Religion is a well-established social determinant of population health [2]: religiously involved individuals report fewer chronic diseases and tend to live longer [3, 4]. Religious involvement may therefore be a critical factor in addressing HIV/AIDS as a public health threat

✉ Yusuf Ransome
yusuf.ransome@yale.edu

Extended author information available on the last page of the article

[5]. In fact, two recent systematic reviews (2016 and 2017) reported that in more than 67% of studies analyzed, religiosity was associated with better HIV-related clinical outcomes, which included higher CD4 + cell count, higher quality of life, higher viral load, and lower mortality risk [6, 7].

With tremendous advancements in antiretroviral medication (ART), such as less toxicity in drugs with fewer side effects and improved tolerability [8], over time, ART has dramatically improved clinical outcomes among HIV infected individuals, such as fewer opportunistic infections and higher survival and quality of life [9–11]. Early initiation of ART reduced sexual transmission of HIV in serodiscordant couples by more than 96% [12, 13]. In one study among men and transgender women who have sex with men, when ART medication has been used as a Pre-Exposure Prophylaxis (PrEP), the result was a decrease in HIV incidence by 44% [14]. Early initiation of ART among all HIV infected individuals is now a cornerstone of treatment as prevention (TasP) globally [15].

Religious involvement may have positive impacts on health behaviors that prolong life for persons living with HIV [16, 17] since it is postulated to increase social support, help individuals cope, and improve self-esteem and a sense of purpose in life [18, 19]. Some studies found a protective association between religious beliefs and both self-reported and biomarker measures of ART adherence across adult and pediatric populations [20, 21]. For example, in a multivariable regression including religious factors, such as positive coping and religious attendance, praying daily or several times a day was significantly associated with higher self-reported ART adherence (≥ 90%) in a sample of adults living with HIV from a university-affiliated health center and AIDS service organizations in the Southeastern United States [22]. In one qualitative study of HIV-infected people from Papua New Guinea, participants expressed that faith in God was central to healing, and belief in faith also required them to be faithful in being adherent to ART, since ART was viewed as God's miracle to help people with HIV [23].

On the other hand, a competing hypothesis is that religious involvement can negatively impact ART adherence. For instance, some religious institutions may espouse stigmatizing views of HIV and/or persons living with HIV [24] and/or endorse doctrines that encourage seeking God/higher power as the primary source of healing instead of medications [25, 26]. Empirical findings reflect both hypotheses [7]. In contrast, other studies found a negative association [27] and some reasons included believing that HIV was a punishment from God [28].

Other possible reasons for the discrepancy in religion and ART adherence findings could be related to methodological differences in how religious involvement and ART were measured, as well as discrepancies in analytic approaches among studies [7]. For example, some studies used a binary indicator of service attendance to measure religious involvement [21] while other studies used established scales, or multiple items to form an index [27].

Next, we study social support as one focal variable in this study. Although substantial evidence documented that social support is associated with higher ART adherence [29, 30], studies have not yet directly tested whether it is a mediator between religious involvement and ART in populations from low-income settings.

Given that systematic reviews documented greater support for protective associations between religion and HIV clinical outcomes, including ART [6, 7], we hypothesize that higher religious involvement is associated with better ART adherence ability and mediated by higher social support.

In addition to the main effects of religion and ART, there are a number of moderators, such as gender and sexual orientation [31, 32] and religious tradition [27, 33], for which the magnitude of association between religious involvement and ART adherence could be weaker or stronger. While empirical studies are needed to assess the following, it is plausible that compared to heterosexuals, religious involvement might have a negative or weaker association with ART adherence for sexual minorities involved in a non-affirming church where levels of homophobia are high. Regarding gender, we think that because women attend church more frequently than men, they may internalize religious messages more readily, and are therefore more likely to translate teachings into actual behavior.

One gap in existing literature on religious involvement at ART adherence is the limited examination of potential mechanisms that link them. We posit that alcohol use is one potential mechanism. Evidence suggests that religious involvement is prospectively related to lower alcohol use problems, and lower consumption among those who drink [34, 35]. Problematic alcohol use can impede ART adherence [36–38] and increase the progression from HIV to AIDS [39] that heightens transmission risk in the population [40]. Findings from this study's cohort documented a 29% lower odds of ART adherence for each 10% increase in alcohol problems [41].

Alcohol use, however, is amendable to HIV prevention interventions [42] and if data obtained here show that religious involvement can buffer this association and indirectly affect ART adherence, incorporating religious involvement could play a useful part in a comprehensive secondary HIV prevention strategy. We hypothesize that the association between alcohol use problems and ART adherence would be weaker among individuals with higher levels of religious involvement.

Methods

Study Design and Participants

HPTN 063 was an observational, longitudinal year-long, multisite cohort study of HIV-infected individuals in care in Brazil (Rio De Janeiro), Thailand (Chiang Mai), and Zambia (Lusaka) [43]. HPTN 063 was designed as a preparedness study to acquire data to develop interventions to decrease sexual transmission by people living with HIV, and to determine whether the same interventions could be effectively deployed in patients from multiple risk groups and cultural settings. Participants aged 18 years and older were recruited if they were infected with HIV, engaged in HIV care (defined as at least two visits at a clinic or hospital in the past 9 months), or met criteria for sexual risk behavior in the past 12 months (e.g., history of condomless insertive penile, receptive vaginal, or anal intercourse with a sexual partner of unknown HIV status), including evidence of acquisition of a sexually transmitted infection in the past 12 months or anal intercourse without a condom [43]. Details of the study design, recruitment, and enrollment have been described in depth [41, 43]. A total of N = 749 participants were recruited across the three sites: Brazil: 263, Thailand: 300, and Zambia: 186. Our analytic sample included N = 647 participants (Brazil: 185, Thailand: 290, and Zambia: 172) who had no missing data from the outcomes, exposure, and covariates, which we describe below.

Ethical Approval

Institutional review boards (IRB) within each country approved the study. In Thailand, the IRB approvers were the Human Experimentation Committee of the Research Institute for Health Sciences at Chiang Mai University and the Johns Hopkins Bloomberg School of Public Health. In Zambia, the IRB approvers were the Zambian Ministry of Health, the University of Zambia, and the University of Alabama at Birmingham. In Brazil, the IRB approvers were the Evandro Chagas Clinical Research Institute and the National Committee for Ethics in Research. Each participant provided written informed consent, which was a part of the IRB protocol for each site.

Measures

ART adherence was assessed at baseline and each follow-up study visit among individuals on ART in the past 3 months. A single-item question with ordinal Likert-type response categories was used to measure self-reported ART adherence; prior research has documented this item as both a reliable and valid measure [44, 45]: "In the last 3 months, on average, how would you rate your ability to take all your ART as your doctor prescribed?" Response options were (very poor, poor, fair, good, very good, and excellent). Consistent with coding conventions used in a previous HPTN 063 study [46] and due to small sample size, the variable was recoded into three levels (0 = poor/very poor, 1 = fair, 2 = good/very good/excellent). High self-reported ART adherence refers to the category good/very good/excellent.

Plasma HIV-RNA viral load (copies/mL) within 6 months was obtained among a subset of individual medical records at baseline and subsequent study visits, which we used as a biomarker of ART adherence in sensitivity analysis. Only Brazil and Thailand at the time of the study tested for plasma HIV-RNA as part of routine care, so data are not available for Zambia.

Religious service attendance was the primary variable of interest. In our study, as with other studies not designed to study religion, it was the primary variable measured. It was assessed at baseline visit with a single-item question: "How often do you attend religious services?" Response options were (more than once a week, about once a week, a few times a month, about once a month, a few times a year, very rarely, and never). There is no consensus on how many categories to assess religious service attendance or how categories should be combined. For instance, one large scale study included three categories with never, less than once per week, and once or more than once per week [47]. Based on sample size considerations and the author's prior experience analyzing this variable [48], we derived a variable with four levels (1 = rarely/never, 2 = a few times a year, 3 = a few times a month/about once a month, 4 = about once a week/more than once a week).

We checked, in the combined-country sample, whether the categories combined in this collapsed variable differed in mean self-reported ART adherence by conducting Analysis of Variance (ANOVA) and investigating Tukey–Kramer (TK) pairwise comparisons for unequal group sizes, which adjusts for multiple comparisons. Lastly, we conducted sensitivity analysis by regressing ART adherence using the uncollapsed religious service attendance variable to examine the extent of any possible differences in magnitude of associations from the 4-level variable.

Other Variables of Interest

Effect modification by gender was assessed by categorizing the sample as men, women, and other (22 identified as transgender and 55 not as transgender).

Potential effect modification by religious tradition was also examined using the question: "What is your religion?" Response options were Afro-Brazilian, Buddhism, Christianity, Hinduism, Islam, Judaism, Spiritism/Kardecism,

indigenous religion, no religion, and other. Despite the various "other" groupings across country, Christianity and no-religion were recorded across all study sites, so we therefore recoded this into (Christianity vs. other vs. no religion).

Psychosocial and Behavioral Mechanisms

The first of two variables that are mechanisms that link religious service attendance with ART adherence was social support in the past 4 weeks, which was assessed using the Multidimensional Scale of Perceived Social Support (MSPSS), a 9-item measure that captures support across family, friends, and partners [49]. Example items include: I can talk about my problems with my family, my friends really try to help me, and there is a special person who is around when I am in need. Response options range from (1 = strongly disagree to 5 = strongly agree). The measure is summed with range of 0–45. The Cronbach's alpha for this sample was 0.839, which reflects good internal consistency. Three equal groups were also created using tertile cut points to indicate low, medium, and high social support.

The second variable was excessive alcohol use in the past 3 months, conceptualized as alcohol use problems. That variable was assessed using the Alcohol Use Disorders Identification Test (AUDIT), a 10-item measure that captures severity of alcohol use. Example items include questions of how many drinks containing alcohol one had on a typical day and how often one is not able to stop drinking once started [50]. The measure is summed with range from 0 to 40, where higher indicates greater problems and a score of 8 or more indicates an alcohol problem [50]. The Cronbach's alpha for the items in this sample was 0.738, which reflects acceptable internal consistency.

Other variables and covariates were age group (18–24, 25–44, 45 years and older), sexual orientation (heterosexual men, heterosexual woman, MSM), marital status (married vs. unmarried), employment (employed vs. unemployed), education (secondary school or greater vs. primary school vs. other), and self-rated health (excellent, very good, good, fair, and poor).

Statistical Analysis

Characteristics of the study sample at baseline across each study site, as well as the combined sample, was described using frequency distributions for categorical variables and means with standard deviations for continuous variables. Bivariate associations between each variable and ART adherence, across each site and for the combined sample, were estimated using ordinal logistic regression and the standard errors were corrected for clustering because participants attended multiple (n = 5) visits. We plotted the mean of self-reported ART attendance across study visits. Next, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The ORs indicate the probability of being in the highest category of ART adherence per one-unit change in the exposure variable, if continuous, or compared to the reference group, if categorical. Within each site, variables significant at $p < 0.25$ were included as potential covariates in the multivariable analyses [51]. We evaluated the interaction terms between gender and service attendance and between religious tradition and service attendance, but no interactions were statistically significant, therefore, we retained gender and religious tradition in the multivariable model as main effect variables.

We tested the sensitivity of the self-reported adherence measure by analyzing the continuous measure of plasma HIV-RNA viral load. We used a log10 transformation to correct for the right-skewed distribution and conducted ordinary least squares regression. Analyses were conducted separately for Brazil and Thailand because of wide variation in plasma levels between the two sites. Plasma data were not available in Zambia. Self-reported ART adherence was also included as a variable in regressions that examined the main and interaction associations involving religious service attendance and plasma HIV-RNA viral load.

We built the multivariable models by first examining, in country-specific models, the main associations of religious service attendance, and of religious service attendance by gender, and of religious service attendance by religious tradition on ART adherence. We then replicated those analyses in a combined-country model, but also added religious service attendance by country/study site interaction term. In each model, statistically significant covariates identified from the bivariate associations were included. We assessed the statistical significance of the effect modification (i.e., interaction terms) with a Wald Chi square test with degrees of freedom (df) (n − 1 level) and $p < 0.10$, which are not displayed in the tables. We selected a liberal alpha for significance testing because HPTN 063 was not powered to test interactions between religious service attendance and variables in association with ART adherence, and the presence of an interaction can go undetected without appropriate statistical power [52].

Indirect/Mediating and Moderating Effects of Psychosocial and Behavioral Mechanisms

Figure 1 is a conceptual model showing the relationships we investigated. First, we examined whether religious service attendance was associated with social support (path a), and then the indirect pathway from religious service attendance at baseline through social support in association with ART adherence at follow-up (paths a * b). Second, we examined whether religious service attendance buffered the negative

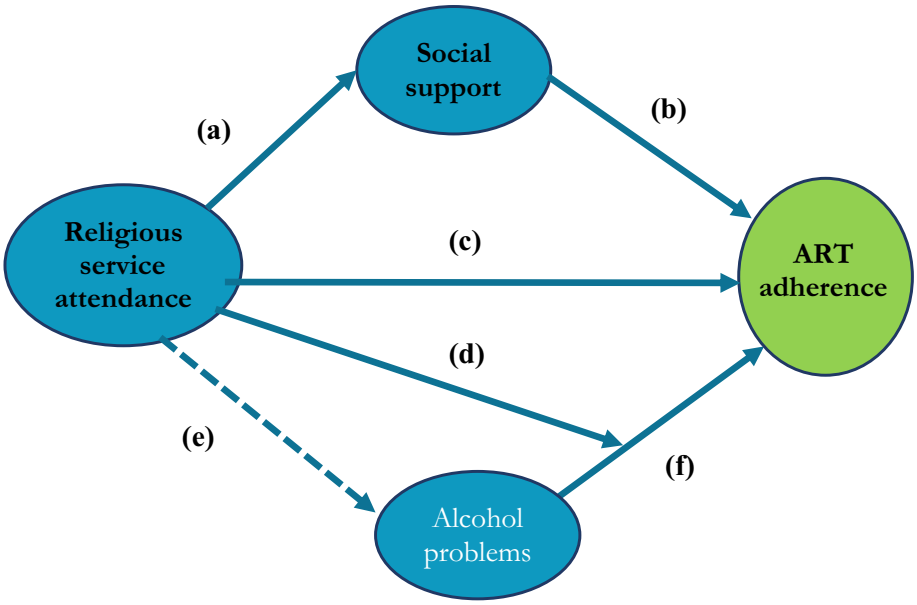

Fig. 1 Conceptual model showing the relationship among religious service attendance and the psychosocial and behavioral variables (social support and alcohol problems) and ART adherence in this study. When we fit the generalized structural equation models, we include covariates although they are not displayed in this figure. This study focused on paths a*b (indirect/mediating association), c (direct association), and d (effect modificationassociation)

associations between alcohol use problems and ART adherence (path d).

We conducted the indirect/mediating analysis (i.e., with social support) using Generalized Structural Equation Model (GSEM) because it can handle response variables with non-parametric distributions (e.g., binary, ordered, multinomial) and can provide a direct statistical test of coefficients from mediation analyses [53]. No evidence of mediation was found for social support so we include it as a variable but focused on the effect modification with alcohol problems. All statistical analyses were conducted using STATA v14.2 [54].

Results

Descriptives on Religious Involvement

Table 1 contains the descriptive results for the total sample and by country/study site. Among Brazilian participants, 85.5% reported attending religious services, 54% reported Christianity, and 27% reported other, which included Afro-Brazilian and Spiritism/Kardecism. Among Thai participants, 99.3% reported attending religious services, 4% reported Christianity, while 96% reported other, which was Buddhism. Among Zambian participants, 94.6% reported attending religious services, 93% reported Christianity, and 2% reported other, which was Islam and non-specified.

For the analysis that examined the potential sensitivity when using a 4-level collapsed version of each religious service attendance level (e.g., combining never with very rarely, once with few times per month, and once per week with greater than a week) compared to the original variable with 7-levels, statistical significance is assessed by comparing the mean difference to a Studentized range critical value of (0.05, 7, 640) = 4.18, where any TK-test value greater than 4.18 indicates a significant difference, based on the data of the entire combined-country study population.

The mean differences in self-reported ART adherence among those reporting never versus very rarely attending religious services were 0, with a TK-test value of 0, (i.e., they were not different). The mean difference in ART adherence between those reporting attending religious services a few times a month versus about once a month was 0.012, with a TK-test value of 0.44, and the difference between about once a week versus more than once a week was 0.102, with a TK-test value of 2.71. No TK-value was greater than 4.18, which indicates no significance difference between the categories that were combined (results not displayed). Sensitivity analysis with the original religious service attendance variable showed similar magnitude of associations as with the 4-level variable, so all results are reported using the collapsed version given the advantages of greater power and stability in multivariable analysis.

Descriptives on ART Adherence

High self-reported ART adherence (good/very good/excellent) versus low (fair/poor/very poor) was highest among Zambian participants (94.8%), followed by Brazilian participants (84.2%) and then Thai participants (83.8%). Plasma HIV-RNA viral load was only available in Brazil and Thailand. In Brazil, on average across all study periods, 21% of respondents had missing data on self-report ART adherence. However, among the 78 with missing self-reported ART adherence at baseline, 40% (n = 31/78)

Table 1 Characteristics of the study sample at baseline

	Brazil N = 263 N (%)	Thailand N = 300 N (%)	Zambia N = 186 N (%)	Combined N = 749 N (%)
Religious service attendance				
More than once per week	52 (19.77)	19 (06.33)	95 (51.08)	166 (22.16)
About once per week	36 (13.69)	33 (11.00)	47 (25.27)	116 (15.49)
A few times a month	22 (08.37)	74 (24.67)	05 (02.69)	101 (13.48)
About once per month	37 (14.07)	44 (14.67)	20 (10.75)	101 (13.48)
A few times a year	29 (11.03)	100 (33.33)	1 (00.54)	130 (17.36)
Very rarely	49 (18.63)	28 (09.33)	8 (04.30)	85 (11.35)
Never	38 (14.45)	2 (00.67)	10 (05.38)	50 (06.68)
Religious tradition				
Christianity	143 (54.37)	12 (04.00)	173 (93.01)	328 (43.79)
Other	70 (26.62)[a]	288 (96.00)[b]	4 (02.15)[c]	362 (48.33)
No religion	50 (19.01)	–	9 (04.84)	59 (07.88)
Age group				
18–24	20 (07.60)	11 (03.67)	04 (02.13)	35 (04.67)
25–44	196 (74.52)	208 (69.33)	141 (76.06)	545 (72.76)
45 >	47 (17.87)	81 (27.00)	41 (21.81)	169 (22.56)
Gender				
Man	160 (60.84)	120 (40.00)	86 (46.24)	366 (48.87)
Woman	101 (38.40)	103 (34.33)	100 (53.76)	304 (40.59)
Other	2 (00.76)	77 (25.67)[d]	–	79 (10.55)
Sexual identity				
Heterosexual man	64 (24.33)	100 (33.33)	86 (46.24)	250 (33.38)
Heterosexual woman	99 (37.64)	100 (33.33)	100 (53.76)	299 (39.92)
MSM	100 (38.02)	100 (33.33)	–	200 (26.70)
Marital status				
Married	48 (17.87)	151 (50.33)	134 (72.04)	330 (44.06)
Unmarried	216 (82.13)	149 (49.67)	52 (27.96)	419 (55.94)
Employment				
Employed	188 (71.48)	265 (88.33)	85 (45.70)	538 (71.83)
Unemployed	75 (28.52)	35 (11.67)	101 (54.30)	211 (28.17)
Education				
Secondary school or greater	151 (57.41)	135 (45.00)	107 (57.53)	393 (52.47)
Primary school	104 (39.54)	130 (43.33)	65 (34.95)	299 (39.92)
Other (none/technical)	8 (03.04)	35 (11.67)	14 (07.53)	57 (07.61)
Self-rated health				
Excellent	53 (20.31)	12 (04.00)	11 (05.91)	76 (10.17)
Very good	53 (20.31)	67 (22.33)	99 (53.23)	222 (29.72)
Good	72 (27.59)	144 (48.00)	54 (29.03)	270 (36.14)
Fair	51 (19.54)	72 (24.00)	20 (10.75)	143 (19.14)
Poor	29 (11.11)	5 (01.67)	2 (01.08)	36 (04.82)
Social support				
Low (IQR 25–31)	119 (45.25)	102 (34.00)	37 (19.89)	258 (34.45)
Medium (IQR 33–35)	52 (19.77)	68 (22.67)	40 (21.51)	160 (21.36)
High (IQR 36–40)	92 (34.98)	130 (43.33)	109 (58.60)	331 (44.19)
Continuous, M (SD)	32.45 (07.47)	33.82 (04.83)	35.11 (04.57)	33.66 (05.92)
Alcohol use problems				
No (AUDIT score ≤ 8)	192 (73.00)	214 (71.33)	156 (83.87)	562 (75.03)
Yes (AUDIT score > 8)	71 (27.00)	86 (28.67)	30 (16.13)	187 (24.97)

Table 1 (continued)

	Brazil N = 263 N (%)	Thailand N = 300 N (%)	Zambia N = 186 N (%)	Combined N = 749 N (%)
Continuous, M (SD)	5.97 (7.01)	5.54 (6.36)	3.24 (6.45)	5.12 (06.70)
Plasma HIV-RNA Viral Load[e], M (SD)	3145.73 (12, 957)	621.46 (4945)	–	1514 (8739)
Antiretroviral ART Adherence[f]				
Good/very good/excellent	156 (84.32)	243 (83.79)	163 (94.77)	562 (86.86)
Fair	22 (11.89)	42 (14.48)	7 (4.07)	71 (10.97)
Poor/very poor	7 (3.78)	5 (1.72)	2 (1.16)	14 (2.16)

MSM men who have sex with men, *AUDIT* alcohol use identification test, *M* mean, *SD* standard deviation, – data were not available in that category

[a]In Brazil (N = 30, Spiritism/Kardecism; N = 30 Afro-Brazilian; N = 4 Buddhism; N = 6 other)

[b]In Thailand (N = 285 Buddhism, N = 3 Islam)

[c]In Zambia (N = 2 Islam, N = 1 Spiritism/Kardecism, N = 1 other)

[d]Men who have sex with men where N = 22 report transgender, and N = 55 not transgender)

[e]Plasma Level (N = 390 combined, N = 138 Brazil, N = 252 Thailand, N = 0 in Zambia)

[f]Self-reported ART Adherence sample (N = 647 combined, N = 185 Brazil, N = 290 Thailand, N = 172 Zambia)

had plasma HIV-RNA viral load data. Among the 36 with missing self-reported ART adherence at 12-month follow-up, 50% (n = 18/36) had plasma HIV-RNA viral load data. The mean HIV-RNA viral load among Brazilian participants was 3145.73 copies/mL. At Baseline, mean HIV-RNA viral load was lower among those with self-reported ART adherence (2607.69 copies/ml), compared to those with missing self-reported ART adherence (5002.84 copies/ml), (z-score from Ranksum test = 6.57, p = 0.000, results not displayed). In Thailand, at baseline, only 10 individuals had missing data on self-reported ART adherence, but 99% of those with viral load data did self-report ART adherence. The mean viral load among Thai participants was 621.46 copies/ml.

When we used Spearman correlation test to examine the overall concordance between the self-reported ART adherence variable and a marker of virologic suppression (1 if viral load plasma HIV-RNA > 400 copies/ml, vs. 0 if else), the correlation coefficient rho was 0.18, p = 0.004 (results not displayed).

Figure 2 shows that most participants reported between modest (where 2 is fair) and high (where 3 is good/very good/excellent) self-reported ART adherence, which appeared stable over the five study visits. Self-reported ART adherence was highest in Zambia and lowest in Brazil.

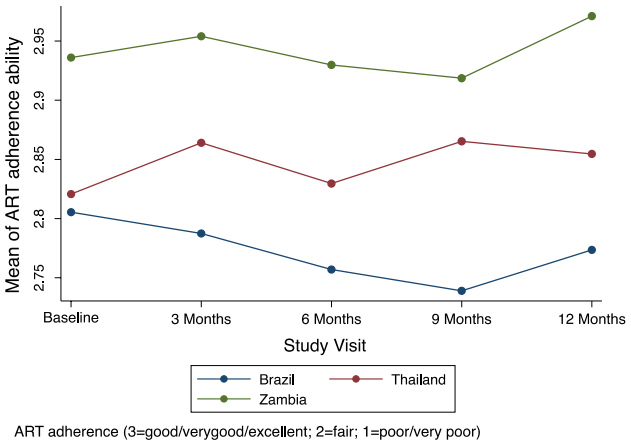

Fig. 2 Distribution of self-reported ART adherence across study visits by study country

Descriptives of Social Support and Alcohol Use Problems

The proportion of participants reporting high social support was 35% for Brazil, 43% for Thailand, and 57% for Zambia. The proportion of participants who met criteria for alcohol use problems (i.e., AUDIT score > 8) was 27% for Brazil, 29% for Thailand, and 16% for Zambia.

Bivariate Analyses Between Religious Involvement, Covariates, and ART Adherence

Table 2 contains the bivariate results of each study variable in association with self-reported ART adherence. Religious service attendance did not have significant independent associations with ART adherence in any country. In Brazil, heterosexual women had lower odds of (high vs. low) self-reported ART adherence (OR 0.51, 95% CI [0.30, 0.86], p = 0.01) compared to heterosexual men; as were those with only a primary school education (OR 0.56, 95% CI [0.33,

Table 2 Ordinal logistic regression assessing the bivariate association between study variables and antiretroviral ART adherence at follow-up

	Brazil N = 185 OR (95% CI)	Thailand N = 290 OR (95% CI)	Zambia N = 172 OR (95% CI)	Combined[a] N = 647 OR (95% CI)
Religious service attendance[b]				
Never/very rarely	Reference	Reference	Reference	Reference
A few times a year	0.98 (0.42, 2.26)	1.51 (0.68, 3.33)	0.15 (0.05, 0.44)	0.98 (0.56, 1.72)
Once/few times per month	0.94 (0.44, 1.99)	1.94 (0.87, 4.36)	0.58 (0.88, 1.19)	1.17 (0.67, 2.01)
Once per week or greater	0.60 (0.30, 1.18)	1.95 (0.81, 4.67)	0.67 (0.21, 2.14)	0.89 (0.53, 1.49)
Religious tradition				
Christianity	Reference	Reference	Reference	Reference
Other	1.12 (0.62, 2.03)	1.33 (0.56, 3.16)	NA	1.21 (0.74, 2.00)
No religion	0.69 (0.33, 1.44)	NA	1.51 (0.37, 6.14)	0.73 (0.37, 1.45)
Age group				
18–24	Reference	Reference	Reference	Reference
25–44	1.01 (0.38, 2.63)	2.47 (1.10, 5.54)		1.59 (0.87, 2.91)
45 >	1.11 (0.37, 3.33)	6.15 (2.54, 14.87)	0.68 (0.33, 1.42)	2.38 (1.22, 4.65)
Gender				
Man	Reference	Reference	Reference	Reference
Woman	0.51 (0.31, 0.86)	0.94 (0.56, 1.57)	1.08 (0.53, 2.20)	0.72 (0.51, 1.01)
Other	NA	0.82 (0.46, 1.48)	NA	0.73 (0.42, 1.26)
Risk group				
Heterosexual man	Reference	Reference	Reference	Reference
Heterosexual woman	0.50 (0.25, 1.00)	1.06 (0.63, 1.81)	1.08 (0.53, 2.20)	0.81 (0.56, 1.17)
MSM	0.73 (0.36, 1.45)	1.02 (0.59, 1.80)	NA	0.95 (0.63, 1.43)
Marital status				
Married	Reference	Reference	Reference	Reference
Unmarried	0.40 (0.20, 0.80)	0.83 (0.53, 1.30)	1.58 (0.66, 3.75)	0.5 (0.54, 1.03)
Employment				
Employed	Reference	Reference	Reference	Reference
Unemployed	1.14 (0.66, 1.97)	1.21 (0.68, 2.15)	0.65 (0.32, 1.30)	1.05 (0.72, 1.51)
Education				
Secondary school or greater	Reference	Reference	Reference	Reference
Primary school	0.56 (0.33, 0.95)	0.77 (0.47, 1.25)	1.50 (0.72, 3.12)	0.73 (0.53, 1.01)
Other (none/technical program)	0.81 (0.38, 1.72)	0.65 (0.30, 1.43)	4.42 (0.62, 31.68)	0.77 (0.42, 1.43)
Self-rated health	1.61 (1.33, 1.95)	2.35 (1.80, 3.08)	1.60 (1.04, 2.47)	1.83 (1.57, 2.13)
Social support				
Low (IQR 25–31)	Reference	Reference	Reference	Reference
Medium (IQR 33–35)	1.83 (1.01, 3.31)	1.26 (0.81, 1.96)	2.69 (0.83, 8.67)	1.51 (1.07, 2.10)
High (IQR 36–40)	1.32 (0.79, 2.20)	2.01 (1.27, 3.16)	2.62 (1.43, 4.77)	1.74 (1.27, 2.38)
Alcohol use problems				
No (AUDIT score ≤ 8)	Reference	Reference	Reference	Reference
Yes (AUDIT score > 8)	0.71 (0.44, 1.13)	0.58 (0.38, 0.88)	0.36 (0.17, 0.75)	0.59 (0.44, 0.80)

Modeled using ordinal logistic regression with 3 categories (3 = good/very good/excellent, 2 = fair, 1 = poor/very poor). Standard errors and 95% Confidence Intervals (CI) are adjusted for clustering of multiple visits over the study periods. ART Adherence is longitudinal. OR represents the probability of being in the highest category of ART adherence for a one unit change in the exposure variable if continuous, or compared to the reference group if categorical

OR odds ratio, *CI* confidence intervals, *IQR* inter quartile range, *NA* not estimated because fewer than five persons in any of the categories

[a]In the combined model, site is a covariate with Thailand set as the reference group

[b]Religious service attendance assessed at baseline

0.95], p = 0.03) compared to those with secondary education or greater; and those who were unmarried (OR 0.40, 95% CI [0.20, 0.80], p = 0.01) compared to those who were married. In Thailand, higher odds of (high vs. low) self-reported ART adherence was associated with being older than 24 years compared to those aged 18–24 years (OR 2.48, 95% CI [1.10, 5.54], p = 0.03). In Zambia, unemployed people had lower odds of (high vs. low) self-reported ART adherence (OR 0.65 95% CI [0.32, 1.31], p = 0.22) compared to those who were employed. Self-rated health was associated with greater odds of high self-reported ART adherence in all country/study sites, and in the combined-country model (all p < 0.05), which controlled for age group, marital status, education, and self-rated health.

Multivariable Association Between Religious Involvement and ART Adherence

Table 3 contains results from the multivariable models indirect/mediating models with social support via religious service attendance in association with ART adherence and effect modification on alcohol problems by religious service attendance in association with ART adherence. Religious service attendance was not independently associated with high self-reported ART adherence in Brazil, Thailand, or Zambia, or in the combined-country model. In the sensitivity analyses that used plasma HIV-RNA viral load for Brazil and Thailand, the results were in the same direction as with the self-reported measure (results not displayed).

Effect Modification Results by Gender and by Religious Tradition

There was no significant effect modification between religious service attendance by gender or by religious tradition, in association with self-reported ART adherence in the site specific or combined-country models (all p > 0.10). In the combined-country model, effect modification was observed between religious service attendance by study site according to our alpha p < 0.10 criteria, X^2 (df = 2) = 5.24, p = 0.073. Compared to participants in Thailand, those in Zambia had higher odds of ART adherence across the categories of religious service attendance: once/few times per month and once per week or greater (results not displayed).

Results from the Associations with the Psychosocial and Behavioral Mechanisms

In all countries, religious service attendance was not statistically associated with higher social support (all p > 0.05, results not displayed), so there was no indirect association according to a causal steps framework [55]. In terms of the main effect associations, among Brazilian participants, medium levels of social support (adjusted Odds Ratio, aOR 1.98; 95% CI [1.04, 3.75], p = 0.03) and among Thai participants (aOR 1.88; 95% CI [1.17, 3.03], p = 0.01) and Zambian participants (aOR 2.38; 95% CI [1.23, 4.62], p = 0.01), high levels of social support were associated with higher adjusted odds of (high vs. low) self-reported ART adherence.

In the combined-country model, religious service attendance significantly modified the association between alcohol use problems and self-reported ART adherence, X^2 (df = 3) = 9.15, p = 0.03. As alcohol use problems increased, the odds of (high vs. low) self-reported ART adherence was lower for those who reported attending religious services once/few times per month (aOR 0.94; 95% CI [0.88, 1.00], p = 0.04), and once per week or greater (aOR 0.92; 95% CI [0.86, 0.98], p = 0.01), compared to those who reported never/very rarely attending services.

Religious service attendance significantly modified the association between alcohol use problems and ART adherence in Brazil χ^2 (df = 3) = 6.25, p = 0.01. In Brazil, as alcohol problems increased (i.e., higher AUDIT scores), the odds of (high vs. low) self-reported ART adherence was weaker for those who reported attending religious services once/few times per month (aOR 0.92; 95% CI [0.85, 0.99], p = 0.03) and once per week or greater (aOR 0.91; 95% CI [0.84, 0.99], p = 0.02), compared to those who reported never/rarely attending services.

In Zambia, religious service attendance significantly modified the association between alcohol use problems and self-reported ART adherence, X^2 (df = 3) = 67.97, p = 0.00. In Zambia, as alcohol use problem scores increased, the odds of (high vs low) self-reported ART adherence was higher for those who reported attending a few times a year (aOR 1.51; 95% CI [1.30, 1.76], p = 0.00), compared to those who reported never/very rarely attending services.

Figure 3a, b, c illustrates the effect modification associations described above.

Sensitivity Analyses of the Relationship Between Religious Service Attendance and Using Plasma HIV-RNA Viral Load Indicator of ART Adherence

The directions and magnitudes associations from multivariable analyses using the viral load marker was consistent with the self-reported indicator of ART adherence.

In a combined-country model, as alcohol use problems increased, the plasma viral load was lower at once/few times per month ab = − 0.02; 95% CI [− 0.04, − 0.02], p = 0.02) and once per week or greater (ab = − 0.02; 95% CI [− 0.04, − 0.00], p = 0.04) compared to those reporting never/rarely attending services. In Brazil, as alcohol use problems increased, the plasma HIV-RNA viral load was lower at once/few times per month adjusted beta (ab) of Log10Plasma HIV-RNA (ab = − 0.04; 95% CI [− 0.07,

Table 3 Ordinal logistic regression assessing the multivariable association between religious service attendance at baseline and ART adherence at follow-up

	Brazil N = 185	Thailand N = 290	Zambia N = 172	Combined[a] N = 647
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Religious service attendance[b]				
Never/very rarely	Reference	Reference	Reference	Reference
A few times a year	1.40 (0.49, 4.05)	0.53 (0.18, 1.58)	0.00 (0.00, 0.1)	0.84 (0.41, 1.72)
Once/few times per month	1.18 (0.46, 3.03)	0.78 (0.26, 2.37)	0.18 (0.02, 1.51)	0.96 (0.47, 1.99)
Once per week or greater	0.71 (0.29, 1.73)	0.59 (0.18, 1.87)	0.23 (0.03, 1.65)	0.77 (0.39, 1.53)
Religious tradition				
Christianity	Reference	Reference	Reference	Reference
Other	1.06 (0.53, 2.13)	1.17 (0.49, 2.79)	NA	1.13 (0.69, 1.85)
No religion	0.47 (0.21, 1.05)	NA	NA	0.54 (0.26, 1.14)
Gender				
Men	Reference	Reference	Reference	Reference
Women	0.81 (0.58, 1.12)	1.14 (0.68, 1.91)	0.57 (0.23, 1.46)	0.81 (0.58, 1.12)
Other	NA	1.07 (0.58, 2.00)	NA	NA
Social support				
Low	Reference	Reference	Reference	Reference
Medium	1.98 (1.04, 3.75)	1.20 (0.76, 1.90)	2.44 (0.77, 7.79)	1.57 (1.06, 2.32)
High	1.08 (0.61, 1.92)	1.88 (1.17, 3.03)	2.38 (1.23, 4.62)	1.53 (1.09, 2.17)
Alcohol use problems[c]	1.02 (0.95, 1.08)	0.90 (0.83, 0.98)	0.89 (0.79, 1.01)	1.00 (0.95, 1.06)
Religious service attendance * alcohol use problems[d]				
Never/very rarely	Reference	Reference	Reference	Reference
A few times a year	0.95 (0.84, 1.06)	1.10 (1.00, 1.21)	1.51 (1.30, 1.76)	0.97 (0.91, 1.04)
Once/few times per month	0.92 (0.85, 0.99)	1.05 (0.95, 1.16)	1.12 (0.97, 1.30)	0.94 (0.88, 1.00)
Once per week or greater	0.91 (0.84, 0.99)	1.09 (0.95, 1.24)	1.03 (0.91, 1.17)	0.92 (0.86, 0.98)
Site				
Thailand				Reference
Brazil				0.97 (0.60, 1.56)
Zambia				3.07 (1.63, 5.79)

Modeled using ordinal logistic regression with 3 categories (3 = good/very good/excellent, 2 = fair, 1 = poor/very poor). Standard errors and 95% Confidence Intervals (CI) are adjusted for clustering of multiple visits over the study periods. ART Adherence is longitudinal. OR represents the probability of being in the highest category of ART adherence for a one-unit change in the exposure variable if continuous, or compared to the reference group if categorical

aOR adjusted odds ratios, *CI* confidence intervals, *NA* not estimated because fewer than five persons in one of the categories, and for Zambia, the parameter estimates for religious tradition was unstable when comparing Christian to other only, so the variable is not included in the multivariable analysis

[a]In the combined model, site is a covariate with Thailand set as the reference group

[b]Religious service attendance assessed at baseline

[c]Modeled continuously

[d]Represents the effect of religious service attendance at mean levels of alcohol problems, which is 5.12 on a scale of 0–32, where 8 is the AUDIT cut-point for high alcohol problems. Brazil model adjusted for sexual identity, marital status, education, and self-rated health. Gender in the Brazil model is male versus female. Thailand model adjusted for age, and self-rated health. Religious tradition in Thailand model is Christianity vs other. Zambia model adjusted for unemployment and self-rated health. Gender in the Zambia model is male versus female. Religious tradition in the Zambia is Christianity vs other, only. Combined model adjusted for age, marital status, education, self-rated health, and study site

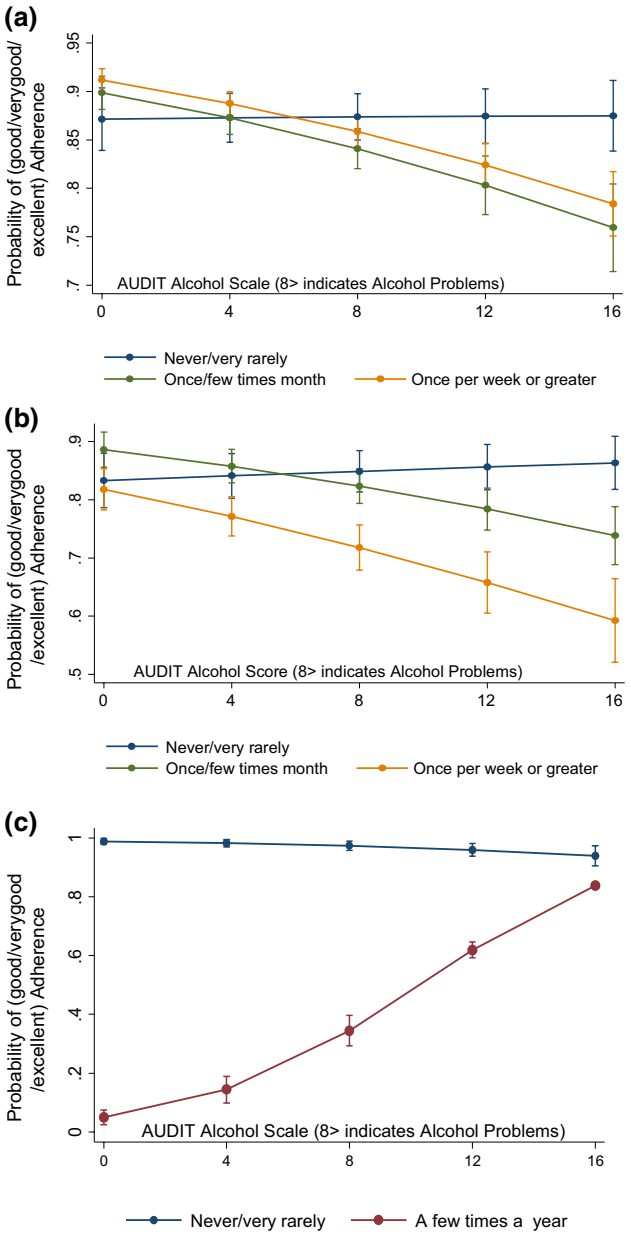

Fig. 3 Predicted probability of ART adherence and standard errors based on results from ordinal logistic multivariable models of **a** the combined country model, **b** Brazil, and **c** Zambia. Graphs depict how the association between alcohol problems ART adherence varies by frequency of religious service attendance. Comparisons are between the service attendance categories only that were statistically different from the reference group (never/very rarely). Each bar Y-axis has a different scale range because the range of probabilities will differ across models and graphs are not meant to be compared

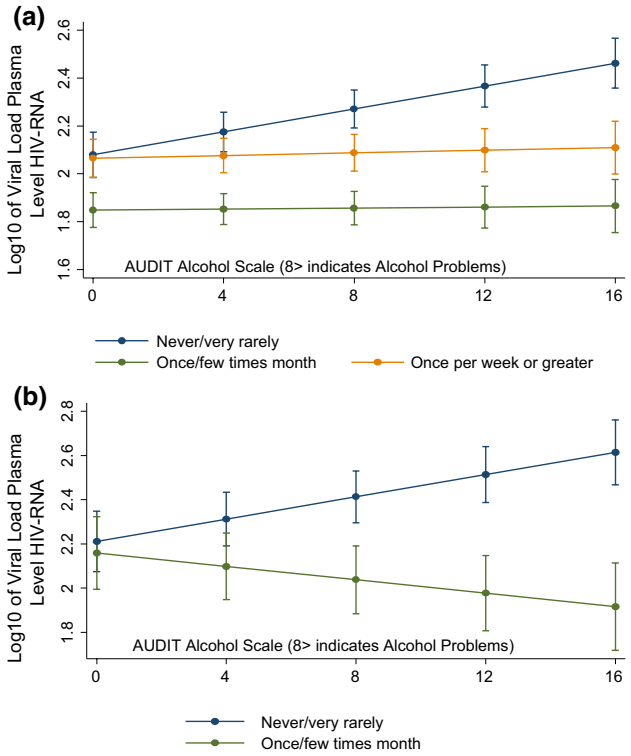

Fig. 4 Predicted levels of Plasma HIV-RNA viral load on the Log10 scale and standard errors based on multivariable models of **a** the combined country model, and **b** Brazil. Graphs depict how the association between alcohol problems ART adherence varies by frequency of religious service attendance. Comparisons are between the service attendance categories only that was statistically different from the reference group (Never/very rarely). Each bar Y-axis has a different scale range because the range of probabilities will differ across models and graphs are not meant to be compared

−0.01], p = 0.01) compared to those who reported never/rarely attending services.

Figure 4a, b illustrate the effect modification associations described above for the plasma HIV-RNA viral load marker.

Discussion

We examined the association between religious involvement and ART adherence, and whether any link is influenced via social support and alcohol use. This study advances the topic by evaluating (a) the potential indirect/mediating association of social support between religious service attendance and ART adherence, and (b) effect modification association of alcohol problems by religious service attendance on ART adherence.

We hypothesized that any health promoting relationship would be mediated by higher social support. Problematic alcohol use worsens clinical outcomes among people with HIV [39]. Many religious traditions—even those that allow alcohol consumption—stigmatize and to some extent sanction problematic/unhealthy levels of alcohol use [56, 57]. Alternately, persons religiously involved may practice moderate alcohol use since religious doctrines generally promote healthy behaviors [19]. Empirical studies have documented that alcohol use problems have been shown to

be lower among HIV-infected people who are religiously involved [58]. We therefore hypothesized that the association between alcohol use problems and ART adherence would be weaker among people with higher frequency of religious involvement.

We found that in Brazil, Thailand, and Zambia, more than 85% of this sample reported some religious services attendance. Most participants (83%) reported high ART adherence (good/very good/excellent). Despite high frequency of religious service attendance, results from multivariable models indicated no statistically significant relationships between service attendance and either self-reported ART adherence or viral load plasma HIV-RNA.

Next, we examined effect modification, given that prior evidence found that main effect associations might not be present due to effect modification by gender or by religious tradition [31, 33]. We did not find support for effect modification by either variable on the association between religious service attendance and ART adherence. We are unclear why gender did not play a role here, but for religious tradition, it could be related to the crude categorization of Christianity versus other versus no-religion. For instance, one study among HIV-infected persons in Uganda examined a wider range of traditions (e.g., Protestant, Catholic, Muslim, Pentecostal) and found that Pentecostal and Muslim participants had higher religious behavior scores and higher ART adherence [33]. The authors then surmised that higher levels among those two traditions reflect an ethos in those faiths where parishioners are encouraged by their religious leaders to attend services and worship more frequently than parishioners of the other traditions in the study [33].

Religion-health theory posits that social support is one mechanism that links attending services to health and to HIV clinical outcomes [16, 19]. We hypothesized a mediating role if any association was found between attendance and ART adherence, which has not sufficiently been assessed in prior studies. Social support in some countries had a main effect association. We found that a medium level and high level of social support (relative to lower levels), in Brazil and Zambia, respectively, were significantly associated with better ART adherence. Relative to Zambia, a medium level of social support to achieve higher ART adherence in Brazil might be related to ART medication being more widely available and adopted earlier in the epidemic [59], and thus ART use may be more normalized in Brazil. However, our hypothesis was not supported as these associations did not operate via religious service attendance. We speculate that one reason social support was not a significant mediator could reflect the broad and vague nature of the measure used in this study, in contrast to HIV-specific social support indicators [60] with direct questions about social support for helping with medication adherence or religious-based social support scales with direct questions about support from leaders or others in the congregation [61]. It is also possible that relevant confounding variables between social support and ART adherence (for instance, self-efficacy) were omitted or that the association holds for some subgroups across age, sexual orientation and gender [60], or that people derived social support from other sources besides religion, which can include sex-partners, families, and communities.

There is strong evidence that alcohol use problems are lower among individuals with higher religious involvement [34, 35, 62]. Our hypothesis that association between alcohol problems and ART adherence would be weaker at higher levels of religious service attendance was not supported. Instead we observed an opposite direction of association using both self-reported ART use and plasma HIV-RNA viral load indicators. Specifically, in Brazil and in a combined-country model, the highest frequencies of religious service attendance (compared to never/rarely attending) were associated with lower likelihood of ART adherence as alcohol problems increased. Substance use, including problematic alcohol use, was related to lower ART adherence [63, 64] and higher STI incidence and HIV transmission risk in the HPTN 063 cohort [43]. In one independent sample of persons in HIV outpatient care in Rio Grande, Brazil, the prevalence of unhealthy alcohol use prevalence among people living with HIV was 29% [65]. Within that context, the effect modification findings on ART adherence could mean that the higher exposure of the religious environment through service attendance may create a stigmatizing environment for persons struggling with alcohol problems and could possibly result in negative coping strategies [16], including not taking their ART medications.

In Zambia, we found a different pattern where, as alcohol problems increased, the odds of ART adherence among those attending religious services a few times a year was higher compared to those who never or rarely attend, however, we are unsure about why that phenomenon occurred in that context. Nonetheless, the effect modification analyses should be replicated within other settings before we draw any major conclusions.

The study has some limitations. We used religious service attendance at baseline as a predictor of ART adherence at follow-up. However, while individuals were all HIV-infected at enrollment, our data could not discern temporality as a function of the clinical course of HIV or adherence. There is some evidence of temporal patterns in both directions between religious involvement and HIV prevalence, as well as HIV-related risk and protective behaviors in the population [66, 67]. Next, service attendance was the primary measure of religious involvement, which is one component of religious experiences. Other religious involvement measures, such as spirituality, deal with personal and non-organizational aspects of religiosity [68], and have independent protective effects on health

[69]. For instance, spirituality was shown to improve coping among individuals newly diagnosed or living with HIV over time [70], and was prospectively associated with better clinical HIV outcomes, such as lower plasma HIV-RNA viral load [71]. Religious service attendance was very high in our sample, however, there is no gold-standard or objective ways to measure attendance besides self-reporting, so we are unable to assess potential social reporting bias.

An indicator for individuals prescribed but not using ART was not available, so such individuals would be coded as not adherent. In Brazil, while across 12 months, an average of 21% of respondents were missing data on self-reported ART adherence, among those same persons, plasma HIV-RNA viral load data was recorded for more than 50% of them at 12-month follow-up. Nevertheless, we found similar directions of associations between religious service attendance by alcohol problems regardless of the ART adherence measure used, so we have greater confidence in the consensus of our findings. Religious service attendance was self-reported, and the prevalence of any attendance in our study was higher than the range of worldwide estimates documenting that more than eight in ten persons are religiously involved [1]. Next, although the main exposure was self-reported ART adherence, and the prevalence was high because this was a sample in HIV care, the biological markers of ART adherence results were in the same direction and similar magnitude. Consequently, results may not be generalizable to HIV-infected individuals in the general population.

Despite the overall study limitations, our study contributes to a growing body of empirical research demonstrating that measures of religious involvement are associated with HIV-clinical outcomes related to TasP [6]. Antiretroviral medication is the cornerstone of TasP worldwide [15] and over 84% of individuals worldwide identify with a religious group, so religiosity could be important for HIV care and prevention. While we did not find any main effect associations between service attendance or interactions with religious denominations on ART, future studies should examine other religious involvement measures such as prayer, religious beliefs, spirituality, the role of healers, and ecological factors such as community level stigma.

We did observe an effect modification association with alcohol use problems in Brazil and Zambia, but not in a healthy or beneficial way, which is important for considering religious-based HIV care or treatment interventions. Our findings suggest that for those with alcohol problems, higher frequency of attendance could be associated with worse ART adherence. Prior work documented that some religious institutions may endorse doctrines that compete with medical models of care, such as relying on spiritual powers for care instead of medications [25, 26]. Other evidence suggests a view of HIV as a punishment from God [28].

In conclusion, research on the role of religiosity and spirituality-based HIV care and treatment interventions for people living with HIV have been increasing [31]. While religious involvement generally is associated with better HIV clinical outcomes [6], in some settings such as Brazil, it may be a potential barrier for people living with HIV and unhealthy alcohol use. Therefore, in HIV care in this setting, clinicians should ascertain data on religious involvement beyond frequency of attendance, including data on the denomination type to tailor recommendations for treating alcohol use problems and promoting ART adherence.

Funding Yusuf Ransome received funding from research grant from the National Institutes of Health/National Institute of Allergy and Infectious Diseases (Grant Number UM1 A1068619). HPTN 063 was funded by the Division of AIDS (DAIDS), National Institute of Allergy and Infectious Disease (NIAID), National Institute on Drug Abuse (NIDA) and the National Institute of Mental Health (NIMH) under Cooperative Agreement # UM1AI068619. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or The HIV Prevention Trials Network. Steven A. Safren time was also supported by the National Institutes of Health (NIH) research Grant (9K24DA040489). Yusuf Ransome time was also supported by the National Institute of Mental Health research Grant (K01MH111374). Kiyomi Tsuyuki time was supported by the National Institute of Alcohol Abuse and Alcoholism (K01AA025009).

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval Ethnical considerations reviewed and approved by institutional review boards (IRB) within each recruitment country.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Pew Research Center. The global religious landscape: a report on the size and distribution of the world's major religious groups as of 2010 Washington, DC: Pew Research Center. 2012. http://www.webcitation.org/query?url=http%3A%2F%2Fwww.pewforum.org%2F2012%2F12%2F18%2Fglobal-religious-landscape-exec%2F&date=2017-04-03. Accessed 4 Mar 2017.
2. Idler EL, editor. Religion as a social determinant of public health. New York: Oxford University Press; 2014.
3. Williams DR, Sternthal MJ. Spirituality, religion and health: evidence and research directions. Med J Aust. 2007;186(10):S47–50.
4. Nelson JM. Religion, spirituality, and physical health. In: Nelson JM, editor. Psychology, religion and spirituality. New York: Springer; 2009. p. 311–47.
5. Muñoz-Laboy M, Garcia J, Moon-Howard J, Wilson PA, Parker R. Religious responses to HIV and AIDS: understanding the role of religious cultures and institutions in confronting the epidemic. Glob Public Health. 2011;6(sup2):S127–31.

6. Doolittle BR, Justice AC, Fiellin DA. Religion, spirituality, and HIV clinical outcomes: a systematic review of the literature. AIDS Behav. 2016. https://doi.org/10.1007/s10461-016-1651-z.
7. Medved Kendrick H. Are religion and spirituality barriers or facilitators to treatment for HIV: a systematic review of the literature. AIDS Care. 2017;29(1):1–13.
8. Trickey A, May MT, Vehreschild J-J, Obel N, Gill MJ, Crane HM, et al. Survival of HIV-positive patients starting antiretroviral therapy between 1996 and 2013: a collaborative analysis of cohort studies. Lancet HIV. 2017;4(8):e349–56.
9. Murphy EL, Collier AC, Kalish LA, et al. Highly active antiretroviral therapy decreases mortality and morbidity in patients with advanced HIV disease. Ann Intern Med. 2001;135(1):17–26.
10. Rai S, Mahapatra B, Sircar S, Raj PY, Venkatesh S, Shaukat M, et al. Adherence to antiretroviral therapy and its effect on survival of HIV-infected individuals in Jharkhand, India. PLoS ONE. 2013;8(6):e66860.
11. Kakinami L, de Bruyn G, Pronyk P, Mohapi L, Tshabangu N, Moshabela M, et al. The impact of highly active antiretroviral therapy on activities of daily living in HIV-infected adults in South Africa. AIDS Behav. 2011;15(4):823–31.
12. Cohen MS, Chen YQ, McCauley M, Gamble T, Hosseinipour MC, Kumarasamy N, et al. Prevention of HIV-1 infection with early antiretroviral therapy. N Engl J Med. 2011;365(6):493–505.
13. Grinsztejn B, Hosseinipour MC, Ribaudo HJ, Swindells S, Eron J, Chen YQ, et al. Effects of early versus delayed initiation of antiretroviral treatment on clinical outcomes of HIV-1 infection: results from the phase 3 HPTN 052 randomised controlled trial. Lancet Infect Dis. 2014;14(4):281–90.
14. Grant RM, Lama JR, Anderson PL, McMahan V, Liu AY, Vargas L, et al. Preexposure chemoprophylaxis for HIV prevention in men who have sex with men. N Engl J Med. 2010;363(27):2587–99.
15. Günthard HF, Saag MS, Benson CA, Del Rio C, Eron JJ, Gallant JE, et al. Antiretroviral drugs for treatment and prevention of HIV infection in adults: 2016 recommendations of the International Antiviral Society–USA panel. JAMA. 2016;316(2):191–210.
16. Pargament KI, McCarthy S, Shah P, Ano G, Tarakeshwar N, Wachholtz A, et al. Religion and HIV: a review of the literature and clinical implications. South Med J. 2004;97(12):1201–10.
17. Bazant ES, Boulay M. Factors associated with religious congregation members' support to people living with HIV/AIDS in Kumasi, Ghana. AIDS Behav. 2007;11(6):936–45.
18. Levin JS. Religion and health: is there an association, is it valid, and is it causal? Soc Sci Med. 1994;38(11):1475–82.
19. Ellison CG, Levin JS. The religion-health connection: evidence, theory, and future directions. Health Educ Behav. 1998;25(6):700–20.
20. Park J, Nachman S. The link between religion and HAART adherence in pediatric HIV patients. AIDS Care. 2010;22(5):556–61.
21. Van Wagoner N, Elopre L, Westfall AO, Mugavero MJ, Turan J, Hook EW. Reported church attendance at the time of entry into HIV care is associated with viral load suppression at 12 months. AIDS Behav. 2016;20(8):1706–12.
22. Dalmida SG, McCoy K, Koenig HG, Miller A, Holstad MM, Thomas T, et al. Examination of the role of religious and psychosocial factors in HIV medication adherence rates. J Relig Health. 2017;56(6):2144–61.
23. Kelly-Hanku A, Aggleton P, Shih P. I shouldn't talk of medicine only: biomedical and religious frameworks for understanding antiretroviral therapies, their invention and their effects. Glob Public Health. 2017. https://doi.org/10.1080/17441692.2017.1377746.
24. Bluthenthal RN, Palar K, Mendel P, Kanouse DE, Corbin DE, Derose KP. Attitudes and beliefs related to HIV/AIDS in urban religious congregations: barriers and opportunities for HIV-related interventions. Soc Sci Med. 2012;74(10):1520–7.
25. Wanyama J, Castelnuovo B, Wandera B, Mwebaze P, Kambugu A, Bangsberg DR, et al. Belief in divine healing can be a barrier to antiretroviral therapy adherence in Uganda. AIDS. 2007;21(11):1486–7.
26. Finocchario-Kessler S, Catley D, Berkley-Patton J, Gerkovich M, Williams K, Banderas J, et al. Baseline predictors of ninety percent or higher antiretroviral therapy adherence in a diverse urban sample: the role of patient autonomy and fatalistic religious beliefs. AIDS Patient Care STDS. 2011;25(2):103–11.
27. Vyas KJ, Limneos J, Qin H, Mathews WC. Assessing baseline religious practices and beliefs to predict adherence to highly active antiretroviral therapy among HIV-infected persons. AIDS Care. 2014;26(8):983–7.
28. Tumwine C, Neema S, Wagner G. Reasons why high religiosity can co-exist with and precipitate discontinuation of antiretroviral therapy among different HIV clients in Uganda: an exploratory study. Religions. 2012;3(3):817–32.
29. Pichon LC, Rossi KR, Ogg SA, Krull LJ, Griffin DY. Social support, stigma and disclosure: examining the relationship with HIV medication adherence among Ryan White Program Clients in the Mid-South USA. Int J Environ Res Public Health. 2015;12(6):7073–84.
30. Kumarasamy N, Safren SA, Raminani SR, Pickard R, James R, Krishnan AKS, et al. Barriers and facilitators to antiretroviral medication adherence among patients with HIV in Chennai, India: a qualitative study. AIDS Patient Care STD. 2005;19(8):526–37.
31. Szaflarski M. Spirituality and religion among HIV-infected individuals. Curr HIV/AIDS Rep. 2013;10(4):324–32.
32. Parsons SK, Cruise PL, Davenport WM, Jones V. Religious beliefs, practices and treatment adherence among individuals with HIV in the southern United States. AIDS Patient Care STDs. 2006;20(2):97–111.
33. Kisenyi R, Muliira J, Ayebare E. Religiosity and adherence to antiretroviral therapy among patients attending a public hospital-based HIV/AIDS clinic in Uganda. J Relig Health. 2013;52(1):307–17.
34. Borders TF, Curran GM, Mattox R, Booth BM. Religiousness among at-risk drinkers: is it prospectively associated with the development or maintenance of an alcohol-use disorder? J Stud Alcohol Drugs. 2010;71(1):136–42.
35. Lambert NM, Fincham FD, Marks LD, Stillman TF. Invocations and intoxication: does prayer decrease alcohol consumption? Psychol Addict Behav. 2010;24(2):209–19.
36. Parsons JT, Rosof E, Mustanski B. The temporal relationship between alcohol consumption and HIV-medication adherence: a multilevel model of direct and moderating effects. Health Psychol. 2008;27(5):628–37.
37. Sileo KM, Simbayi LC, Abrams A, Cloete A, Kiene SM. The role of alcohol use in antiretroviral adherence among individuals living with HIV in South Africa: event-level findings from a daily diary study. Drug Alc Depend. 2016;167:103–11.
38. Kahler CW, Liu T, Cioe PA, Bryant V, Pinkston MM, Kojic EM, et al. Direct and indirect effects of heavy alcohol use on clinical outcomes in a longitudinal study of HIV patients on ART. AIDS Behav. 2016;21(7):1825.
39. Williams EC, Hahn JA, Saitz R, Bryant K, Lira MC, Samet JH. Alcohol use and Human Immunodeficiency Virus (HIV) infection: current knowledge, implications, and future directions. Alcohol Clin Exp Res. 2016;40(10):2056–72.
40. Hahn JA, Woolf-King SE, Muyindike W. Adding fuel to the fire: alcohol's effect on the HIV epidemic in Sub-Saharan Africa. Curr HIV/AIDS Rep. 2011;8(3):172.
41. Magidson J, Li X, Mimiaga M, Moore A, Srithanaviboonchai K, Friedman R, et al. Antiretroviral medication adherence and amplified HIV transmission risk among sexually active HIV-infected

individuals in three diverse international settings. AIDS Behav. 2015. https://doi.org/10.1007/s10461-015-1142-7.
42. Kalichman SC, Simbayi LC, Vermaak R, Cain D, Smith G, Mthebu J, et al. Randomized trial of a community-based alcohol-related HIV risk-reduction intervention for men and women in Cape Town South Africa. Ann Behav Med. 2008;36(3):270–9.
43. Safren SA, Hughes JP, Mimiaga MJ, Moore AT, Friedman RK, Srithanaviboonchai K, et al. Frequency and predictors of estimated HIV transmissions and bacterial STI acquisition among HIV-positive patients in HIV care across three continents. J Int AIDS Soc. 2016;19(1):21096.
44. Feldman B, Fredericksen R, Crane PK, Safren S, Mugavero M, Willig JH, et al. Evaluation of the single-item self-rating adherence scale for use in routine clinical care of people living with HIV. AIDS Behav. 2013;17(1):307–18.
45. Lu M, Safren SA, Skolnik PR, Rogers WH, Coady W, Hardy H, et al. Optimal recall period and response task for self-reported HIV medication adherence. AIDS Behav. 2008;12(1):86–94.
46. Ojikutu BO, Pathak S, Srithanaviboonchai K, Limbada M, Friedman R, Li S, et al. Community cultural norms, stigma and disclosure to sexual partners among women living with HIV in Thailand, Brazil and Zambia (HPTN 063). PLoS ONE. 2016;11(5):e0153600.
47. VanderWeele TJ, Li S, Tsai AC, Kawachi I. Association between religious service attendance and lower suicide rates among US women. JAMA Psychiatry. 2016;73(8):845–51.
48. Ransome Y, Gilman SE. The role of religious involvement in black-white differences in alcohol use disorders. J Stud Alc Drugs. 2016;In Press.
49. Zimet GD, Powell SS, Farley GK, Werkman S, Berkoff KA. Psychometric characteristics of the multidimensional scale of perceived social support. J Pers Assess. 1990;55(3–4):610–7.
50. Saunders JB, Aasland OG, Babor TF, De la Fuente JR, Grant M. Development of the alcohol use disorders identification test (AUDIT). WHO collaborative project on early detection of persons with harmful alcohol consumption-II. Addiction. 1993;88:791–804.
51. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source Code Biol Med. 2008;3(1):17.
52. Jaccard J, Wan CK, Turrisi R. The detection and interpretation of interaction effects between continuous variables in multiple regression. Multivar Behav Res. 1990;25(4):467–78.
53. Gunzler D, Chen T, Wu P, Zhang H. Introduction to mediation analysis with structural equation modeling. Shanghai Arch Psychiatry. 2013;25(6):390–4.
54. StataCorp. Stata statistical software: Release 14.0. College Station: StataCorp LP; 2015.
55. Kenny DA. Mediation 2016. http://www.webcitation.org/query?url=http%3A%2F%2Fdavidakenny.net%2Fcm%2Fmediate.htm&date=2017-01-31. Accessed 31 Jan 2017.
56. Miller WR. Researching the spiritual dimensions of alcohol and other drug problems. Addiction. 1998;93(7):979–90.
57. McGrath J. A glutton and a drunkard: what would Jesus drink? In: Robertson KC, editor. Religion and alcohol: Sobering thoughts. New York: Peter Lang Publishing Inc; 2004. p. 11–44.
58. Adong J, Lindan C, Fatch R, Emenyonu NI, Muyindike WR, Ngabirano C, et al. The relationship between spirituality/religiousness and unhealthy alcohol use among HIV-infected adults in Southwestern Uganda. AIDS Behav. 2017. https://doi.org/10.1007/s10461-017-1805-7.
59. AVERT.org. HIV and AIDS in Brazil United Kingdom, 2017. http://www.webcitation.org/query?url=https%3A%2F%2Fwww.avert.org%2Fprofessionals%2Fhiv-around-world%2Flatin-america%2Fbrazil%23Barriers%2520to%2520HIV%2520prevention%2520in%2520Brazil&date=2018-03-27. Accessed 27 Mar 2018.
60. Qiao S, Li X, Stanton B. Social support and HIV-related risk behaviors: a systematic review of the global literature. AIDS Behav. 2014;18(2):419–41.
61. Fiala WE, Bjorck JP, Gorsuch R. The religious support scale: construction, validation, and cross-validation. Am J Commun Psychol. 2002;30(6):761–86.
62. Cochran JK, Beeghley L, Bock EW. Religiosity and alcohol behavior: an exploration of reference group theory. Sociol Forum. 1988;3(2):256–76.
63. Malow R, Dévieux JG, Stein JA, Rosenberg R, Jean-Gilles M, Attonito J, et al. Depression, substance abuse and other contextual predictors of adherence to antiretroviral therapy (ART) among Haitians. AIDS Behav. 2013;17(4):1221–30.
64. Blashill AJ, Bedoya CA, Mayer KH, O'Cleirigh C, Pinkston MM, Remmert JE, et al. Psychosocial syndemics are additively associated with worse ART adherence in HIV-infected individuals. AIDS Behav. 2015;19(6):981–6.
65. da Silva CM, Mendoza-Sassi RA, da Mota LD, Nader MM, de Martinez AMB. Alcohol use disorders among people living with HIV/AIDS in Southern Brazil: prevalence, risk factors and biological markers outcomes. BMC Infect Dis. 2017;17:263.
66. Goodman MS. Comparison of small-area analysis techniques for estimating prevalence by race. Prev Chronic Dis. 2010;7(2):A33.
67. Trevino KM, Pargament KI, Cotton S, Leonard AC, Hahn J, Caprini-Faigin CA, et al. Religious coping and physiological, psychological, social, and spiritual outcomes in patients with HIV/AIDS: cross-sectional and longitudinal findings. AIDS Behav. 2010;14(2):379–89.
68. Zinnbauer BJ, Pargament KI, Cole B, Rye MS, Butter EM, Belavich TG, et al. Religion and spirituality: unfuzzying the fuzzy. J Sci Study Relig. 1997;36(4):549–64.
69. Powell LH, Shahabi L, Thoresen CE. Religion and spirituality: linkages to physical health. Am Psychol. 2003;58(1):36–52.
70. Tarakeshwar N, Khan N, Sikkema KJ. A relationship-based framework of spirituality for individuals with HIV. AIDS Behav. 2006;10(1):59–70.
71. Ironson G, Stuetzle R, Fletcher MA. An increase in religiousness/spirituality occurs after HIV diagnosis and predicts slower disease progression over 4 years in people with HIV. J Gen Intern Med. 2006;21(S5):S62–8.

Affiliations

Yusuf Ransome[1,2] · Kenneth H. Mayer[3,4,5] · Kiyomi Tsuyuki[6] · Matthew J. Mimiaga[7] · Carlos E. Rodriguez-Diaz[8] · Kriengkrai Srithanaviboonchai[9] · Ruth K. Friedman[10] · Mohammed Limbada[11] · Steven A. Safren[12] · for the HIV Prevention Trials Network 063 Team

[1] Department of Social and Behavioral Sciences, Yale School of Public Health, 60 College Street, LEPH 4th Floor, New Haven, CT 06510, USA

[2] Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, USA

[3] The Fenway Institute, Fenway Health, Boston, MA, USA

[4] Department of Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA

[5] Harvard Medical School, Boston, MA, USA

[6] Division of Global Public Health, School of Medicine, University of San Diego, San Diego, CA, USA

[7] Department of Social and Behavioral Sciences, Brown University School of Public Health, Providence, RI, USA

[8] University of Puerto Rico School of Public Health, San Juan, PR, USA

[9] Faculty of Medicine, and Research Institute for Health Sciences, Chiang Mai University, Chiang Mai, Thailand

[10] Instituto de Pesquisa Clinica Evandro Chagas, Rio de Janeiro, Brazil

[11] Zambart, Lusaka, Zambia

[12] Department of Psychology, University of Miami, Coral Gables, FL, USA