



# HIV Disclosure to Family Members and Medication Adherence: Role of Social Support and Self-efficacy

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## Abstract

Although antiretroviral therapy (ART) is vital to people living with HIV (PLWH) by suppressing the virus and in turn preventing onward HIV transmission and reducing AIDS-related morbidity and mortality, the rates of optimal ART adherence continuously remain low. Disclosure of HIV status is considered to be a critical predictor of ART adherence. However, few studies have explored the mechanisms underlying the association between disclosure and medication adherence. The current study aims to examine the mediating role of social support and self-efficacy underlying the relationship between HIV disclosure to family members and ART adherence. PLWH in China provided data on HIV disclosure, ART adherence, perceived social support on medication adherence, adherence self-efficacy, and social-demographic information. The path analyses revealed that disclosure to family members had significant indirect effects on adherence via social support and self-efficacy. Our findings suggested that HIV disclosure might positively affect ART adherence through two psychosocial pathways: social support and self-efficacy. Future intervention to improve medication adherence among PLWH should consider targeting these two factors.

**Keywords** HIV/AIDS · Disclosure · ART · Social support · Self-efficacy

## Introduction

There are approximately 36.9 million people living with HIV (PLWH) globally, among whom 1.8 million are newly infected with HIV in 2017 [1]. The use of antiretroviral therapy (ART) dramatically improves health outcomes and prolongs life expectancy of PLWH [2]. With the increasing coverage of ART, 21.7 million PLWH have initiated ART by the end of 2017 [1]. Adherence to ART regimen is essential for sustained viral suppression [3], which prevents onward HIV transmission to others [4] and reduces AIDS-related

mortality [5]. Optimal adherence, which is often considered as 95% or more of prescribed doses taken [6–8], is linked to better inhibition of viral mutation thereby avoiding evolution of drug resistant viruses [9]. Unfortunately, the adherence rates continue to remain low with only 61%–83% across various cultural settings [10–12]. Given the importance of optimal adherence, a better understanding of influential factors of medication adherence becomes pressing and urgent.

ART adherence is influenced by many factors, including personal attributes, institutional resources, treatment related factors, and psychosocial factors [13]. One of the key and complex predictors is disclosure of HIV diagnosis [14], which refers to revealing personal HIV seropositive status to others. For PLWH, HIV disclosure might be an important step in engaging in HIV care [15]. A previous study found that greater disclosure was significantly related with better adherence after controlling other relevant variables [16]. Another study also found that participants who disclosed to more than two family members and/or steady partners were more likely to take all of the prescribed doses in the past 4 days [17]. Family members were more likely to become targets of disclosure, and sometimes the initial targets [18]. For example, among 76 men living with HIV

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who had disclosed to at least one person, 62% disclosed to a family member and 21% to a friend [19]. Among 314 women living with HIV who had disclosed, 56.4% of them first disclosed to either parents or husbands [20]. Furthermore, a longitudinal study of HIV-positive mothers reported that a lack of disclosure to family members at baseline predicted missed medical appointments at follow-up, while no significant relationship was found between general disclosure and ART adherence [21]. The disclosure target preference in family members might be due to the emotional support and positive responses that PLWH could receive [18]. Thus, in anticipation of supportive responses, disclosure to family members might be a key factor in improving and maintaining ART adherence [16, 22, 23]. Although research investigating pathways underlying disclosure to family members and ART adherence is limited, some of the psychosocial variables that are associated with disclosure may also influence ART adherence, both theoretically and empirically.

According to the Disclosure Processes Model [14, 24], social support is a potential mediator explaining the effect of disclosure on adherence. The model posits that multiple processes exist between disclosure and various long-term outcomes. Specifically, disclosure has effect on social, contextual, dyadic (e.g., spousal or family relationship), and clinical outcomes (e.g. medication adherence) through three possible mediation processes, including alleviation of inhibition, changes in social information, and social support [14]. Consistent with the theoretical framework, qualitative data from 152 HIV infected adults suggested that disclosure and adherence could influence each other, in which social support was speculated as an active element [25]. On one hand, HIV disclosure, especially to family members [26], has been associated with social support across ethnicity, gender and sexual orientation [27–31]. On the other hand, a number of cross-sectional studies reported that high levels of perceived social support were linked with optimal ART adherence [32–36]. Although few studies have directly explored the mediation role of social support, these existing empirical data generally support the premise of the theoretical conjecture that disclosure might benefit adherence through augmenting social support [14]. Meanwhile, comparing with general social support, medication-specific social support might be a proximal predictor of ART adherence. Researchers argue that general social support is more useful in predicting psychological outcomes rather than behavioral outcomes but specific social support may work in the opposite direction [37]. Consistent with this line of reasoning, a study found that medication-specific social support significantly influenced ART adherence, while general social support did not [38].

Self-efficacy might be another potential mediator underlying the association between disclosure and ART adherence. According to the Social Cognitive Theory, individuals

who have higher self-efficacy to perform health promoting behavior are more likely to do so [39, 40]. Although few, if any, research has directly explored the mediation role of self-efficacy between disclosure and ART adherence, studies have proved that self-efficacy is associated with ART adherence as well as disclosure [41–43]. Compared with general self-efficacy, the association with ART adherence is especially solid for medication-specific self-efficacy [44]. Medication self-efficacy refers to an individual belief that oneself will be able to take medication as prescribed. Medication self-efficacy has been evidenced as a stronger predictor of ART adherence in comparison with key sociodemographic variables (e.g., age), treatment-related factors (e.g., duration of ART), disease-related conditions (e.g., CD4 cell count), interpersonal correlates (e.g., social support), and other behavioral predictors (e.g., current substance use) [45]. The significant association between medication self-efficacy and ART adherence has been reported in a number of studies [44–46]. Considering the theoretical basis and empirical evidence, it is plausible to hypothesize that treatment self-efficacy might play a mediation role between disclosure and adherence.

The serial mediating effect of social support and self-efficacy between disclosure and ART adherence has not been established, while it might possibly exist. The Social Cognitive Theory indicates that social support is likely to engender self-efficacy beliefs, which in turn improve health outcomes [47]. Align with the theory, two cross-sectional studies suggested that social support was indirectly associated with ART adherence through self-efficacy [48, 49]. However, whether disclosure might impact adherence through social support and self-efficacy successively still needs to be clarified. Testing serial (“chain”) mediation is necessary since it might uncover complex mechanisms between disclosure and adherence in future studies [50]. Given the theoretical backdrop and empirical findings, serial mediation effect of social support and self-efficacy may exist between the relationship of disclosure and adherence. However, these mediational chains have not been empirically tested to date. Meanwhile the impact of potential serial mediators has also not been fully examined. The main purpose of the present study is to explore whether medication social support and treatment adherence self-efficacy mediate the relationship between disclosure to family members and ART adherence.

Two main hypothesized models are proposed to investigate mechanisms linking disclosure and adherence. First, social support and self-efficacy serve as individual mediators. With parallel models in which two mediators do not interact with each other [51], social support and self-efficacy are hypothesized to be predicted by the disclosure and to then predict ART adherence separately (i.e., disclosure → social support → ART adherence; disclosure → self-efficacy → ART adherence). Second, social support and self-efficacy

function in a sequential chain of mediators between disclosure and ART adherence (i.e., disclosure → social support → self-efficacy → ART adherence).

## Method

### Study Sites

Data were drawn from a cross-sectional survey designed to explore psychosocial and behavioral factors related to mental and physical health among PLWH [52]. The survey started in October 2012 and lasted for 10 months in Guangxi Autonomous Region (Guangxi) in China. Guangxi was ranked first in 2012 in number of newly reported HIV/AIDS cases among 34 provinces and autonomous regions in China [53]. From all of 17 cities and 75 counties, the top 2 cities and 10 counties in terms of the number of cumulative HIV/AIDS cases were selected as study sites. The selected study sites had about 43% of total reported cases in Guangxi in 2012 [34].

### Participants

Approximately 10% of the reported HIV/AIDS cases at each participating site were randomly recruited by the staff at the local centers for disease control and prevention (CDC). About 90% of recruited cases gave their consent to attend the study. Among the 2987 PLWH who participated in the study, parents (N=1254) who had children of 5 to 16 years old were asked to complete an additional section on HIV disclosure. The current study sample consisted of 874 (69.70%) of these parents who initiated ART and provided data regarding ART adherence.

### Survey Procedure

Based on participants' personal preference or literacy level, about three quarters (77.78%) of the current study sample completed the survey via face-to-face interviews, whereas the rest of participants completed the survey on their own. To assure confidentiality, the survey was conducted in private offices of local community health centers or HIV clinics where participants received medical care. The entire survey took about 75–100 min to complete. After completion, each participant received a five-dollar-worth household item for compensation for their time. The research protocol was approved by Institutional Review Boards at both Wayne State University in the United States and Guangxi CDC in China.

## Measures

### Disclosure to Family Members

One multiple-response question was administered to assess participants' disclosure to their family members (i.e., "Whom have you told about your HIV infection?"). Fourteen options were provided, including spouse/steady sexual partners, casual sexual partners, father, mother, brothers, sisters, grandparents, adult children, minor children, other relatives, friends, co-workers or bosses, others, or no one. Following a similar procedure in the existing study [15], a continuous variable was created by counting the number of positive ("yes") response to options of family member (e.g., spouse, parents, siblings, grandparents, and children). The possible scores of disclosure to family members ranged from 0 to 8 with a higher score indicating a higher level of disclosure to family members.

### Medication Social Support

Medication-specific social support was measured with an 8-item scale [38] to identify how often participants received help for their medication taking over a three-month period (e.g., "Someone reminded you to take your medicine") on a 5-point scale ranging from "never" (0) to "always" [4]. The responses to all 8 items in the scale were averaged to form an index of medication-specific social support. The index score ranged from 0 to 4 with a higher score indicating a higher level of medication social support. A previous study showed that the scale has a high reliability and a good construct validity [33]. Cronbach  $\alpha$  was 0.92 for the scale in the current study.

### Treatment Adherence Self-efficacy

Self-efficacy of treatment adherence was assessed with a 12-item scale used in a previous study [46]. The scale consists of statements that reflect participants' confidence of following directions on medication, controlling side effects, and managing treatment-related health problems. These statements were rated on 5-point Likert response ranging from 1 (completely not sure) to 5 (completely sure). A composite score was calculated by summing the responses to 12 items. The composite scores ranged from 12 to 60 with a higher score indicating better self-efficacy on HIV treatment adherence. Cronbach  $\alpha$  was 0.92 for the scale in the current study.

### ART Adherence

Five items were employed to assess adherence to ART. The first two items asked participants if they had missed any dose in the past weekend/ever before with responses being recorded to reflect an adherence (1 = not missed, 0 = missed).

The other three items inquired the total number of prescribed doses and the number of doses that participants actually took within three specific time windows (i.e., past 3 days, past weekend, or past month). The responses to each of these items were first converted into percentage of doses taken as scheduled and then dichotomized into 1 ( $\geq 95\%$  of prescribed doses) or 0 ( $< 95\%$ ). The threshold of 95% is used in current study as the existing literature suggested that 95% as the optimal level of adherence to sustain viral suppression [3] and to avoid evolution of drug resistant viruses [9]. An adherence index score was generated by summing the dichotomous scores of the five items to reflect an optimal adherence (score=5) or suboptimal adherence (score  $< 5$ ).

### Potential Covariates

Data on the following covariates that were identified in a previous study [50] were collected and included in the final path analysis.

### Demographic Information

Participants were asked to provide information on their age, gender, ethnicity, marital status, residence status, employment status, education in years, monthly household income, drug use, duration since diagnosis, and HIV infection among other family members.

### Depression

Depressive symptoms were assessed with the short 10-item version of the Center for Epidemiological Studies Depression Scale (CESD-10) [54]. Each CESD-10 item was rated on a 4-point scale (0 = never, 1 = sometime, 2 = often, and 3 = always). A total score ranging from 0 to 30 was created with higher scores indicating a higher depressive symptom (Cronbach  $\alpha = 0.78$ ).

### Stigma

HIV-related stigma was assessed using 14 items with a 4-point scale (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree) [55]. A composite score was calculated by summing the scores of 14 items. The HIV-related stigma scale had a Cronbach's  $\alpha$  of 0.93 in the current study.

### Data Analysis

First, independent-samples  $t$  test or  $\chi^2$  test was performed to examine the differences of demographic variables, treatment factors, and psychological factors between optimal adherence group and suboptimal adherence group. All the covariates that were significantly different between

adherence groups (e.g., age, ethnicity, data collection mode, and income), as well as predictors of adherence that were identified in previous studies (e.g., stigma, depression), were included in the further path analysis.

Second, the correlation coefficients were calculated among main study variables. Finally, path analyses of both parallel mediation and serial mediation models were conducted using PROCESS for SPSS [51], providing estimates of path coefficients ( $\beta$ ) and bootstrapped 95% confidence intervals (95% CI) for indirect effects based on 5000 resamples. In addition, an alternative model with reversed pathways was tested with the same procedure. Due to smaller variances accounted by the alternative model, only results from the originally hypothesized models were reported. Among the 874 participants in the current analysis, 678 (77.57%) had complete data (i.e., non-missing) in any of the study variables. The maximum percentage of missing responses for any single variable was less than 5%. The expectation maximization method was used to impute missing data [56]. All statistical analyses were performed using SPSS 24.0. A  $p$  value of less than 0.05 was employed to indicate statistical significance

## Results

### Sample Characteristics

As shown in Table 1, the average age of the study sample ( $n = 874$ ) was 37.23 years old ( $SD = 5.90$ ). The majority of the participants were male (57.67%), of Han ethnicity (71.05%), married (78.56%), and living in rural area (71.79%). The rates of unemployment, part-time job and full-time job were 17.55, 37.61 and 44.84%, respectively. Their average years of formal schooling were about 7.16 years ( $SD = 2.67$ ). More than half of the participants reported less than 1000 Chinese yuan (or approximately 159 US dollars) of household income per month, which was less than half of that for the local population at the provincial level [57]. The average length of HIV diagnosis was 45.07 months ( $SD = 28.43$ ). About one half (51.83%) of the participants reported that at least one other family member was also infected with HIV.

### Group Differences by Adherence

About half of the participants ( $n = 468$ , 53.55%) were considered having optimal adherence, while the others ( $n = 406$ , 46.45%) were considered as having suboptimal adherence. Table 1 presents the differences of key variables between two adherence groups. Most of the variables (e.g., gender, ethnicity, marital status, residence status, work status, education in years, household income, duration since diagnosis,

**Table 1** Sample Characteristics by ART Adherence Group

N (%)	Overall 874 (100%)	ART adherence group	
		Optimal 468 (53.55%)	Suboptimal 406 (46.45%)
Age (years)	37.23 (5.90)	37.64 (6.15)	36.76 (5.56)*
Gender (male)	504 (57.67%)	262 (55.98%)	242 (59.61%)
Ethnicity (Han)	621 (71.05%)	322 (68.80%)	299 (73.65%)
Marital status (married)	667 (78.56%)	354 (78.67%)	313 (78.45%)
Residence status (urban)	246 (28.21%)	119 (25.54%)	127 (31.28%)
Work status			
Full-time	391 (44.84%)	222 (47.54%)	169 (41.73%)
Part-time	328 (37.61%)	170 (36.40%)	158 (39.01%)
Unemployment	153 (17.55%)	75 (16.06%)	78 (19.26%)
Education in years	7.16 (2.67)	7.15 (2.71)	7.18 (2.63)
Data collection mode (interview)	679 (77.78%)	381 (81.41%)	298 (73.58%)*
Monthly household income (Chinese yuan)			
< 1000	483 (55.84%)	267 (57.91%)	216 (53.47%)
1000–1999	248 (28.67%)	124 (26.90%)	124 (30.69%)
2000–2999	87 (10.06%)	49 (10.63%)	38 (9.41%)
≥ 3000	47 (5.43%)	21 (4.56%)	26 (6.44%)
Drug use (yes)	173 (19.93%)	80 (17.20%)	93 (23.08%)*
HIV infection			
Duration since diagnosis (month)	45.07 (28.43)	43.38 (28.60)	47.02 (28.13)
Other HIV infection in family (yes)	453 (51.83%)	253 (54.06%)	200 (49.26%)
Psychological factors			
Depression	9.23 (6.10)	9.10 (6.17)	9.38 (6.02)
HIV stigma	34.59 (7.01)	34.74 (7.24)	34.42 (6.74)
Disclosure to family members	1.74 (1.39)	1.68 (1.34)	1.81 (1.43)
Medication social support	1.32 (0.91)	1.34 (0.95)	1.30 (0.85)
Treatment adherence self-efficacy	46.17 (6.48)	47.10 (5.86)	45.09 (6.99)**

\* $p < 0.05$ ; \*\* $p < 0.01$ 

other HIV infection in family, depression, HIV stigma, disclosure to family members, social support to treatment) did not significantly differ between the adherence groups (all  $ps > 0.05$ ). Compared to participants in suboptimal group, those in the optimal group were older (37.64 vs. 36.76 years,  $p < 0.05$ ) and had a lower proportion of drug use (17.20% vs. 23.08%,  $p < 0.05$ ). Moreover, participants in the optimal group had a higher proportion of completing the survey via face-to-face interview than those in suboptimal group (81.41% vs. 73.58%,  $p < 0.05$ ) and a higher score of self-efficacy (47.10 vs. 45.09,  $p < 0.01$ ).

### Associations Among Main Study Variables

As displayed in Table 2, disclosure to family members was positively associated with drug use ( $r = 0.11$ ,  $p < 0.01$ ), social support ( $r = 0.13$ ,  $p < 0.01$ ) and self-efficacy ( $r = 0.15$ ,  $p < 0.01$ ). Social support had a positive relationship with treatment self-efficacy ( $r = 0.19$ ,  $p < 0.01$ ). ART adherence also showed a significantly positive correlation with

treatment self-efficacy ( $r = 0.25$ ,  $p < 0.01$ ). In addition, the disclosure to family member was negatively associated with participants' age ( $r = -0.16$ ,  $p < 0.01$ ).

### Path Analysis

The results of final parallel mediation models (e.g., estimates of path coefficients, percentage of variance explained in each key variable) were presented in Fig. 1a (social support model) and Fig. 1b (self-efficacy model). The results of the serial mediation model were presented in Fig. 1c.

As shown in Table 3, the parallel mediation analysis indicated that the mediating effect of social support (Fig. 1a) was not significant ( $\beta = 0.005$ , 95% CI [-0.001, 0.01]), while self-efficacy (Fig. 1b) was a significant mediator of the relationship between disclosure and adherence ( $\beta = 0.03$ , 95% CI [0.01, 0.05]). The parallel models explained 1.74% and 3.22% of the variance in social support and self-efficacy, respectively. The social support model and self-efficacy

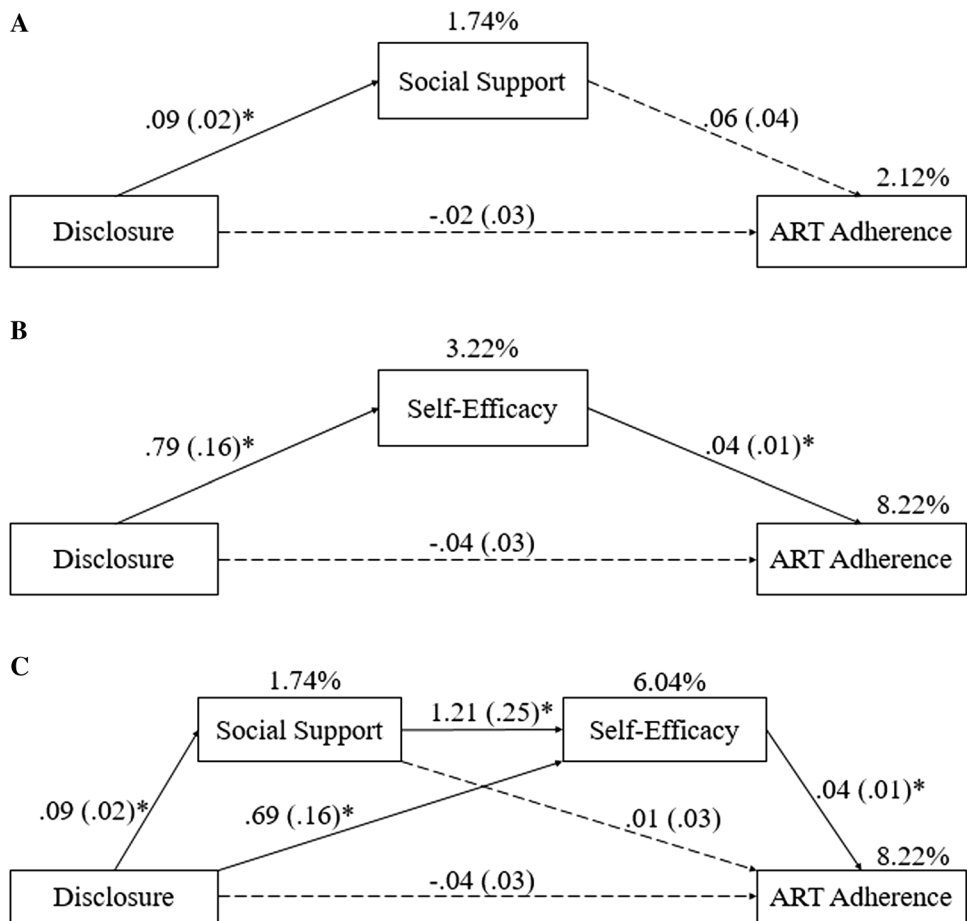
**Table 2** Descriptive statistics and correlation matrix of main measures

	Range	<i>M</i>	<i>SD</i>	1	2	3	4	5
1. Age	21.08–59.33	37.23	5.90					
2. Drug use <sup>a</sup>	0–1	19.93%		–0.02				
3. Disclosure to family	0–8	1.74	1.39	–0.16**	0.11**			
4. Medication social support	0–4	1.32	0.91	0.02	0.01	0.13**		
5. Treatment adherence self-efficacy	12–60	46.17	6.48	0.02	–0.07	0.15**	0.19**	
6. ART adherence	0–5	4.28	1.02	0.05	–0.13**	–0.03	0.04	0.25**

<sup>a</sup>Drug use coded as 0 = No, 1 = Yes

\*\**p* < 0.01; Only those significant in independent-samples *t* test or  $\chi^2$  test were included in this table

**Fig. 1** Path analysis model for the direct and indirect effects of disclosure to immediate family members on medication adherence via social support and adherence self-efficacy. Potential confounding variables which were significantly associated with ART adherence were controlled in the model as covariates, including age, ethnicity, monthly household income, data collection mode, depression, and stigma. Correlations between covariates and ART adherence have been omitted for reasons of presentation simplicity. The solid line and dashed line indicated significant and non-significant path coefficients, respectively. \**p* < 0.05; \*\**p* < 0.01



model explained 2.12% and 8.22% of the variance in ART adherence, respectively.

Serial mediation analysis (Fig. 1c) showed that the hypothesized model with both direct and indirect paths from disclosure to adherence accounted for 1.74% variances in social support, 6.04% variances in self-efficacy and 8.22% in ART adherence. The direct effect of disclosure on adherence was not significant ( $\beta = -0.04$ , 95% CI [-0.09, 0.004]), so was the direct effect of social support on adherence ( $\beta = 0.01$ , 95% CI [-0.07, 0.08]), while self-efficacy showed a significant direct

effect on adherence ( $\beta = 0.04$ , 95% CI [0.03, 0.05]). As shown in Table 3, the indirect effect of the serial mediation from disclosure to adherence via social support and self-efficacy was significant ( $\beta = 0.004$ , 95% CI [0.002, 0.01]).

**Table 3** Decomposition of the effect of disclosure on ART adherence

	ART adherence	
	$\beta$	95% CI
Direct effect		
Disclosure	−0.04	(−0.09, 0.004)
Medication social support	0.01	(−0.07, 0.08)
Treatment adherence self-efficacy	0.04	(0.03, 0.05)
Indirect effects through		
Medication social support	0.005	(−0.001, 0.01)
Treatment adherence self-efficacy	0.03	(0.01, 0.05)
Medication social support and treatment adherence self-efficacy	0.004	(0.002, 0.01)

$\beta$  values are unstandardized coefficients; 95% CI=95% bootstrapped confidence intervals

## Discussion

The results of the present study indicate a potential indirect effect of disclosure of HIV status to family members on ART adherence, through both individual mediators and serial mediators. The findings suggested that disclosure was positively associated with adherence self-efficacy, which is related to a better adherence. The pathway suggests that adherence self-efficacy plays an important role in disclosure-adherence association. As adherence self-efficacy reflects one's confidence to deal with health problems related to treatment, adhere to ART regimen, and manage side effects [46], high self-efficacy might help augment the benefits of disclosure and buffer the possible and often unexpected negative effects of disclosure on adherence, which in turn amplify the overall advantage of disclosure on adherence. This finding is consistent with previous studies, in which medication self-efficacy acted as a protector to alleviate negative influence of stigma on quality of life [52] and was introduced as a facilitator to ART adherence [46].

The indirect path from disclosure to adherence via medication-specific social support and adherence self-efficacy is also significant. The combined indirect effect of social support and self-efficacy suggests that disclosure might give rise to greater social support, which leads to better self-efficacy, which finally positively impacts disclosure. Given that mediating effect of social support alone between disclosure and adherence is not significant in current study, the significant mediating role of social support and self-efficacy may imply an interlinked effect. Instead of operating separately, social support aroused by disclosure might be conducive to adherence only when it facilitates self-efficacy. Should it be the case, self-efficacy would be a more immediate cause than social support and social support would be in vain if oneself have no confidence to adhere. This finding is consistent with previous study in which treatment adherence self-efficacy

was found to mediate the relationship between general social support and adherence [48]. The same study also showed that the association between general social support and self-efficacy was no longer significant when patient satisfaction with healthcare providers was taken into consideration, which suggested that social support from a healthcare provider was more important than general support in enhancing self-efficacy [48]. In line with this evidence, our finding also implies that treatment or adherence specific social support and self-efficacy might be better indicators in studies related to ART treatment, compared with general social support and self-efficacy.

In consistent with some previous studies, the direct path between disclosure and adherence was not significant. This result suggests a possibility of both positive and negative effects of disclosure. On the one hand, disclosure is beneficial when it alleviates depression and anxiety [58], enhances social support [28] and releases the stress of secrecy [59]. On the other hand, disclosure (especially those that are unplanned, or culturally or developmentally inappropriate) could be harmful when it disrupts relationships with families or communities [60], evokes partner violence [61], increases the perceptions of stigma [14], and leads to psychological distress [62]. Our result provides evidence to support the notion that not all the disclosures necessarily appear to benefit adherence [63]. In addition, disclosure could be associated with adherence through different pathways, in which mechanisms are complex and diverse.

The results extend our understanding about how disclosure of HIV status is related with ART adherence by uncovering the role of social support towards treatment adherence and self-efficacy in taking medications and managing the disease. The findings might have several implications for future interventions aimed at improving ART adherence. First, the present study suggests possible efforts which may bolster the effectiveness of various existing interventions of ART adherence. For example, a cognitive-behavioral therapy-based intervention was developed in order to facilitate adherence [59]. The intervention contained 12 sessions to discuss difficulties and progresses in adherence and to generate strategies to solve the problems. The present study implies that the existing intervention of adherence might be further enhanced by adding sessions targeting disclosure management, perceived social support, and self-efficacy enhancement. Second, the results suggest a chain relationship among disclosure, social support and self-efficacy, which indicate that disclosure management may help to improve social support [26, 64] and then self-efficacy [65] in a row. This finding may also contribute to intervention improvement. While some interventions solely targeted on disclosure [43] or social support [66] as a means of improving ART adherence, our results indicate that further interventions may combine or integrate the efforts in managing

disclosure, improving social support and self-efficacy, so the intervention motivating disclosure could also be efficacious to energize social support and self-efficacy and improve adherence at the same time.

Inevitably, this study has some limitations. First, questions concerning HIV are always sensitive so that the responses would be influenced by social desirability [67], especially when questions are presented via face-to-face interviews compared to self-administered survey [68]. Social desirability might account for the difference in adherence between participants who completed survey via face-to-face interview and participants who completed questionnaires by themselves. Besides the bias produced by social desirability, self-report may result in overestimation of adherence because of the inaccuracy in recalling times of medicine taking over a long retrospective window (e.g. 30 days) [69]. However, although self-report is subject to social desirability and recall bias, it is generally considered a valid assessment technique of adherence that associates steadily and consistently with biological markers of medical treatment such as viral load and CD4 count [38, 65, 70]. Even so, it is suggested to combine different measurements of adherence, such as electric monitoring and self-report, to improve the assessment accuracy in future research [70].

Second, our findings should be considered preliminary. Although some of the pathways were significant, the percentage of variance explained in each key variable by the serial mediation model was small (e.g., 1.74% in social support, 6.04% in self-efficacy, and 8.22% in ART adherence). The insufficient variances explained suggest that there may be other important factors besides social support and self-efficacy that impact ART adherence. As a matter of fact, existing literature has suggested numerous factors that may impact adherence, including psychological symptoms [71], stigma [72], frequency of religious attendance [73], financial status [74], even demographics such as age [75], gender [76] and ethnicity [77]. Third, our data were derived from a cross-sectional survey, where causal inference cannot be generated. Although we tested an alternative model with reversed pathways and found less variance that would be accounted by the model, we still could not rule out the reverse-causality. The preliminary nature of this study suggests the potential tenuousness of the effect. For future research, longitudinal and prospective research is needed to evaluate causal relationships and to examine further impacts that disclosure may have on adherence over time.

In summary, the results of the current study indicated a role of social support and self-efficacy in mediating the relationship between HIV disclosure to family members and medication adherence among PLWH. Though the indirect effect was small, the findings extend our understanding of the relationship among disclosure, social support, self-efficacy, and ART adherence, which could be critical for

improvement and implementation of future interventions with an ultimate goal of improving ART adherence among PLWH in China and other cultural settings.

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## Compliance with Ethical Standards

**Conflict of interest** Authors declare no of conflict of interest.

**Ethical Approval** The study protocol received review and approval from the Institutional Review Boards at Guangxi CDC in China and Wayne State University in the United States.

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

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