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DOI: 10.1111/tmi.13654

RESEARCH ARTICLE

HIV care and treatment models and their association with medication possession ratio among treatment-experienced adults in three African countries

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Abstract

Objective: How clinics structure the delivery of antiretroviral therapy (ART) services may influence patient adherence. We assessed the relationship between models of HIV care delivery and adherence as measured by medication possession ratio (MPR) among treatment-experienced adults in Tanzania, Uganda and Zambia.

Methods: Eighteen clinics were grouped into three models of HIV care. Model 1-Traditional and Model 2-Mixed represented task-sharing of clinical services between physicians and clinical officers, distinguished by whether nurses played a role in clinical care; in Model 3-Task-Shifted, clinical officers and nurses shared clinical responsibilities without physicians. We assessed MPR among 3,419 patients and calculated clinic-level MPR summaries. We then calculated the mean differences of percentages and adjusted residual ratio (aRR) of the association between models of care and incomplete adherence, defined as a MPR <90%, adjusting for individual-level characteristics.

Results: In the adjusted analysis, patients in Model 1-Traditional were more likely than patients in Model 2-Mixed to have MPR <90% (aRR = 1.60, 95% CI 1–2.48). Patients in Model 1-Traditional were no more likely than patients in Model 3-Task-Shifted to have a MPR <90% (aRR = 1.58, 95% 0.88–2.85). There was no evidence of differences in MPR <90% between Model 2-Mixed and Model 3-Task-Shifted (aRR = 0.99, 95% CI 0.59–1.66).

Conclusion: Non-physician-led ART programmes were associated with adherence levels as good as or better than physician-led ART programmes. Additional research is needed to optimise models of care to support patients on lifelong treatment.

KEYWORDS
antiretroviral therapy, HIV/AIDS, medication adherence, Tanzania, Uganda, Zambia

Sustainable Development Goal: Good health and well-being

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INTRODUCTION

Country adoption of WHO's recommendation to task-shift antiretroviral therapy (ART) services has contributed to the rapid scale-up of HIV care and treatment in sub-Saharan Africa. In eastern and southern Africa, the number of ART patients had increased from 625,500 in 2005 [1] to 15 million by 2019 [2]. Task-shifting involves the redistribution of health tasks by extending the scope of practice for existing health workers (e.g. allowing nurses to prescribe ART) or creating auxiliary cadres to substitute for health professionals (e.g. creation of adherence support workers to provide clinic-based adherence counselling or expert patients to relieve nurses of administrative tasks, such as patient file retrieval and clinic navigation) [3]. Another form of redistributing tasks is task-sharing, whereby a team of health cadres provide differentiated care for patients depending on the severity of illness [4]. For example, clinical officers and nurses may be tasked with monitoring stable patients, while physicians manage patients with complex opportunistic infections or chronic diseases. Task-shifting and task-sharing allows for limited human resources for health to be strategically deployed for differentiated service delivery of ART for people living with HIV [5–7].

Previous studies have examined the impact of discrete aspects of task-shifting/task-sharing of ART on virologic failure [8–12] and mortality [8,9,11], but just two of these examined the impact on patient adherence. One study in Zambia compared how patients counselled by lay or professional staff varied in self-reported adherence in the past 3 days [13]. Another study in a clinical trial context in Uganda compared ART pill counts 6–12 months after ART initiation among patients in a nurse-peer counsellor model of care (including home visits) versus a physician-centred model of care [10]. Neither study found evidence of significance difference in adherence outcomes.

While existing studies provide a strong evidence base for task-shifting and task-sharing of ART services, they often focus narrowly on a limited range of services, including ART prescription, management and adherence counselling. To more comprehensively identify models of care, we previously conducted a cluster analysis and Delphi survey to describe healthcare staffing of comprehensive ART services in 19 health facilities in Tanzania, Uganda and Zambia [14]. The analysis identified three models of care: Model 1-Traditional, where major clinical responsibilities were shared between physicians and clinical officers; Model 2-Mixed, where major clinical responsibilities were shared between physicians, clinical officers and nurses; and Model 3-Task-Shifted, where clinical officers and nurses completed all major clinical duties, while lay health workers facilitated ancillary services. These models of care were further characterised by environmental factors (e.g. health facility level, urban/rural setting, government/non-profit status) and programme characteristics (e.g. ART refill schedule, adherence support strategies and alternatives to clinic-based ART distribution).

Objective

Here, we assess the relationship between these three models of care and ART adherence using the ART medication possession ratio (MPR) measure – a validated adherence measure predictive of virologic failure [15–18]. Our objectives were to assess the association between task-shifting/task-sharing models of care and the MPR in the past 6 months, and to determine whether any association remains after adjusting for individual patient-level factors.

METHODS

Design and setting

We used cross-sectional data from an ART retention and adherence study conducted in Tanzania, Uganda and Zambia led by FHI 360 (2008–2012). The parent study's purpose was to characterise retention and adherence rates in 19 ART clinics and to examine programmatic and individual factors related to adult retention and adherence [16]. Clinics were purposefully selected with country stakeholders to include those with ≥300 patients from different urban–rural locations with varying characteristics, including public/private/faith-based organisations, primary/secondary/tertiary-levels and different ART adherence and provision strategies [16,19]. Eligible patients were at least 18 years old at ART initiation, had initiated ART at least 6 months prior to data collection and spoke one of the study languages. Participants were systematically sampled, and if a patient was ineligible, unwilling or unavailable, the study team selected the next ART patient attending the clinic. All participants underwent a screening and consent process by trained interviewers. Interviewers also abstracted data from the patient's medical, pharmacy and laboratory records using structured data abstraction forms. Data collection from patients and medical chart abstractions took place in 2011. Information on the 19 ART clinics' task-shifting/task-sharing characteristics was collected in a cross-sectional survey with ART clinic managers in 2010–2011.

Measures

Participant adherence, the dependent variable, was assessed by medication possession ratio (MPR). MPR is based on pharmacy refill data and has been shown to significantly correlate with virologic failure among adults [16]. The MPR summarised the number of pills dispensed to participant in the 6 months prior to the interview divided by the total number of pills the participant should have received during that time [16]. The MPR was dichotomised into <90% or ≥90%; this cut-off was selected based on a previous analysis relating adherence measures to virologic failure and receiver operating characteristic analysis with HIV RNA at least 1,000 copies/ml as the reference standard [16].

Task-shifting/task-sharing models of care, the independent variable, was constructed by cluster analysis described

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elsewhere [14]. Other variables included individual-level factors relevant to patient adherence to ART: demographic variables including sex, marital status and household wealth index; psychosocial variables including internalised stigma, stigma against HIV disclosure, depressive symptoms, social support assistance, alcohol abuse, HIV-related traditional healer/herbalist visits, average cost and average time to reach the HIV clinic; and clinical variables including current ART regimen, time on ART, daily pill burden, self-reported HIV symptoms in the past four weeks, pre-ART WHO stage and pre-ART CD4 cell count [16]. We did not include country as a covariate because we accounted for clustering at the health facility level and this should sufficiently cover higher-level clustering, particularly when country-level differences are experienced at the health facility level.

Cluster-level analysis

We assessed the association between task-shifting model of care and patient MPR using generalised estimating equations to account for intra-cluster correlation in the data at the health facility level. The mean differences of percentages of MPR <90% and 95% confidence intervals (CI) were computed for each model of care compared to each other model (e.g. model-1 minus model-2). Each difference was assessed with a Student *t*-test and the corresponding 95% CI for the mean difference.

Adjusted residual ratios (aRRs) were calculated by generating standardised clinic-level summaries. aRRs were calculated as the ratio of observed to expected outcomes predicted by fitting a logistic regression model on individual-level data with the MPR <90% as the dependent variable [20]. The final logistic regression included all independent variables that were significantly associated with MPR <90% ($p < 0.05$) in the bivariate analysis (Table 2). Independent variables included age, household wealth, internalised stigma against HIV, potential depression, time to clinic, current ART regimen, time on ART, pill burden and pre-ART CD4 cell count. Statistical significance was assessed with the Student *t*-test on the sets of logarithms of the aRRs of the two models being compared, and corresponding 95% CIs, and then exponentiating to obtain an aRR.

Subgroup analyses were performed by ART duration (<5.3 or ≥5.3 years). Significance tests of interaction were conducted between ART duration and task-shifting/task-sharing model of care. Statistical analyses were performed using SAS/STAT Version 9 (SAS Institute, Cary, NC, USA).

All patients and ART managers provided written informed consent prior to data collection, and the study was approved by seven Institutional Review Boards.

RESULTS

Characteristics of ART clinics and participating patients by task-shifting/task-sharing model and by MPR <90% outcome are summarised in Tables 1a–1c and Table 2, respectively.

Characteristics of ART clinics

Eighteen ART facilities had the MPR outcome and were included in the analysis. Of these, seven were in Tanzania, six in Uganda and five in Zambia. The 18 facilities were diverse in health facility level (4 national referral hospitals, 8 provincial or district hospitals and 5 primary health centres), management (9 government, 5 faith-based missions and 4 non-profit, non-religious organisations) and size (5 sites with <1,000 ART patients, 3 with 1,000–2,000 patients, 7 with 2,000–4,000 patients and 3 with >4,000 patients). Most facilities were based in urban locales (14 urban, 4 rural) (Table 1a).

Staffing patterns for each model are summarised in Table 1b. Only nurse/midwife and ART counsellors were assigned to provide adherence counselling in Model 1-Traditional as compared to Model 2-Mixed and Model 3-Task-Shifted where a wider range of staff, including medical officer, clinical officer, nurse/midwife, ART counsellor, dispenser and lay or expert patients, were engaged to provide adherence counselling. For tracing of patients who have missed appointments or defaulted, all three models primarily relied on lay or expert patients to provide this service (Table 1b).

Programmatic details for each model are summarised in Table 1c. Notable differences in programmatic factors included number of counselling sessions required before ART initiation, routine pill counts during ART adherence counselling, community-based distribution of ART and frequency of ART refill schedule. 40% of clinics in Model 1-Traditional required ≥3 pre-ART counselling sessions vs. 90% of clinics in Model 2-Mixed and 75% clinics in Model 3-Task-Shifted (Table 1c). 60% of clinics in Model 1-Traditional conducted routine pill counts for patients on ART vs. 89% of clinics in Model 2-Mixed and 75% of clinics in Model 3-Task-Shifted (Table 1c). 30% of clinics in Model 2-Mixed and 25% of clinics in Model 3-Task-Shifted offered community-based distribution of ART vs. 0% in Model 1-Traditional (Table 1c). Finally, 40% clinics in Model 1-Traditional offered 2 or more months of ARV drug refills for stable patients who had been on ART for 6 months or longer vs. 78% of clinics in Model 2-Mixed and 50% clinics in Task-Shifted (Table 1c).

Characteristics of study participants

Overall, 3,419 participants were eligible for analysis. Of these, 73% (2,496/3,419) were 35 years or older at the time of the interview; 67% (2,282/3,419) were female. Only 25% (859/3,419) had been on ART for less than 2.2 years (Table 2). Overall, 25% of patients (842/3,411) attended Model 1-Traditional clinics, 54% (1,843/3,411) attended Model 2-Mixed clinics, and 21% (726/3,411) attended Model 3-Task-Shifted clinics. Patients with <90% MPR were significantly younger, wealthier and needed more time to travel to the clinic than patients who achieved better MPR (Table 2). Patients with <90% MPR also reported significantly greater levels of internalised or self-stigma living with HIV, positive screening for depression, higher pill burden, and were more

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TABLE 1A Contextual characteristics of the ART clinics in 2011, by the 3 task-shifting/task-sharing models of care

Model of service delivery	Country	Facility level	Managing authority	Number of current ART patients	Urban or rural	Number of providers on a typical clinic day				
						# medical officer	# clinical officer	# nurse/ midwife	# lay worker	# total
1-traditional (n = 5 clinics)	Tanzania	Nat Ref	Mission	1,000–2,000	Urban	3	3	2	0	8
	Tanzania	Nat Ref	Mission	<1,000	Urban	5	0	3	0	8
	Tanzania	District	Government	2,000–4,000	Urban	3	2	10	2	17
	Uganda	Nat Ref	NPNR	>4,000	Urban	7	0	8	4	17
	Zambia	Nat Ref	Government	2,000–4,000	Urban	3	1	2	2	8
2-mixed (n = 9 clinics)	Tanzania	Provincial	Mission	1,000–2,000	Urban	1	2	3	2	8
	Tanzania	District	Government	<1,000	Rural	2	2	1	1	6
	Uganda	PHC	NPNR	2,000–4,000	Urban	1	2	3	5	11
	Uganda	PHC	Mission	2,000–4,000	Urban	4	1	12	0	17
	Uganda	PHC	NPNR	2,000–4,000	Urban	2	5	5	4	16
	Uganda	PHC	NPNR	2,000–4,000	Urban	1	1	3	0	5
	Zambia	District	Mission	>4,000	Urban	1	2	3	3	9
	Zambia	District	Government	<1,000	Rural	3	5	1	2	11
	Zambia	Provincial	Government	>4,000	Urban	1	2	5	1	9
3-task-shifted (n = 4 clinics)	Tanzania	District	Government	<1,000	Rural	0	1	3	0	4
	Tanzania	Provincial	Government	1,000–2,000	Urban	0	2	9	1	12
	Uganda	District	Government	<1,000	Rural	0	1	6	8	15
	Zambia	PHC	Government	2,000–4,000	Urban	0	2	4	1	7

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TABLE 1B Staffing patterns of the ART clinics in 2011 by the 3 task-shifting/task-sharing models of care

Tasks, by cadre	Model 1: traditional (*n* = 5 clinics)	Model 2: mixed (*n* = 9 clinics)	Model 3: task-shifted (*n* = 4 clinics)
Registration			
Medical officer	0 (0%)	1 (11%)	0 (0%)
Clinical officer	0 (0%)	1 (11%)	1 (25%)
Nurse/midwife	3 (60%)	2 (22%)	2 (50%)
ART counsellor	0 (0%)	4 (44%)	0 (0%)
Phlebotomist	0 (0%)	1 (11%)	0 (0%)
Dispenser	0 (0%)	1 (11%)	1 (25%)
Records clerk	2 (40%)	2 (22%)	1 (25%)
Lay or expert patient	1 (20%)	5 (56%)	1 (25%)
Initial ART prescription			
Medical officer	5 (100%)	8 (89%)	0 (0%)
Clinical officer	2 (40%)	8 (89%)	4 (100%)
Nurse/midwife	0 (0%)	4 (44%)	3 (75%)
ART monitoring & management			
Medical officer	5 (100%)	9 (100%)	0 (0%)
Clinical officer	2 (40%)	8 (89%)	4 (100%)
Nurse/midwife	2 (40%)	3 (33%)	3 (75%)
Dispenser	0 (0%)	0 (0%)	1 (25%)
Laboratory technician	0 (0%)	0 (0%)	1 (25%)
Lay or expert patient	1 (20%)	0 (0%)	0 (0%)
Adherence counselling	[a](*n* = 4)		
Medical officer	0 (0%)	3 (33%)	0 (0%)
Clinical officer	0 (0%)	3 (33%)	1 (25%)
Nurse/ midwife	2 (50%)	7 (78%)	2 (50%)
ART counsellor	2 (50%)	6 (67%)	2 (50%)
Dispenser	0 (0%)	3 (33%)	1 (25%)
Lay or expert patient	0 (0%)	3 (33%)	0 (0%)
ART dispensing	[a](*n* = 4)		
Nurse/midwife	1 (25%)	4 (44%)	4 (100%)
Pharmacist/dispenser	4 (100%)	7 (78%)	1 (25%)
Lay or expert patient	1 (25%)	1 (11%)	1 (25%)
Phlebotomy	[a](*n* = 4)		
Clinical officer	0 (0%)	0 (0%)	1 (25%)
Nurse/midwife	0 (0%)	4 (44%)	1 (25%)
ART counsellor	0 (0%)	1 (11%)	0 (0%)
Laboratory technician	4 (100%)	7 (78%)	3 (75%)
Lay or expert patient	0 (0%)	1 (11%)	0 (0%)
Patient tracing on missed appointments and defaulters	[a](*n* = 4)		
Medical officer	0 (0%)	1 (11%)	0 (0%)
Clinical officer	0 (0%)	2 (22%)	0 (0%)
Nurse/midwife	0 (0%)	3 (33%)	1 (25%)
ART counsellor	0 (0%)	5 (56%)	0 (0%)
Records clerk	1 (25%)	1 (11%)	1 (25%)
Lay or expert patient	3 (75%)	6 (67%)	3 (75%)

Note: The percentage is calculated for each cadre to enable comparison across each model of care.

[a]The question was not answered by one of sites grouped in Model 1: Traditional; therefore, percentages are calculated out of a total denominator of 4 ART clinics.

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TABLE 1C Programmatic characteristics of the ART clinics in 2011 by the 3 task-shifting/task-sharing models of care

Programmatic characteristics, by cadre	Model 1: traditional (*n* = 5 clinics)	Model 2: mixed (*n* = 9 clinics)	Model 3: task-shifted (*n* = 4 clinics)
ART initiation preparedness			
Counselling required to initiate ART (yes)	5 (100%)	9 (100%)	4 (100%)
Treatment supporter required to initiate ART (yes)	4 (80%)	8 (89%)	3 (75%)
# Counselling pre-ART counselling sessions			
1 session	1 (20%)	0 (0%)	1 (25%)
2 sessions	2 (40%)	1 (11%)	0 (0%)
3 sessions	2 (40%)	8 (89%)	3 (75%)
Methods of Pre-ART counselling			
Individual	5 (100%)	8 (89%)	4 (100%)
Individual with treatment supporter	5 (100%)	9 (100%)	4 (100%)
Group	3 (60%)	6 (67%)	3 (75%)
Pill count	3 (60%)	5 (56%)	2 (50%)
Total number of counselling methods used			
2 methods	1 (20%)	0 (0%)	1 (25%)
3 methods	2 (40%)	8 (89%)	1 (25%)
4 methods	2 (40%)	1 (11%)	2 (50%)
Clinic has referral linkage to CHW trained in adherence support (yes)	3 (60%)	8 (89%)	3 (75%)
ART adherence counselling after initiation			
Methods of counselling			
Individual	4 (80%)	7 (78%)	4 (100%)
Individual with treatment supporter	5 (100%)	7 (78%)	3 (75%)
Group	5 (100%)	5 (56%)	3 (75%)
Pill count practice	3 (60%)	8 (89%)	3 (75%)
Total number of counselling methods used			
2 methods	0 (0%)	2 (22%)	1 (25%)
3 methods	3 (60%)	5 (56%)	1 (25%)
4 methods	2 (40%)	2 (22%)	2 (50%)
Frequency of ART refill			
In the first month on ART			
Every 2 weeks	5 (100%)	9 (100%)	4 (100%)
In the second to sixth months on ART			
Every month	5 (100%)	8 (89%)	4 (100%)
Every 2 months	0 (0%)	1 (11%)	0 (0%)
After 6 months on ART			
Every month	3 (60%)	2 (22%)	2 (50%)
Every 2 months	1 (20%)	6 (67%)	1 (25%)
Every 3 months	1 (20%)	1 (11%)	1 (25%)
Pharmacy support for ART adherence			
Methods			
Patient self-report adherence assessment	3 (60%)	6 (67%)	4 (100%)
Dispenser adherence assessment	4 (80%)	6 (67%)	3 (75%)
Verify refill dates	4 (80%)	7 (78%)	4 (100%)
Total number of pharmacy-based methods used			
None (zero method)	1 (20%)	2 (22%)	0 (0%)

(Continues)

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TABLE 1C (Continued)

Programmatic characteristics, by cadre	Model 1: traditional (*n* = 5 clinics)	Model 2: mixed (*n* = 9 clinics)	Model 3: task-shifted (*n* = 4 clinics)
3 methods	1 (20%)	4 (44%)	2 (50%)
4 methods	3 (60%)	3 (33%)	2 (50%)
Social support for ART adherence			
PLHIV support group	5 (100%)	7 (78%)	4 (100%)
Adherence support worker	4 (80%)	7 (78%)	3 (75%)
Home-based care worker	3 (60%)	5 (56%)	2 (50%)
Community-based ART adherence services			
Methods			
Distribution of ARV drugs	0 (0%)	3 (33%)	1 (25%)
Home-based care	3 (60%)	6 (67%)	3 (75%)
Adherence support	3 (60%)	7 (78%)	4 (100%)
Emotion/social support	3 (60%)	8 (89%)	3 (75%)
Follow-up of missed appointments	3 (60%)	8 (89%)	3 (75%)
Nutritional support	2 (40%)	5 (56%)	3 (75%)
Number of community-based methods (out of 7)			
No methods	1 (20%)	1 (11%)	0 (0%)
1–4 methods	1 (20%)	1 (11%)	1 (25%)
5–7 methods	3 (60%)	7 (78%)	3 (75%)
Stock outs of ART in the last 6 months	1 (20%)	0 (0%)	4 (100%)
Provided viral load testing as needed	3 (60%)	2 (22%)	1 (25%)

likely to have missing pre-CD4 cell count than patients with higher MPR (Table 2). Finally, significantly fewer patients with <90% MPR were on AZT/3TC/EFV regimen and had more than 5.3 years of experience on ART than patients with higher MPR (Table 2).

Unadjusted proportions and residual ratio of MPR <90% by models of care

Cluster-level analysis found that 57% of patients had MPR <90% (SD +17.59) in Model 1-Traditional, 35% (SD +12.92) for Model 2-Mixed and 34% (SD +17.37) for Model 3-Task-Shifted (Table 3). Patients in Model 1-Traditional were significantly more likely than patients in Model 2-Mixed to have an MPR <90% (difference in mean = −22.54, 95% CI −42.07, −3.01), and a similar trend was observed comparing patients in Model 1-Traditional to Model 3-Task-Shifted (difference in mean = −23.42, 95% CI −55.17, 8.33). There was no evidence of statistical difference in MPR <90% between patients in Model 2-Mixed and Model 3-Task-Shifted (difference in mean = −0.88, 95% CI −21.64, 19.87) (Table 3).

Adjusted residual ratio of MPR <90% by models of care

Adjusted results from the cluster-level analysis found that patients in Model 1-Traditional were more likely than patients in Model 2-Mixed to have MPR <90% (aRR = 1.60, 95% CI 1.03, 2.48). Patients in Model 1-Traditional also showed a trend towards being more likely than patients in Model 3-Task-Shifted to have an MPR <90%, but this difference was not statistically significant (aRR = 1.58, 95% CI 0.88, 2.85) (Table 3). There was no evidence of a difference in proportions of patients with an MPR <90% between Model 2-Mixed and Model 3-Task-Shifted (aRR = 0.99, 95% CI 0.59, 1.66) (Table 3).

DISCUSSION

Patients in Model 1-Traditional were 60% more likely to have incomplete ART adherence with an MPR <90% than patients in Model 2-Mixed. Similarly, there was some indication that patients in Model 1-Traditional were more likely to have an MPR <90% than patients in Model 3-Task-Shifted, but this difference was not statistically significant, possibly due to the small number of clinics in Model 3 (*n* = 4). These results suggest that differences in ART service delivery are related to varying patient adherence.

Differences in ART service delivery may result from different cadres providing health services or from differences in how ART and related tasks are implemented. Our findings indicate that non-physician-led ART programmes supported adherence levels better than physician-led ART programmes, and task-shifting and task-sharing of ART services were not associated with poorer patient adherence. These findings

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TABLE 2 Summary of analysis population by task-shifting/task-sharing model and adherence outcome

	N = 3,411	Model 1: traditional % (*n* = 842)	Model 2: mixed % (*n* = 1,843)	Model 3: task-shifted % (*n* = 726)	*p*	Total %	MPR <90% (*n* = 1,997)	MPR ≥90% (*n* = 1,414)	On MPR <90% odds ratio (95% CI)	*p*
Demographics										
Age (in years)										
<35	921	23.16	30.66	22.18	<0.0001	27.00	29.99	24.89	1.293 (1.110, 1.505)	0.0010
≥35 years	2,490	76.84	69.34	77.82		73.00	70.01	75.11	1	
Female sex	2,277	66.51	65.76	69.56	0.1814	66.75	68.46	65.55	0.877 (0.758, 1.014)	0.0756
Marital status										
Single	334	12.59	9.39	7.58	0.0121	9.79	10.25	9.46	3.836 (0.443, 33.187)	0.4631
Separated/ divorced/ widowed	1,199	34.20	34.56	37.74		35.15	35.79	34.70	3.650 (0.425, 31.339)	
Married or cohabitating	1,872	53.09	55.94	54.27		54.88	53.89	55.58	3.432 (0.400, 29.433)	
Missing	6	0.12	0.11	0.41		0.18	0.07	0.25	1	
DHS wealth index										
Low	1,107	7.96	41.35	38.29	<0.0001	32.45	28.15	35.50	0.638 (0.540, 0.755)	<0.0001
Middle	1,135	28.86	34.35	35.67		33.27	33.17	33.35	0.801 (0.679, 0.944)	
High	1,169	63.18	24.31	26.03		34.27	38.68	31.15	1	
Psychosocial factors										
Stigma internalised										
High (>median)	1,156	37.17	34.89	27.55	0.0001	33.89	37.69	31.20	1.334 (1.156, 1.540)	<0.0001
Low	2,255	62.83	65.11	72.45		66.11	62.31	68.80	1	
Stigma disclosure										
High (>median)	951	28.15	29.73	22.87	0.0022	27.88	29.63	26.64	1.160 (0.997, 1.349)	0.0549
Low	2,460	71.85	70.27	77.13		72.12	70.37	73.36	1	
Potential depression										
Positive screen	437	7.84	15.46	11.85	<0.0001	12.81	14.71	11.47	1.332 (1.089, 1.629)	0.0053
Negative screen (REF)	2,974	92.16	84.54	88.15		87.19	85.29	88.53	1	
Ever-disclosed HIV status										
Yes	3,250	96.67	94.47	95.73	0.0353	95.28	95.62	95.04	0.879 (0.635, 1.217)	0.4374
No	161	3.33	5.53	4.27		4.72	4.38	4.96	1	

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TABLE 2 (Continued)

	N = 3,411	Model 1: traditional % (*n* = 842)	Model 2: mixed % (*n* = 1,843)	Model 3: task-shifted % (*n* = 726)	*p*	Total %	MPR <90% (*n* = 1,997)	MPR ≥90% (*n* = 1,414)	On MPR <90% odds ratio (95% CI)	*p*
Social support care										
Lower 10th percentile	427	10.45	14.76	9.23	<0.0001	12.52	11.53	13.22	0.855 (0.694, 1.053)	0.1415
Higher	2,984	89.55	85.24	90.77		87.48	88.47	86.78	1	
Social support help										
Lower 10th percentile	461	9.62	15.95	11.85	<0.0001	13.52	12.94	13.92	0.919 (0.752, 1.123)	0.4101
Higher	2,950	90.38	84.05	88.15		86.48	87.06	86.08	1	
CAGE alcohol abuse										
Positive ≥2	796	23.63	24.04	21.21	0.3045	23.34	24.47	22.53	1.114 (0.949, 1.307)	0.1880
Negative <2 (REF)	2,615	76.37	75.96	78.79		76.66	75.53	77.47	1	
Traditional healer										
Ever consulted	224	15.20	4.23	2.48	<0.0001	6.57	6.86	6.35	1.085 (0.825, 1.426)	0.5589
Never consulted	3,187	84.80	95.77	97.52		93.43	93.14	93.64	1	
Cost to clinic										
≥1 USD	1,486	42.28	39.77	54.68	<0.0001	43.56	43.49	43.62	0.995 (0.867, 1.142)	0.9437
<1 USD	1,925	57.72	60.23	45.32		56.44	56.51	56.38	1	
Time to clinic										
≥30 min	2,739	80.17	79.00	83.75	0.0244	80.30	78.43	81.62	0.891 (0.691, 0.970)	0.0210
<30 min	672	19.83	21.00	16.25		19.70	21.57	18.38	1	
Clinical characteristics										
ART regimen (rcurrartfinal2)										
1 = D4T,3TC,NVP	570	12.95	15.57	23.97	<0.0001	16.71	15.63	17.48	0.814 (0.639, 1.038)	<0.0001
2 = AZT,3TC,EFV	659	26.72	15.52	20.39		19.32	14.92	22.43	0.606 (0.477, 0.769)	
3 = AZT,3TC,NVP	1,227	26.84	49.75	34.44		35.97	39.46	33.50	1.072 (0.871, 1.320)	
4 = other regimen	443	12.83	12.75	13.77		12.99	14.14	12.17	1.058 (0.819, 1.367)	
5 = TDF,3TC/FTC,EFV (ref)	512	20.67	15.41	7.44		15.01	15.84	14.42	1	
Time on ART										
<2.2	859	19.60	29.19	21.49	<0.0001	25.18	23.55	26.34	1.147 (0.942, 1.397)	<0.0001
2.2–5.3	1,714	47.39	49.81	54.68		50.25	55.37	46.62	1.524 (1.285, 1.807)	
>5.3	838	33.02	21.00	23.83		24.57	21.07	27.04	1	

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TABLE 2 (Continued)

	N = 3,411	Model 1: traditional % (*n* = 842)	Model 2: mixed % (*n* = 1,843)	Model 3: task-shifted % (*n* = 726)	*p*	Total %	MPR <90% (*n* = 1,997)	MPR ≥90% (*n* = 1,414)	On MPR <90% odds ratio (95% CI)	*p*
Pill burden (self-report)										
<4	2,766	86.22	81.55	73.97	<0.0001	81.09	78.15	83.17	0.723 (0.609, 0.859)	0.0002
≥4	645	13.78	18.45	26.03		18.91	21.85	16.83	1	
HIV symptoms index (≥median)	1,808	50.00	56.81	46.83	<0.0001	53.00	54.17	52.18	0.923 (0.805, 1.058)	0.2506
Pre-ART WHO stage										
Missing	290	15.80	5.81	6.89	<0.0001	8.50	8.63	8.41	1.040 (0.804, 1.345)	0.9214
Stage IV	408	9.98	13.56	10.19		11.96	12.38	11.67	1.076 (0.860, 1.346)	
Stage III	1,351	39.67	35.32	50.41		39.61	39.39	39.76	1.005 (0.862, 1.171)	
Stage I and II	1,362	34.56	45.31	32.51		39.93	39.60	40.16	1	
Pre-ART $CD4^+$ cell count (cells/μl)										
Missing	671	17.22	18.77	24.79	<0.0001	19.67	21.78	18.18	1.242 (1.045, 1.477)	0.0288
>250	424	10.81	14.27	9.64		12.43	11.74	12.92	0.942 (0.762, 1.164)	
≤250	2,316	71.97	66.96	65.56		67.90	66.48	68.90	1	

are congruous with other research that has demonstrated comparable standards of care in HIV care and treatment by trained clinical officers and nurses compared to physicians [21–24], and similar mortality, mean CD4 cell count, and virologic failure in effectiveness studies [8,9,11,12].

Differences in staffing for ART service delivery may result in different implementation approaches. Recognising the complexity of this subject and the fact that observed differences in models of care cannot fully explain the differences observed in MPR, we noted three main aspects distinguishing the three models of care which may have helped patients pick-up their pills.

First, Model 1-Traditional clinics were less likely to require three adherence counselling sessions before ART initiation than Model 2 and 3 clinics. Adherence may have been greater among patients in Models 2 and 3 because these patients had more pre-ART counselling sessions and were more prepared for lifelong HIV treatment. However, research on the value of more pre-ART counselling sessions for adherence is inconclusive [25]. Benefits of pre-ART counselling must be balanced by risks of early mortality and greater morbidity associated with delayed ART initiation [26]. Given the emphasis on immediate ART initiation within the test and treat approach, it is important to strengthen adherence support for patients at ART initiation and throughout their life on ART [27]. An example strategy to strengthen post-initiation adherence includes task-sharing of adherence counselling to lay or peer health workers [13].

Second, Model 1-Traditional clinics were less likely to practice routine pill counts for patients during ART refill visits in contrast to Model 2-Mixed and Model 3-Task-Shifted clinics. While most literature discusses pill counts as a measure of adherence, some have hypothesised that routine pill counts serve as an intervention shaping patient adherence behaviour. This research suggests that the repeated process of expecting to have pills counted, organising medication for pill counts, and receiving increased attention from the person conducting the pill count can have a 'reactive effect' for patients, resulting in improved ART adherence [28]. This hypothesis is supported by a Kenyan study which found a dose–response relationship between clinician pill count and adherence – the greater the number of pill counts conducted, the more adherent patients were [29].

Finally, some clinics in Models 2 and 3 provided patients with alternatives to clinic-based pill pick-up, which may have helped overcome common barriers to non-adherence by making ART more accessible and affordable [30–32]. Models of decentralised ART delivery varied from distribution of ART from mobile, satellite ART clinics within the community to home-based ART distribution by trained lay workers, and are coupled with multi-month dispensing of ART for stable patients (at the time of study stable was defined as patients who have been on ART for 6 months or longer, without VL results). Altogether, these models can allow patients to travel shorter distances, spend less on transport and reduce time spent for medication pick-up [31,33–35], overcoming key deterrents to treatment interruption.

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TABLE 3 Percentages, mean difference and adjusted relative risks of non-adherence between the three task-sharing/task-sharing models of care in antiretroviral therapy

	Model 1: traditional	Model 2: mixed	Model 3: task-shifted	Effect estimates	*p*
Number of ART clinics	5	9	4		
Percentages of non-adherence based on cluster summaries (SD)	57.30 (17.59)	34.77 (12.92)	33.88 (17.37)		
Mean difference and 95% CI					
Model 1-traditional minus 2-mixed				−22.54 (−42.07, −3.01)	0.0272
Model 1-traditional minus 3-task-shifted				−23.42 (−55.17, 8.33)	0.1246
Model 2-mixed minus 3-task-shifted				−0.88 (−21.64, 19.87)	0.9270
Analyses based on ratio-residuals					
Adjusted[a] relative risk and 95% CI					
Model 1-traditional vs. 2-mixed				1.60 (1.04, 2.46)	0.0354
Model 1-traditional vs. 3-task-shifted				1.59 (0.88, 2.85)	0.1054
Model 2-mixed vs. 3-task-shifted				0.99 (0.59, 1.65)	0.9720

[a]Adjusted for age, household wealth, internalised stigma against HIV, potential depression, time to clinic, ART regimen, time on ART, pill burden and pre-ART CD4 cell count.

Strengths and limitations

A strength of our study was the inclusion of 18 ART programmes in three countries – a considerably larger and more diverse sample than past research, which has generally described task-shifting/task-sharing practices of a few clinics in one country [10,13,36–41]. While our evaluation offered more information than previously available, the sample of 18 clinics still left us inadequately powered to examine all the associations between models of care and ART adherence. The sites were not randomly selected so data may not be generalisable to ART clinics in these countries or elsewhere in sub-Saharan Africa. Clinics were purposefully selected with national partners to be diverse on a range of characteristics; however, while diverse, they were not randomly selected and therefore not representative of all ART clinics in these countries. In particular, because of our requirements to have a minimum of 300 ART clients, the selected clinics may have been larger and have more established ART programmes. For these reasons, our findings may not be generalisable to all ART clinics in the three countries or elsewhere in sub-Saharan Africa.

Another strength was our comprehensive measure of task-shifting/task-sharing practices to characterise models of HIV care. Prior research has described task-shifting/task-sharing models of care broadly as 'doctor-centred', 'nurse-centred', 'non-physician care', 'peer-led' or 'community-supported care' [8,10–12,21,27,38,39,42–45], while the model of care is based on a few discrete ART-related tasks, such as non-physician ART initiation or clinical monitoring of patients [10,11,38,40,45–48], or lay health worker adherence counselling and support [13,49]. In contrast, our measure included healthcare staffing patterns from patient registration, triage, ART prescription, adherence counselling, dispensing, clinical monitoring, phlebotomy for laboratory testing, to tracing of patients lost to follow-up and medical records management, and added clarity to what the model of care entails. This comprehensive measure better considers the many facets that contribute to patient outcomes. A limitation to this measure is that we were unable to consider other important details, such as intensity and coverage of services per patient (and thus workload), or service quality.

Another strength of our analysis was our inclusion of a comprehensive range of factors affecting adherence, including socio-demographic, psychosocial, clinical and structural characteristics. However, country was not included as a covariate in the analysis. This may limit the accuracy of the model as it will not account for country-level factors, such as national policies on differentiated models of ART. Also, the cross-sectional design of the study restricted interpretations to associations rather than temporal relationships and causations.

Using MPR to measure adherence meant that we cannot know if patients actually ingested their drugs or achieved viral suppression. However, MPR is not as vulnerable as self-reported measures to social desirability or recall bias. Another advantage of MPR that it captures both individuals' ability to access drugs and the system's ability to dispense drugs to facilitate maximum possible adherence. Interestingly, MPR was not correlated to ART stock-outs in the past 6 months in this study. Our findings suggest a relationship between model of care and MPR – highlighting the importance of access to ART and support for adherence. However, it is not possible to isolate whether it is the health cadres or the ART programme that is related to MPR, and further research is needed to elucidate these complex relationships.

CONCLUSIONS

Patient data from 18 routinely implemented ART programmes in Tanzania, Uganda and Zambia provide

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evidence that non-physician clinicians can support favourable levels of ART adherence and result in non-inferior adherence outcomes compared to physician-based models of care. Data on task-shifting/task-sharing models of care suggest further room to optimise the implementation of ART services to improve patient adherence, and additional research to enhance post-ART initiation adherence support is needed.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the invaluable contributions of the people living with HIV who participated in the study and the staff of the health facilities where the research was conducted.

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How to cite this article: Tsui S, Kennedy CE, Moulton LH, Chang LW, Farley JE, Torpey K, et al. HIV care and treatment models and their association with medication possession ratio among treatment-experienced adults in three African countries. Trop Med Int Health. 2021;26:1481–1493. https://doi.org/10.1111/tmi.13654

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