

HIV/AIDS strategies should focus on outcomes and the psychological status of older patients diagnosed with HIV

Yuan Guan^{1,2,§}, Han Zhu^{1,2,§}, Tangkai Qi², Renfang Zhang², Jun Chen², Li Liu², Yinzhong Shen², Hongzhou Lu^{1,2,3,*}, Qi Tang^{1,2,*}

¹ Scientific Research Center, Shanghai Public Health Clinical Center, Fudan University, Shanghai, China;

² Department of Infection and Immunology, Shanghai Public Health Clinical Center, Fudan University, Shanghai, China;

³ Department of Infectious Diseases, National Clinical Research Center for Infectious Diseases, The Third People's Hospital of Shenzhen, Shenzhen, Guangdong Province, China.

SUMMARY In the context of an aging global population, the aging of patients with HIV is an issue that society will have to face. Data indicate that between 2011 and 2019, the proportion of patients age 60 and over who were newly diagnosed with HIV in China increased from 12% to 25%. In contrast to younger groups, the special characteristics of older patients pose major challenges to the management of their disease. The current study examined the clinical outcomes and psychological status of patients age 50 and over who were diagnosed with HIV. Out of a total of 566 older patients from eastern China, viral suppression was achieved in 446 (78.8%), treatment was immunologically effective in 410 (72.4%), and treatment was effective in 324 (57.2%). Thirty-nine patients (6.9%) had significant anxiety and 143 (25.3%) exhibited depressive tendencies. Level of education and the time from diagnosis to treatment were associated with the effectiveness of treatment. Age, sleep quality, chronic illness, exercise, and travel time to medical appointments were associated with depressive symptoms. These findings suggest that the burden of HIV among the older population remains high in more economically developed areas. The urgent need for HIV education and screening programs, as well as follow-up visits and early initiation of treatment in older patients, is called for.

Keywords effectiveness of HAART, HIV/AIDS, older patients, depressive symptoms

1. Introduction

In recent years, aging has further intensified in China (1). According to data from China's 7th National Census, the country's population totaled 141.78 million, of which 18.70% were age 60 and over and 13.50% were age 65 and over. The proportions of these two age groups increased by 5.44% and 4.63%, respectively, compared to 2010 (2). As the older population continues to grow, society will be confronted by the aging of patients infected with HIV. Relatively stable viral suppression has been achieved in an increasing number of patients with HIV through highly active antiretroviral therapy (HAART). This is reflected at the epidemiological level in the reduction in mortality and prolonged survival for patients with HIV. According to a report in the United States and dependent areas, the number of people over the age of 55 years with HIV increased from 2014-2018 (Figure 1) (3). A point worth mentioning is that most older patients with HIV are currently infected and diagnosed in midlife (4). Data indicate that between

2011 and 2019 the proportion of patients age 60 and over who were newly diagnosed with HIV in China increased from 12% to 25% (Figure 2) (5). This indicates that the incidence of new HIV infections in older people in China is also increasing each year.

Compared to the general population, older patients have some specific problems, such as reduced immune function, a high risk of chronic comorbidities, and high levels of anxiety and depression. All of these problems pose significant challenges to health management. An increase in the CD4⁺ T lymphocyte count (CD4) over 2 years in patients receiving HAART is negatively correlated with age (6). Despite receiving HAART, older patients have a worse prognosis and more rapid disease progression compared to younger patients. In older patients, HIV is often transmitted through heterosexual sex, and a higher proportion of those patients are males (7). Older men need not consider contraception, and they often do not use condoms when having sex with their spouse or sexual partners. These behaviors increase the risk of HIV infection for themselves and their sexual

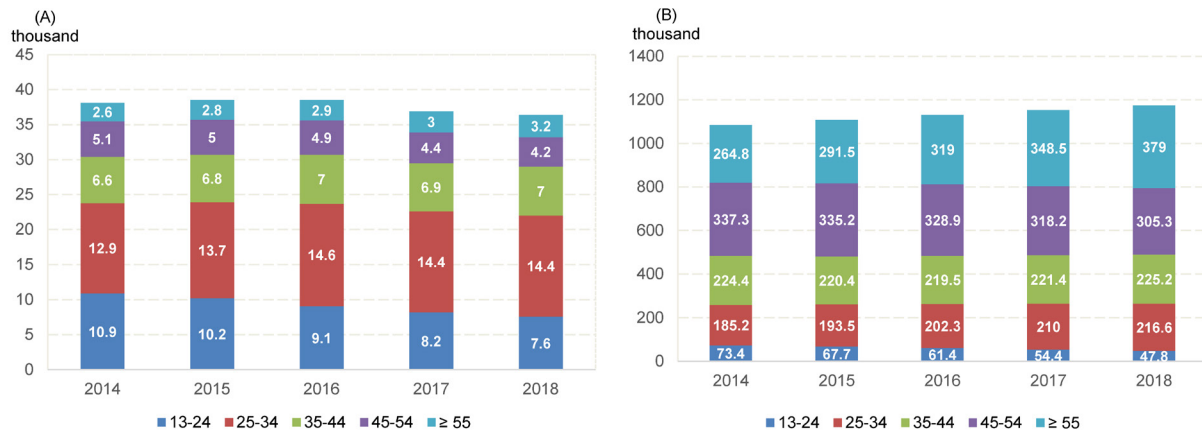


Figure 1. HIV incidence and prevalence among persons \geq the age of 13 in the United States from 2014 to 2018. Based on data from the Center for Disease Control and Prevention, the number of patients newly diagnosed with HIV \geq the age of 55 increased from 26,000 in 2014 to 32,000 in 2018 and the number of people living with HIV age 55 or over increased from 264,800 in 2014 to 379,000 in 2018.

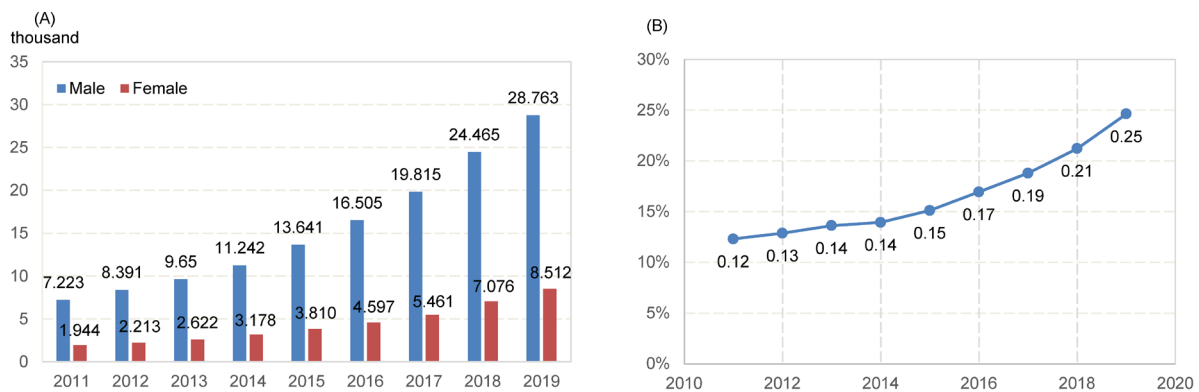


Figure 2. Gender distribution and proportion of patients age 60 and over newly diagnosed with HIV in China from 2011-2019. Based on data from the Chinese CDC and Public Health Science Data Center, the number of male patients newly diagnosed with HIV \geq the age of 60 in China increased from 7,223 in 2011 to 28,763 in 2019 and the number of female patients increased from 1,944 to 8,512. The ratio of male to female patients was relatively consistent during the 9 years in question, with more than three times as many male patients as female patients. The proportion of patients age 60 and over newly diagnosed with HIV increased from 12% in 2011 to 25% in 2019.

partners (8). A study has found that older patients may face more complex physical, psychological, and social adjustment challenges due to the double whammy of aging and AIDS (9). Havlik *et al.* (10) reported that more than 50% of older patients had depressive symptoms. Therefore, the factors associated with infection and treatment need to be promptly ascertained in order to control the spread of outbreaks among older patients.

Shanghai is a typical large metropolis with one of the largest elderly populations in China. Although the prevalence of HIV is low, data indicate that the prevalence of HIV and the proportion of older patients with HIV are increasing in Shanghai (5,11). The current study was conducted in patients age 50 and over who were newly diagnosed with HIV in Shanghai. Their clinical outcomes and their virological and immunological status were described and analyzed in a real-world context. Their anxiety and depression profiles were also analyzed to ascertain the characteristics of their distribution and factors influencing those conditions in order to provide a scientific basis for the formulation

of prevention and treatment strategies targeting older patients.

2. Materials and Methods

2.1. Study design

A cross-sectional study was conducted by administering a one-on-one questionnaire in an outpatient clinic. Data on outcome measures were obtained from clinic files or the hospital information system (HIS). The questionnaire consisted of three parts: the first part concerned demographic characteristics (age, gender, marital status, level of education, *etc.*); the second part concerned information related to HAART (route of infection, chronic disease, CD4 count, viral load, *etc.*); and the third part concerned psychological status (anxiety/depression) and the Hospital Anxiety and Depression Scale (HADS). This study was approved by the Ethics Committee of the Shanghai Public Health Clinical Center (approval no. 2019-S054-02). Informed

consent was obtained from all participants.

2.2. Study population

Potential participants were patients seen at the outpatient clinic of the Department of Infection and Immunology, Shanghai Public Health Clinical Center from September 2019 to September 2020. These patients were positive for HIV antibodies according to primary screening *via* an enzyme-linked immunosorbent assay, and those results were confirmed using Western blotting. Participants were all age 50 years or over at the time of HIV diagnosis and they had received HAART for three years or longer. Patients over 50 years of age who were newly diagnosed with HIV were deemed to be "older" while those <the age of 50 were deemed to be "younger" (7). Potential participants with a history of substance abuse or drug use or who were unable to clearly provide consent were excluded. Potential participants who for any reason might not be able to complete this study were also excluded.

2.3. Outcomes

2.3.1. Clinical outcomes and the effectiveness of treatment

(i) Viral suppression: According to Chinese guidelines on treatment of HIV (12), virological indicators are the most important indicators. Viral load is mainly used to evaluate the effectiveness of viral suppression after HAART in patients with HIV. A recent viral load < 20 copies/mL was deemed to be complete viral suppression.

(ii) Immunological indicators: In this study, an increase in CD4 cells served as a supplementary indicator to further corroborate the effectiveness of treatment. According to the aforementioned guidelines, an increase in CD4 cells > 100 cells/uL or an increase > 30% after 1 year of HAART suggests that immunotherapy has been effective (12).

(iii) Immune reconstitution: Levels of CD4 cells are mainly used to evaluate the immune status of patients with HIV. Considering the specificity of the population, CD4 cells of 350 cells/uL or more after three years of HAART was deemed to be immune reconstitution.

In this study, treatment was deemed to be effective with an increase in CD4 cells > 100 cells/uL or > 30% after 1 year of HAART and a viral load < 20 copies/mL.

2.3.2. Psychological status

The HADS can rapidly screen anxious/depressed patients and is now widely used to assess depression and anxiety status in inpatients (13). In the current study, the HADS was used to evaluate psychological symptoms of anxiety/depression with 14 items, including two

subscales for anxiety (7 items) and depression (7 items). A study participant was considered positive for anxiety/depression if his or her score was ≥ 8 , with a maximum score of 21.

2.4. Statistical analysis

IBM SPSS Statistics 23.0 was used for data analysis. The normality of data was tested. The mean \pm standard deviation was used to describe data with a normal distribution, quartiles were used to describe data with a non-normal distribution, and the percentage (%) was used to describe numerical data. Differences between groups were analyzed using ANOVA for normally distributed data. Non-parametric tests were used to analyze non-normally distributed data, and the chi-square test and Fisher's exact probability test were used to analyze numerical data. Logistic regression analysis was used to analyze influencing factors. A *P* value < 0.05 was considered significant.

3. Results and Discussion

3.1. Descriptive statistics overall and by HIV status

Table 1 summarizes the demographic of characteristics of the sample of older patients from 1994 to 2017. This study involved 566 patients infected with HIV (496 males (87.6%) and 70 females (12.4%)) from eastern China. As is apparent from the table, most participants (57.2%) were 60-70 years of age, and 18.7% were over 70 years of age. Most participants (64.0%) had a BMI from 18.5 to 23.9 kg/m². Few of the participants (7%) lived in rural areas. Most participants (409 patients, 72.3%) were married, most (458 patients, 80.9%) had a junior high school or high school level of education, and most (446 patients, 78.8%) were retired. Few participants (158 patients, 27.9%) lived alone. This study found that a slightly higher percentage of participants had same-sex HIV infections than heterosexual infections. And the ratio of male to female patients differed significantly (more than 7 times as many males as females). This reflects the seriousness of the HIV status among elderly men who have sex with men in Shanghai. Elderly males may have a greater desire for sex than females. In addition, the sex life and risky sexual behavior of elderly males are key reasons for HIV infection (14,15).

3.2. Clinical outcomes and psychological characteristics of older patients

Table 2 summarizes the clinical outcomes and psychological characteristics of older patients. Viral suppression was achieved in a total of 446 participants (78.8%). Levels of viral suppression were similar across three age groups, with the highest rate of suppression being 82.4% among participants under the age of

60. Treatment was immunologically effective in 410 participants (72.4%). Treatment was effective in a total of 324 participants (57.2%). In this study, immunological nonresponse (INR) after long-term HAART was defined

as a CD4 cell count < 350 cells/ μ l in patients who had received HAART for more than 36 months. An INR was present in 257 older patients (45.4%), and the rate of INR was similar across all age groups. Thirty-nine patients (6.9%) exhibited symptoms of anxiety and 143 (25.3%) had depressive tendencies, while the younger group (under 60 years of age) had the lowest percentage of both psychological symptoms.

Table 1. Descriptive statistics overall and by HIV status (n = 566)

Characteristics	n	%
Gender		
Male	496	87.6
Female	70	12.4
Age (years)		
< 60	136	24
60 ~	324	57.2
≥ 70	106	18.7
BMI (Kg/m ²)		
< 18.5	32	5.7
18.5-23.9	362	64.0
24-28	146	25.8
≥ 28	26	4.6
Residence		
Rural	40	7
Non-rural	526	93
Annual household income (\$)		
< 10,700	318	56.2
≥ 10,700	248	43.8
Personal medical expenses annually (\$)		
< 466	217	38.3
≥ 466	349	61.7
Living conditions		
Living alone	158	27.9
Living with others	408	72.1
Level of education		
Primary School or below	52	9.2
Middle School or High School	458	80.9
University or above	56	9.9
Marital status		
Married	409	72.3
Unmarried	52	9.2
Divorced or widowed	105	18.6
Employment status		
Working	92	16.3
Retired	446	78.8
Unemployed	28	4.9

3.3. Analysis of factors influencing the effectiveness of treatment and symptoms of depression

3.3.1. Effectiveness of treatment

Table 3 shows the results of an analysis of the association between each background variable and the effectiveness of treatment in older patients from among the entire sample. Treatment was effective in a total of 324 participants (57.2%). Univariate analysis indicated that significant variables associated with effectiveness of treatment included age, marital status, level of education, living conditions, time from HIV diagnosis to treatment, and anxiety and depression. Multivariate analysis indicated that treatment was more likely to be effective in patients who were college-educated and who underwent treatment within one month of being diagnosed with HIV.

Public education about the HIV epidemic has spread nationwide. HIV screening and treatment have been heavily promoted *via* continued updates of guidelines on HIV prevention and treatment (16-18). Although HIV testing and HAART are free, treatment was not entirely effective in 42.8% of the older patients in the current study. Moreover, nearly half of the participants developed INR. This may be due to a progressive decline in immune function with age, suggesting that advanced age may be a risk factor for INR and adverse outcomes (19). Like a previous study (20) found, our study found that treatment was more likely to be

Table 2. Clinical outcomes and psychological characteristics of older patients

Clinical indicators	n (%)				P
	< 60	60-70	> 70	Total	
Virologic suppression					
Recent viral load < 20 copies/mL	112 (82.4)	250 (77.2)	84 (79.2)	446 (78.8)	0.46
Immunological indicators					
Increase in CD4 cells > 100 cells/uL or an Increase > 30% after 1 year of HAART	103 (75.7)	237 (73.1)	70 (66)	410 (72.4)	0.22
Effective treatment*	83 (61.0)	187 (57.7)	54 (50.9)	324 (57.2)	0.28
Immune reconstitution					
CD4 cells ≥350 cells/uL after 3 years of HAART	76 (55.9)	172 (53.1)	61 (57.5)	309 (54.6)	0.72
Psychological conditions					
Anxiety	6 (4.4)	26 (8.0)	7 (6.6)	39 (6.9)	0.37
Depression	26 (19.1)	82 (25.3)	35 (33.0)	143 (25.3)	0.04

*Treatment was deemed to be effective with an increase in CD4 cells > 100 cells/uL or > 30% after 1 year of HAART and a viral load < 20 copies/mL.

Table 3. Univariate and multivariate logistic regression analysis of the effectiveness of treatment in older patients (n = 566)

Characteristics	Total	Univariate P-value	OR (95%CI)	Multivariate P-value	OR (95%CI)
Age (years)					
< 60	83 (61.0)	0.01	1		
60 ~	187 (57.7)	0.51	0.87 (0.58-1.31)		
≥ 70	54 (50.9)	0.12	0.66 (0.40-1.11)		
Gender					
Male	282 (56.9)		1		
Female	42 (60.0)	0.62	1.14 (0.68-1.90)		
BMI (Kg/m)					
< 18.5	14 (43.8)	0.25	1		
18.5-23.9	211 (58.3)	0.12	1.80 (0.87-3.72)		
24-28	81 (55.5)	0.23	1.60 (0.74-3.46)		
≥ 28	18 (69.2)	0.05	2.89 (0.98-8.58)		
Marital status					
Married	246 (58.9)	0.003	1		
Unmarried	19 (44.2)	0.97	1.01 (0.56-1.81)		
Divorced or widowed	59 (56.2)	0.82	0.95 (0.62-1.46)		
Level of education					
Primary school or lower	24 (46.2)	0.58	1	0.06	1
Middle school or High school	261 (57.0)	0.14	1.55 (0.87-2.75)	0.11	1.62 (0.90-2.93)
University or higher	39 (69.6)	0.01	2.68 (1.22-5.89)	0.02	2.64 (1.12-5.91)
Employment status					
Working	58 (63.0)	0.45	1		
Retired	251 (56.3)	0.23	0.76 (0.48-1.20)		
Unemployed	15 (53.6)	0.37	0.68 (0.29-1.60)		
Route of infection					
Heterosexual transmission	106 (61.3)	0.43	1		
Homosexual transmission	100 (54.9)	0.23	0.77 (0.51-1.18)		
Unknown	118 (55.9)	0.29	0.80 (0.53-1.21)		
Living conditions					
Living alone	77 (48.7)		1		
Living with others	247 (60.5)	0.009	1.63 (1.13-2.35)		
Smoking					
Yes	110 (58.8)		1		
No	214 (56.5)	0.15	1.57 (0.64-1.30)		
Drinking					
Yes	89 (60.5)		1		
No	235 (56.1)	0.08	1.84 (0.57-1.22)		
Exercise					
Yes	189 (55.8)		1		
No	135 (59.5)	0.76	1.08 (0.83-1.64)		
Time*					
≤ 1	213 (60.7)	0.00	1	0.06	1
1-6	55 (49.1)	0.03	0.63 (0.41-0.96)	0.02	0.60 (0.39-0.94)
> 6	56 (54.4)	0.25	0.77 (0.50-1.20)	0.29	0.78 (0.49-1.25)
Chronic diseases					
Yes	153 (55.6)		1		
No	171 (58.8)	0.45	1.14 (0.81-1.59)		
Sleep quality					
Good	196 (58.5)	0.76	0.86 (0.56-1.33)		
Fair	61 (55.0)	0.51	0.90 (0.59-1.37)		
Poor	67 (55.8)	0.61			
Anxiety					
Yes	25 (64.1)		1		
No	299 (56.7)	0.002	1.31 (0.69-2.68)		
Depression					
Yes	86 (60.1)		1		
No	238 (56.3)	0.01	1.28 (0.80-1.73)		

*Time from diagnosis of HIV to drug treatment (months).

effective with the earlier initiation of HAART. However, at least 38% of the participants in the current study started treatment one month after diagnosis. HAART was often initiated late. The time from diagnosis of HIV to initiation of HAART needs to be reduced for people

age 50 and over. Taking HIV medication every day can result in an undetectable viral load. People who have and who maintain an undetectable viral load (or who have viral suppression) can live a long and healthy life. They also have effectively no risk of transmitting HIV

to an HIV-negative sex partner.

3.3.2. Depressive symptoms

Table 4 shows the crude association between each background variable and depressive symptoms for the entire sample. These findings indicate the need to alleviate mental distress in older patients with HIV in eastern China, since approximately 25% of the participants in the current study exhibited possible depressive symptoms. Univariate analysis indicated that significant variables associated with symptoms of

anxiety included age, marital status, level of education, travel time to medical appointments, employment status, smoking, drinking, exercise, chronic illness, and sleep quality. Multivariate analysis indicated that patients of advanced age, who traveled a long time to medical appointments, and who had poor sleep were more likely to have a depressed mood. In contrast, those who exercised regularly and had no chronic illnesses were less likely to be depressed.

Depression has serious negative consequences for older patients. It may increase comorbidities and the risk of suicide and reduce quality of life (21). In the

Table 4. Univariate and multivariate logistic regression analysis of depressive symptoms (n = 566)

	Total	Univariate P-value	OR (95%CI)	Multivariate P-value	OR (95%CI)
Age (years)					
< 60	26 (19.1)	0.00	1	0.08	1
60 ~	82 (25.3)	0.15	1.43 (0.87-2.35)	0.25	1.46 (0.76-2.80)
≥ 70	35 (33.0)	0.01	2.08 (1.16-3.76)	0.03	2.33 (1.08-5.02)
Gender					
Male	127 (25.6)				
Female	16 (22.9)	0.62	0.86 (0.48-1.56)		
BMI (Kg/m)					
< 18.5	119 (34.4)	0.66	1		
18.5-23.9	91 (25.1)	0.26	0.64 (0.30-1.38)		
24-28	35 (24)	0.23	0.60 (0.26-1.37)		
≥ 28	6 (23.1)	0.35	0.57 (0.18-1.84)		
Marital status					
Married	109 (26.1)	0.00	1		
Unmarried	5 (11.6)	0.10	0.52 (0.24-1.14)		
Divorced or widowed	29 (27.6)	0.72	1.09 (0.67-1.77)		
Level of education					
Primary school or lower	13 (25)	0.00	1		
Middle school or High school	124 (27.1)	0.75	1.11 (0.58-2.17)		
University or higher	6 (10.7)	0.06	0.36 (0.13-1.03)		
Employment status					
Working	14 (15.2)	0.02	1		
Retired	118 (26.5)	0.03	2.00 (1.09-3.68)		
Unemployed	11 (39.3)	0.008	3.61 (1.40-9.30)		
Travel time to medical appointments					
0.5 h	6 (10.3)	0.005	1	0.007	1
0.5-1 h	48 (21.6)	0.06	2.39 (0.97-5.90)	0.024	2.94 (1.15-7.52)
1-3 h	84 (31)	0.003	3.89 (1.61-9.42)	0.001	4.44 (1.78-11.1)
> 3 h	5 (33.3)	0.035	4.33 (1.11-16.99)	0.031	4.79 (1.15-19.9)
Route of infection					
Heterosexual transmission	41 (23.7)	0.14	1		
Homosexual transmission	39 (21.4)	0.61	0.88 (0.53-1.45)		
Unknown	63 (29.9)	0.18	1.37 (0.87-2.17)		
Smoking					
Yes	48 (25.1)		1		
No	96 (25.3)	0.002	0.33(0.68-1.51)		
Drinking					
Yes	27 (18.4)		1		
No	116 (27.7)	0.000	0.13 (1.06-2.72)		
Exercise					
Yes	64 (18.9)		1		1
No	79 (34.8)	0.000	0.10 (1.56-3.37)	0.000	0.45 (1.68-4.32)
Chronic diseases					
Yes	86 (31.3)		1		1
No	57 (19.6)	0.001	0.54 (0.36-0.79)	0.04	0.64 (0.41-0.98)
Sleep quality					
Good	68 (20.3)	0.00	1	0.001	1
Fair	24 (21.6)	0.77	1.08 (0.64-1.83)	0.80	1.08 (0.61-1.90)
Poor	51 (42.5)	0.00	2.90 (1.85-4.55)	0.000	2.56 (1.54-4.25)

current study, 35.6% of participants with depressive symptoms reported having poor sleep. In contrast, 16.5% of participants without depressive symptoms reported poor sleep. This finding is consistent with other studies which have found that poor sleep is a major factor for depression (22-23). Some studies have suggested a bidirectional relationship between sleep and depression, where treating depression may improve sleep and treating sleep disorders may reduce the incidence of depression (22-24). Therefore, sleep quality should be assessed and interventions should be promptly implemented for older patients with depressive symptoms. Daily exercise is important for the physical and mental health of patients with HIV. However, the current study found that 40.2% of participants had not engaged in any physical exercise in the last 6 months. Evidence suggests that aerobic and resistance exercise can improve cardiovascular health, enhance muscle strength, and improve quality of life for patients with HIV (25). Group exercise will also increase social participation and reduce HIV-related isolation (26). The current findings indicate that in addition to HIV itself, physical, psychological, and social factors can influence depression-related symptoms.

Given China's large population and its aging, as well as the special problems particular to older patients, greater attention should be paid to HIV prevention and health management. Several targeted strategies are hereby proposed: *i*) Creation of a community-based HIV prevention and education program for the older population. Local CDCs can work together with community health service centers to disseminate HIV-related information to the older population, with a focus on reasonable sexual desires of older males to reduce the potential for infection associated with sexual intercourse. *ii*) Careful follow-up and early initiation of HAART for older patients with HIV. Education about HAART is an important step to ensuring that treatment is effective and adherence to treatment by older patients. Moreover, early initiation of HAART helps to achieve viral suppression and reduce the risk of transmission. Careful attention and follow-up are indispensable, and especially for patients newly diagnosed with HIV. *iii*) Assessment of sleep disorders should be incorporated into routine care. The impact of sleep problems on depressive symptoms is particularly evident in older patients with HIV. Mental health and social support services can be provided to older patients with HIV and sleep disorders in conjunction with sleep clinics.

The current study had several limitations that should be acknowledged. First, information on exposure and outcomes was obtained through a self-reported questionnaire, which may constitute a reporting bias. However, this is likely to be an undifferentiated bias. Second, this study used several self-administered scales and revised some of the original scales. Although reliability tests were conducted for each scale, the reliability of these scales still needs to be validated.

In conclusion, the current findings provide a snapshot of the current status of HAART outcomes and psychological status among older patients newly diagnosed with HIV in eastern China. Out of a total of 566 patients age 50 and over who were diagnosed with HIV in eastern China, treatment was effective in 324 (57.2%). One hundred and forty-three patients (25.3%) exhibited depressive tendencies. Level of education and the time from diagnosis to treatment were associated with the effectiveness of treatment. Age, sleep quality, chronic illness, exercise, and travel time to medical appointments were associated with depressive symptoms. These findings suggest that the burden of HIV among the older population remains high in more economically developed areas. The urgent need for HIV education and screening programs, as well as follow-up visits and early initiation of treatment in older patients, is called for.

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References

1. Chow EP, Wilson DP, Zhang L. HIV and syphilis co-infection increasing among men who have sex with men in China: A systematic review and meta-analysis. *PLoS One*. 2011; 6:e22768.
2. Secretariat for the Seventh National Census, National Bureau of Statistics, State Council. Communiqué on the Seventh National Census. http://www.gov.cn/guoqing/2021-05/13/content_5606149.htm (accessed August 10, 2021). (in Chinese)
3. CDC. Diagnoses of HIV infection in the United States and dependent areas, 2018 (updated). *HIV Surveillance Report* 2020; 31. <https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2018-updated-vol-31.pdf> (accessed September 14, 2021).
4. van Sighem AI, Gras LA, Reiss P, Brinkman K, de Wolf F; ATHENA national observational cohort study. Life expectancy of recently diagnosed asymptomatic HIV-infected patients approaches that of uninfected individuals. *AIDS*. 2010; 24:1527-1535.
5. Chinese CDC. Public Health Science Data Center. https://www.phsciencedata.cn/Share/ky_sjml.jsp?id=%27a56cd203-cd11-414d-9efa-d1583b97476f%27 (accessed September 14, 2021).
6. Althoff KN, Justice AC, Gange SJ, *et al.*; North American AIDS Cohorts Collaboration on Research, Design (NA-ACCORD). Virologic and immunologic response to HAART, by age and regimen class. *AIDS*. 2010; 24:2469-2479.
7. Eduardo E, Lamb MR, Kandula S, Howard A, Mugisha V, Kimanga D, Kilama B, El-Sadr W, Elul B. Characteristics and outcomes among older HIV-positive adults enrolled in HIV programs in four sub-Saharan African countries.

- PLoS One. 2014; 9:e103864.
8. Yang WL, Kouyos RD, Böni J, Yerly S, Klimkait T, Aubert V, Scherrer AU, Shilaih M, Hinkley T, Petropoulos C, Bonhoeffer S, Günthard HF; Swiss HIV Cohort Study (SHCS). Persistence of transmitted HIV-1 drug resistance mutations associated with fitness costs and viral genetic backgrounds. *PLoS Pathogens*. 2015; 11:e1004722.
 9. Grov C, Golub SA, Parsons JT, Brennan M, Karpiak SE. Loneliness and HIV-related stigma explain depression among older HIV-positive adults. *AIDS Care*. 2010; 22:630-639.
 10. Havlik RJ, Brennan M, Karpiak SE. Comorbidities and depression in older adults with HIV. *Sexual Health*. 2011; 8:551-559.
 11. Zou H, Hu N, Xin Q, Beck J. HIV testing among men who have sex with men in China: A systematic review and meta-analysis. *AIDS Behav*. 2012; 16:1717-1728.
 12. AIDS and Hepatitis C Professional Group, Society of Infectious Diseases, Chinese Medical Association; Chinese Center for Disease Control and Prevention. Chinese guidelines for diagnosis and treatment of HIV/AIDS (2018). *Zhonghua Nei Ke Za Zhi*. 2018; 57:867-884. (in Chinese w/English abstract)
 13. Guo C, Huang X. Hospital anxiety and depression scale exhibits good consistency but shorter assessment time than Zung self-rating anxiety/depression scale for evaluating anxiety/depression in non-small cell lung cancer. *Medicine (Baltimore)*. 2021; 100:e24428.
 14. Asher I, Guri KM, Elbirt D, Bezalel SR, Maldarelli F, Mor O, Grossman Z, Sthoeger ZM. Characteristics and outcome of patients diagnosed with HIV at older age. *Medicine (Baltimore)*. 2016; 95:e2327.
 15. Negin J, Geddes L, Brennan-Ing M, Kuteesa M, Karpiak S, Seeley J. Sexual behavior of older adults living with HIV in Uganda. *Archives Sex Behav*. 2016; 45:441-449.
 16. Wu Z. Achievement of HIV/AIDS program in the past 30 years and challenges in China. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2015; 36:1329-1331. (in Chinese)
 17. Yan H, Zhang M, Zhao J, Huan X, Ding J, Wu S, Wang C, Xu Y, Liu L, Xu F, Yang H. The increased effectiveness of HIV preventive intervention among men who have sex with men and of follow-up care for people living with HIV after 'task-shifting' to community-based organizations: A 'cash on service delivery' model in China. *PLoS One*. 2014; 9:e103146.
 18. Wu Z, Wang Y, Detels R, Rotheram-Borus MJ. China AIDS policy implementation: Reversing the HIV/AIDS epidemic by 2015. *Int J Epidemiol*. 2010; 39 Suppl 2:i1-3.
 19. Yang XD, Su B, Zhang T. Review of studies on HIV-1 immunological non-responders. *Int J Virol*. 2020; 27:82-85.
 20. Li CX, Li YY, He LP, Kou J, Bai JS, Liu J, Tian B, Cao LJ, Wang KH, Kuang YQ. The predictive role of CD4⁺ cell count and CD4/CD8 ratio in immune reconstitution outcome among HIV/AIDS patients receiving antiretroviral therapy: An eight-year observation in China. *BMC Immunol*. 2019; 20:31.
 21. American Psychological Association, 2019. Depression in Older Adults Living with HIV. <https://www.apa.org/pi/aids/resources/aging/depression> (accessed September 14, 2021).
 22. Junqueira P, Bellucci S, Rossini S, Reimão R. Women living with HIV/AIDS: Sleep impairment, anxiety and depression symptoms. *Arquivos de Neuro-Psiquiatria*. 2008; 66:817-820.
 23. Leyro TM, Babson KA, Bonn-Miller MO. Anxiety sensitivity in relation to sleep quality among HIV-infected individuals. *J Assoc Nurses AIDS Care*. 2014; 25:638-645.
 24. Ford DE, Kamerow DB. Epidemiologic study of sleep disturbances and psychiatric disorders. An opportunity for prevention? *JAMA*. 1989; 262:1479-1484.
 25. O'Brien KK, Tynan AM, Nixon SA, Glazier RH. Effectiveness of aerobic exercise for adults living with HIV: systematic review and meta-analysis using the Cochrane Collaboration protocol. *BMC Infectious Diseases*. 2016; 16:182.
 26. Treisman G, Fishman M, Schwartz J, Hutton H, Lyketsos C. Prevalence of depression or depressive symptoms among people living with HIV/AIDS in China: A systematic review and meta-analysis. *BMC Psychiatry*. 2018; 18:160.
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- §These authors contributed equally to this work.
- *Address correspondence to:
 Qi Tang, Shanghai Public Health Clinical Center, Fudan University, No.2901, Caolang Road, Jinshan District, Shanghai 201508, China.
 E-mail: tangqi@fudan.edu.cn
- Hongzhou Lu, National Clinical Research Center for Infectious Diseases, The Third People's Hospital of Shenzhen, The Second Affiliated Hospital of Southern University of Science and Technology, No.29, Bulan Road, Longgang District, Shenzhen, Guangdong, 518100, China.
 E-mail: luhongzhou@szsy.sustech.edu.cn
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