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HIV linkage to care and retention in care rate among MSM in Guangzhou, China

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Abstract

Quantifying HIV service provision along the HIV care continuum is increasingly important for monitoring and evaluating HIV interventions. We examined factors associated with linkage and retention in care longitudinally among MSM (n=1974, 4933 person-years) diagnosed and living in Guangzhou, China, in 2008–2014. We measured longitudinal change of retention in care (≥2 CD4 tests per year) from linkage and antiretroviral therapy initiation (ART). We examined factors

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Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical Approval

IRB approval was obtained from the Guangzhou CDC, and the Guangdong Provincial Center for Skin Diseases and STI Control, China, and from University of North Carolina at Chapel Hill.

associated with linkage using logistic regression and with retention using generalized estimating equations. The rate of linkage to care was 89% in 2014. ART retention rate dropped from 71% (Year 1) to 46% (Year 2), suggesting that first-year retention measures likely overestimate retention over longer periods. Lower CD4 levels and older age predicted retention in ART care. These data can inform interventions to improve retention about some subgroups.

Keywords

HIV care continuum; linkage to care; retention in care; China; MSM

INTRODUCTION

There is an increasing need for implementation research on how best to achieve viral suppression for prevention and control of HIV transmission. This is detailed in the World Health Organization (WHO) *Treat All* approach.¹ There are numerous existing studies and interventions focused on improving HIV testing,^{2,3} and so we focused on the subsequent stages of the HIV care continuum: linkage to care, retention in pre-antiretroviral therapy care and antiretroviral therapy (ART) care. Achieving high rates across all stages of the care continuum is important because interventions at these later stages may reduce risk behaviors after diagnosis⁴, promote viral suppression, and save money.⁵ Furthermore, diagnosed patients must be retained in care to receive interventions. In one study from the United States, 61% of HIV transmission was attributable to diagnosed cases lost to follow-up in the later stages of the HIV care continuum.⁶

Attrition at each stage of the HIV care continuum is common even with expansion of the treatment initiation criteria.⁷ Longitudinally, studies examining the change of retention in ART care among people living HIV (PLHIV) showed a decreasing proportion of retained patients over time.^{8–10} However, except for a few short-term (one year or less) pre-ART retention studies in Sub-Saharan Africa and South Africa,^{11,12} most studies focused on retention during ART care instead of during pre-ART care. Until a *Treat All* approach can be fully implemented, the pre-ART and ART care stages are equally important in controlling the HIV epidemic. Previous studies about the longitudinal change of retention in care have focused on PLHIV^{10–12}, people who inject drugs or women.^{8,9,13} With the exception of a few cross-sectional studies,^{14,15} men who have sex with men (MSM) have not yet been systematically studied in low and middle income countries.

China, a middle-income country, has experienced a marked increase in HIV prevalence among MSM from 1% in 2003 to 7.7% in 2014.¹⁶ The Chinese government has made HIV prevention among MSM a national priority.^{16,17} In 2003, the Chinese National Free Antiretroviral Treatment Program was implemented, providing free HIV testing, care, and ART for PLHIV.¹⁸ Treatment initiation criteria were expanded from CD4 200/ μ L to 350/ μ L in 2011, then to 500/ μ L in 2015, and finally to *Treat All* in 2016.¹⁹ Using surveillance data, prior studies have calculated the rate of retention in care in Chinese cities^{20,21} and examined factors associated with cross-sectional retention in care.²² However, only one study has examined the temporal trend of ART attrition for PLHIV,¹⁰ and longitudinal

studies of retention in care in China among MSM have been limited. In this study, we calculated the rate of linkage to care and the longitudinal change of retention in pre-ART and ART care among MSM diagnosed with HIV, and identified factors associated with retention in care in South China.

METHODS

Study population

This study was conducted in Guangzhou, the capital city of Guangdong Province in southern China. The HIV prevalence among MSM in Guangzhou was high at 11.4% in 2013.²³ In Guangzhou, the only location that provides free CD4 tests is the Center for Disease Control and Prevention (CDC). Since 2008, interventions addressing HIV testing, linkage and retention in care have been implemented as collaboration projects between Guangzhou CDC and community-based organizations (CBOs).³ At the time of data collection, all free ART was provided by one hospital in the city and CD4 results were entered into a centralized database, which was accessed for this study. Eighty-nine percent of diagnosed cases self-reported their transmission route at HIV diagnosis or follow-up in 2008–2014. We defined MSM as route of HIV transmission if a man ever self-reported having sexual intercourse with another man either at diagnosis or updated in follow-ups. We selected for MSM living with HIV who were diagnosed and living in Guangzhou at diagnosis (i.e. local MSM) from January 2008 through September 2014 (simplified to 2014 thereafter). MSM diagnosed in the three months prior to the set end point of data collection (31 December 2014) were excluded from analysis due to insufficient follow-up.

Data sources and descriptions

In China, a confirmed case of HIV is one that has tested positive in both a screening test and a confirmatory Western Blot. All diagnoses of HIV are reported to the national web-based HIV reporting system.²⁴ In this study, we accessed the case-reporting and follow-up data for all MSM diagnosed with HIV in Guangzhou. The data was collected from 2008 to 2014, when the reporting database was well-managed, more centralized and systematic. The case-reporting dataset was updated annually. Records of cases who migrated out of Guangzhou to other cities or provinces in China were not included in the case-reporting dataset of the respective year. The database included socio-demographic information, HIV diagnostic results, route of transmission, HIV testing site(s), and history of sexually transmitted diseases (STD). In particular, we categorized HIV testing sites into voluntary counseling and testing sites (VCTs) or CBOs, STD clinics, hospitals (for non-STD patients or patients undergoing surgery), and institutions (including entertainment sites, prison, immigration sites, drug rehabilitation centers, blood transfusion centers and partner service sites). We combined VCT sites and CBOs into one category because there is significant overlap between the two sites. Follow-up datasets recorded date and whether or not patients followed up, any history of STDs, and date and result of all CD4 tests. IRB approval was obtained from the Guangzhou CDC, and the Guangdong Provincial Center for Skin Diseases and STI Control, China, and from University of North Carolina at Chapel Hill.

Definition, data processing and statistical analysis of linkage to care

A case was considered linked to care if the individual received a CD4 test within 90 days of diagnosis.²⁵ We quantified linkage to care in two ways. First, we measured linkage to care of the entire population over time. For each calendar year from 2008–2014, the annual rate of linkage to care in the study population was calculated by dividing the number of linked cases by the total number of new diagnoses in each respective year. We also calculated the amount of time that passed between diagnosis and first CD4 test for each newly diagnosed MSM. Bivariable analysis and multivariable logistic regression were performed in SPSS to compare the characteristics between linked and not linked to care cases.

Definition, data processing and statistical analyses of retention in care

Retention in pre-ART care was defined as an individual receiving ≥ 2 CD4 tests in one year (performed ≥ 3 months apart) from time of linkage²², and retention in ART care was defined with the same criteria from time of ART initiation. Viral load testing criteria were not used as it is optional and infrequently used in China during the study period. Time was calculated in years starting from the date of linkage, regardless of time interval from diagnosis, with months 0–11 defined as year one, months 12–23 as year two, months 24–35 as year three, months 36–47 as year four and months 48–59 as year five. Our data endpoints were defined as either date of death (if applicable) or year of last updated record in the case-reporting dataset (migrated outside the city or data end point). Data from the first five years were included in pre-ART retention analyses and the first three years were selected for ART retention analyses. The sample size in later years was too small for analysis and was therefore removed. The rate of retention for each time period was calculated by dividing the number of cases retained in care by the total number of cases alive and with available records. We did not calculate trend of retention rate by calendar year as it was highly affected by the proportion of diagnosed cases in the first year. Socio-demographic factors including marital status, education level, employment status, Guangzhou registered residence and STD history were updated annually in the longitudinal dataset for analyses, and were transcribed from the corresponding time point in case-reporting dataset. The minimum CD4 level from the previous year was used as an independent variable of retention in care.

Data for retention in pre-ART and ART care (≥ 2 CD4 tests in the year) was a within-subject repeated measurement. As the status changed across time, we used a binary logistic generalizing estimating equation (GEE) in SPSS to analyze this longitudinal pattern.²⁶ In the GEE model of pre-ART care (“in care” as 1, “not in care” as 0), pre-ART care of the year after linkage was used as an outcome variable. In the GEE model of ART care (“in care” as 1, “not in care” as 0), ART care in the year after ART initiation was used as an outcome variable. In GEE, we defined case as a subject-variable and time as a within-subject variable with an unstructured working correlation matrix. Sequential bonferroni adjustments were made for multiple comparisons.

RESULTS

We identified 1974 MSM (4933 person-years follow-up) who were diagnosed with HIV living in Guangzhou between January 2008 and September 2014. The median age at diagnosis was 29 years old (interquartile range (IQR)=24–35), with median CD4 count at diagnosis of 383/ μ L (IQR=277–491.5/ μ L, n=1833). (Table I) At diagnosis, 1147 (79%) MSM were working, 331 (17%) were married, 435 (22%) had a lower education level (below high school), and 564 (29%) had Guangzhou registered residency. Among the 918 MSM with available data on HIV testing experiences, only 149 (16%) had previous HIV testing experience (having tested negative for HIV) before diagnosis. HIV testing sites were mostly CBOs and VCT sites (77%). After diagnosis, 84% of diagnosed MSM were linked within 90 days and 43% of diagnosed MSM were initiated on ART. (Figure 1)

Linkage to care

The rate of linkage to care increased from 69% in 2008 to 89% in 2014. (Figure 2) Cumulatively, from the time of HIV diagnosis, 78% of MSM were linked within one month, and 84% were linked within three months. By the end of study period, 93% of newly diagnosed cases had received their first CD4 test after diagnosis. (Figure 1)

In evaluating linkage to care, MSM with lower education levels (crude odds ratio (OR)=0.60, 95% C.I.=0.46–0.79) and with Guangzhou registered residency (OR=0.44, 95% C.I.=0.35–0.57) were less likely to be linked to care (received a CD4 test within 90 days) in bivariable analysis (Table II). After adjusting for residency in the multivariable logistic regression model, those testing for HIV at CBOs or VCT sites (aOR=3.24; 95% C.I.=2.29–4.59) were more likely to be linked to care than those receiving testing at hospitals (reference group). Education level was not used as a confounder because the change in the adjusted odds ratio was less than 10%.

Retention in pre-ART care

After initial linkage to care, the rate of retention in pre-ART care (2 CD4 tests) dropped sharply from 75% in year one to 43% in year two. The rate then slowly declined to 35% in year five. (Figure 1) The declining rate of retention in care during pre-ART from year one to year five was also observed in the GEE models. (Model A–B, Table III) Baseline variables of HIV testing sites and CD4 levels at linkage were significant predictors of retention in pre-ART care. Comparing with MSM testing for HIV in CBOs or VCT sites (reference group), MSM testing in STD clinics were less likely to be retained in pre-ART (aOR=0.64, 95% C.I.=0.47–0.88 in Model A; aOR=0.63, 95% C.I.=0.46–0.87 in Model B). Comparing with MSM with CD4 >500/ μ L at linkage (reference group), MSM with lower CD4 levels (aOR=1.64 for <200/ μ L, 1.29 for 201–350/ μ L in Model B) were more likely to be retained in pre-ART care. Age at linkage and at CD4 level in the previous year were not predictors of retention in pre-ART care.

Retention in ART care

Among diagnosed MSM (n=1974), 840 (43%) were initiated ART. The median interval from linkage to care to ART initiation was 5.38 months (IQR=1.37–14.95). In year one after

linkage, 45% of cases were eligible for ART (CD4 $\geq 350/\mu\text{L}$), and 53% of eligible cases were initiated on ART. (Figure 1) After ART initiation, retention in ART care declined from 71% in year one to 46% in year two. In comparison with year one after treatment initiation (reference group), MSM in year two and three were less likely to be retained in ART care (aOR=0.31 in year two and aOR=0.13 in year three, Model D in Table III).

Baseline variables of age, CD4 level at linkage, and HIV testing sites were significantly associated with retention in ART care. In comparison with MSM testing for HIV at CBOs or VCT sites, those testing at a STD clinic were less likely to be retained in care (aOR=0.55, 95% C.I.=0.37–0.81, Model D), while those testing at an institution were more likely to be retained in ART care (aOR=1.76, 95% C.I.=1.04–2.97). Comparing with MSM with CD4 $>500/\mu\text{L}$ at linkage, MSM with lower CD4 levels at linkage were more strongly associated with retention in ART care (aOR=3.35 for $200/\mu\text{L}$, 2.69 for 201–350/ μL , 1.79 for 351–500/ μL , Model D). Furthermore, MSM with lower previous year's CD4 levels were more likely to be retained in ART care than those with CD4 $>500/\mu\text{L}$ (reference group) (aOR=9.46 for $200/\mu\text{L}$, 5.49 for 201–350/ μL , 4.29 for 351–500/ μL , Model C). In addition, MSM aged >35 at linkage were more likely (aOR=1.45, 95% C.I.=1.06–1.99, Model D) to be retained in ART care than those aged ≤ 35 . Other variables such as linkage to care within 90 days from diagnosis, employment status, marital status, education level, Guangzhou registered residence and STD history were not significantly associated with retention in pre-ART and ART care over time in the GEE models.

DISCUSSION

The rate of HIV linkage to care was high and significantly associated with HIV testing sites in Guangzhou, China. The rate of retention in both pre-ART care and ART care was high in the first year but dropped significantly in the second year. This study expands on current literature by examining factors associated with longitudinal change of retention in care among MSM in China. HIV testing sites, CD4 levels and age were all significant predictors of retention in care.

The linkage to care rate among MSM in Guangzhou was high, reaching nearly 90% in 2014. If linkage to care was defined using successful follow-up visits rather than CD4 tests, the rate of linkage approached 100%. This rate is consistent with another study completed in Guangzhou,³ and is higher than studies completed in other cities in China (42–82.5%).^{20,21,27} The rates of linkage to care from 2008–2014 were also higher than or equal to those from overseas regions such as Philadelphia in the United States (62%),²⁸ Canada ($>90\%$),²⁹ Europe (84%),³⁰ and Sub-Saharan Africa (80.1%)³¹ despite our stricter definition criteria.

In our study, those testing for HIV at CBOs or VCT sites for HIV diagnosis were more likely to be associated with linkage to care than those testing at hospitals. The significant predictor of testing site is consistent with a linkage to care study in the United States,³² which found that testing in a hospital was less likely to be associated with linkage to care. Our findings highlight the important role of CBOs and VCT sites for providing HIV services, and their contributions in enhancing HIV testing and the HIV care continuum. This is consistent with the previous study that CBOs' involvement in the testing stage could

enhance the care continuum among MSM in China.³³ Both CBOs and VCTs are likely to enhance linkage to care: CBOs focus on building strong relationships with and understanding the MSM population,³⁴ and VCT sites are staffed with HIV specialists to provide counseling services and free HIV testing. In comparison, patients who were tested routinely prior to surgery may receive HIV testing in hospitals not equipped with HIV specialists or counseling services. This underscores the importance of expanding voluntary testing opportunities and providing HIV specialists and counseling services at routine testing sites to optimize linkage to care. The impact of voluntary testing on linkage and retention in care among MSM has been shown in a 2008 collaborative effort between public sector agencies and CBOs in Guangzhou. The collaboration provided integrated HIV services, including pre- and post-test counseling along with psychosocial support through CBOs in the MSM community. This effort resulted in 95% rate of linkage of care, 94% rate of retention in pre-ART care, and 85% rate of ART initiation among participants.³

Our findings show that retention in care among MSM decreased by >25% between the first and second year after linkage. This decrease in retention in pre-ART care over time was similar to findings from a multi-city study in Sub-Saharan Africa and a study from South Africa, both of which described an increasing proportion of attrition from pre-ART care from month 3 to month 12.^{11,12} The decline of ART retention in our study is consistent with findings from another national Chinese study using data from 2003 to 2010, though this group defined retention in care as 1 CD4 test.¹⁰ Demographically, MSM aged >35 were more likely to be retained in ART care than those aged ≤25, which is consistent with other studies.^{10,35} This implies that more efforts should be directed at retaining this younger population group in care.³⁶

The measured CD4 level was a significant predictor of retention in pre-ART and ART care. At linkage, MSM with lower CD4 levels were more likely to be retained in pre-ART and ART care than those with CD4 levels >500/μL (reference group). This is consistent with findings from previous studies.^{7,10,22} On the other hand, CD4 levels from the previous year was a predictor of retention in ART care. If retention in care was defined as at least 1 CD4 test within the year, an additional 32% of cases with a high CD4 level (>500/μL) in the previous year could be regarded as retained in ART care in year two. This finding may be more indicative of inadequate care of MSM with high CD4 levels than of loss to follow-up. Another explanation is that MSM with high CD4 levels may feel reassured of their good health and may not be as persistent in seeking care. This illustrates how defining retention in care as ≥2 CD4 tests per year excludes MSM with relatively high CD4 levels who only undergo CD4 testing once a year. We have performed sensitivity analyses using 1 CD4 tests as an outcome variable in GEE. However, there was no significant change in factors associated with pre-ART and ART care in GEE. Of note, previous studies have shown that younger patients have more satisfactory CD4 recovery after ART initiation than older adults.^{37,38} These all suggest that interventions for enhancing retention in ART care among younger patients and those with higher CD4 levels are needed.

The implementation of *Treat All* as suggested by the WHO¹⁹ will help to improve care as all cases would be eligible for treatment, despite CD4 levels.²⁹ In China, a previous study has demonstrated the satisfactory benefit (62% reduction of mortality) of simplified HIV test

and immediate treatment.³⁹ In 2016, *Treat All* was recommended by the Chinese government.¹⁹ If all patients were initiated on treatment within one year, this would prevent the steep drop in pre-ART care retention from year one to year two. The treatment is a lifelong therapy. Interventions will be necessary to mitigate the steep drop in retention in ART care beyond the first year as observed in this study. Promoting awareness of maintaining good ART care retention despite high CD4 levels will be essential both clinically and epidemiologically. Furthermore, patients achieving stable clinical conditions (e.g. satisfactory CD4 recovery and full viral load suppression) require less frequent follow-up visits. Thus, the definition of retention in care should reflect this in future. Selection and implementation of an ART delivery model, such as a one-stop patient-centered care model and decentralization of ART delivery through the CDC using less well-trained staff, would depend on local epidemiology. The Chinese government has also recommended “one-stop” model in high HIV burden areas.⁴⁰ Previous studies have shown that a “one-stop” model might achieve better retention in care, CD4 recovery and viral load suppression.⁴¹ A CDC-based drug delivery model was found to have lower rate of retention in care despite the extensive network.⁴²

This study has two main limitations. First, our dataset did not clearly document when individuals migrated in and out of the city. We were therefore only able to include cases that were diagnosed and living in the city at time of diagnosis to minimize the influence of migrants. If, among these eligible cases, an individual received an occasional CD4 test outside Guangzhou with no record of migration from the city, they were still included in analyses. Our estimate of the ART retention rate was lower than a Guangdong study (84–94%), which used a crude point estimation of cases remained in ART divided by cases initiated ART in the study period⁴². Thus, the rates of retention in care in our study may be underestimated by excluding possible visits and tests outside the city. However, the estimation reflects the local HIV care continuum. Second, MSM were designated using data entered by doctor as provided by diagnosed patients. Given the stigma against MSM in China, there may have been a social desirability bias in reporting the route of transmission, and some MSM may fail to disclose any previous history of sex with other men. Thus, the retention in care of this group of hidden MSM is unknown, and future research about identifying and analyzing their behaviors is needed.

CONCLUSIONS

High rates of linkage to care and retention in the first year of pre-ART and ART care indicate a good start of the HIV care continuum. However, interventions to maintain retention in ART care beyond the second year are urgently needed, especially after the recommendation of *Treat All* in China in 2016.¹⁹ To enhance retention in ART care, interventions targeting younger patients and those with higher CD4 levels should be considered. In addition, further research is needed to analyze the feasibility and effectiveness of different ART delivery models (i.e. one-stop, patient-centered care and decentralized drug delivery without HIV specialists) to maintain high ART retention rates. We believe that our study methods and results are applicable to other locations with MSM HIV epidemic conditions and HIV service provision systems similar to those in China.

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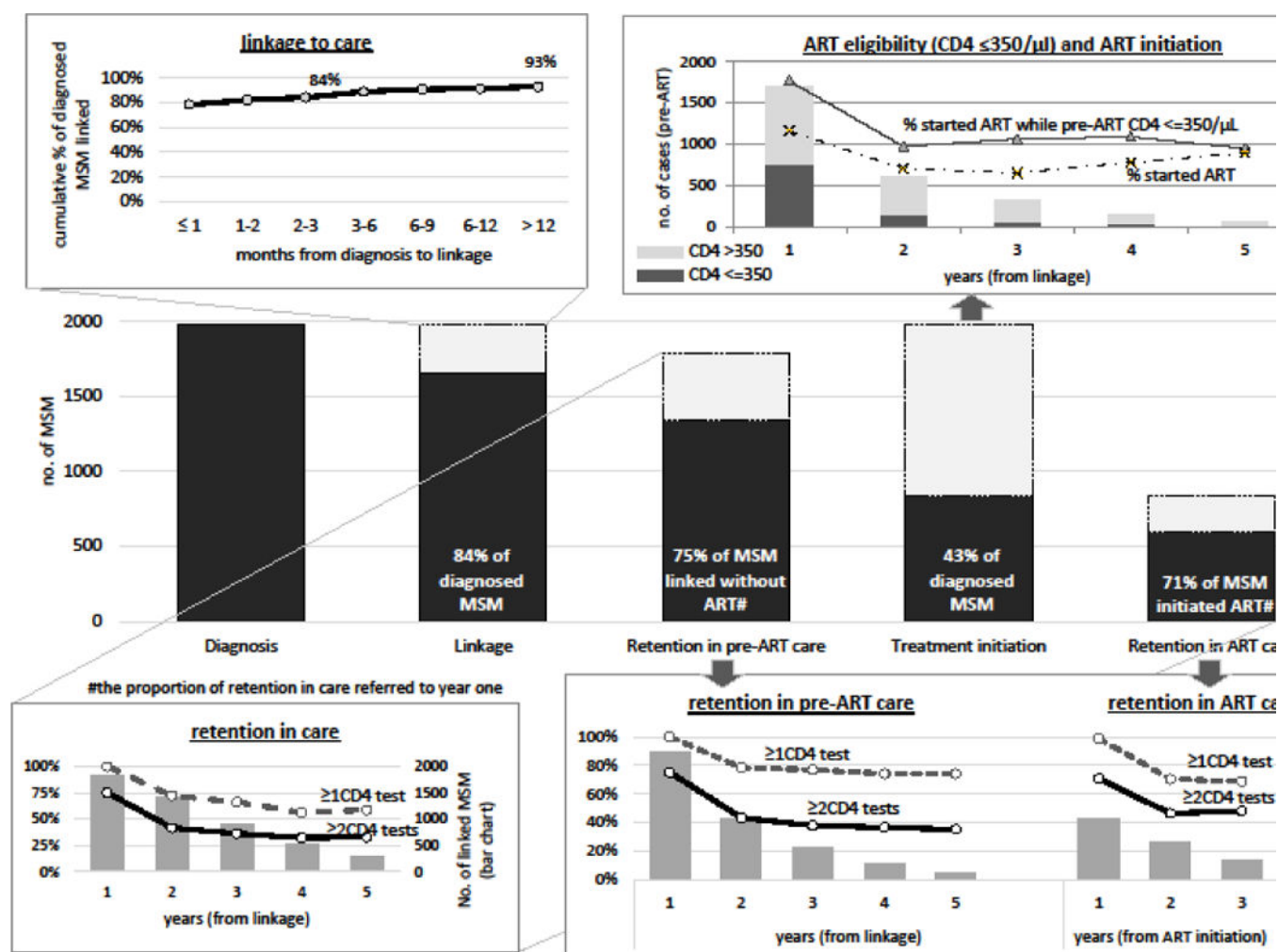


Figure 1.
The HIV care continuum and temporal trend of retention in care among MSM in Guangzhou (January 2008–September 2014)

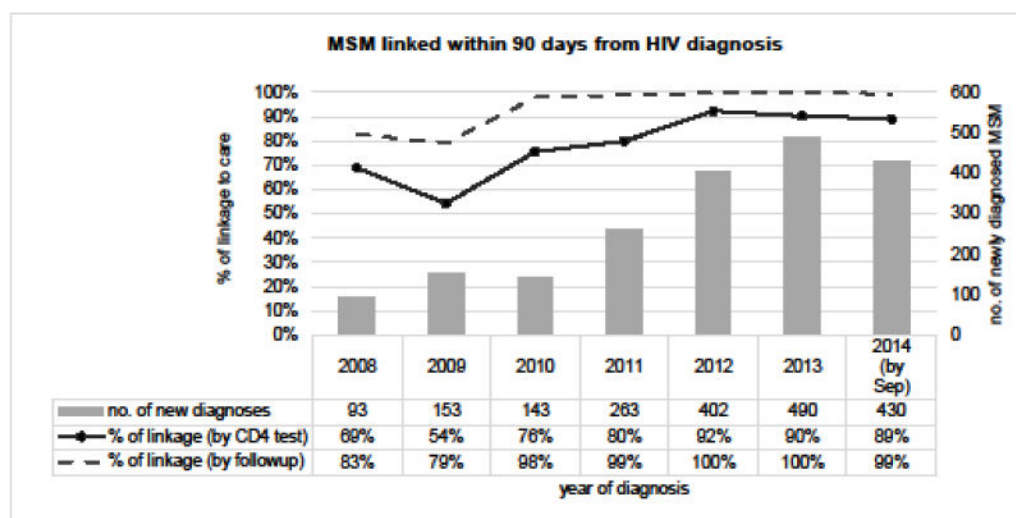


Figure 2.
Temporal trend of linkage to care among newly diagnosed MSM in Guangzhou by calendar year (January 2008–September 2014)

Table I

Characteristics of MSM living with HIV at diagnosis in Guangzhou in January 2008-September 2014
(n=1974)

	Frequency	%
Socio-demographics		
Median age (IQR), n=1974	29	(24–35)
Employment status, n=1449		
Unemployed	302	21%
Employed	1147	79%
Marriage, n=1915		
Single, divorced, widowed	1584	83%
Married	331	17%
Education level, n=1974		
High school or above	1539	78%
Below high school	435	22%
Guangzhou registered residence, n=1973		
No	1409	71%
Yes	564	29%
HIV/STD		
Previous HIV test before diagnosis, n=918		
No	769	84%
Yes	149	16%
History of STDs, n=899		
No	694	77%
Yes	205	23%
HIV testing site, n=1974		
CBOs and VCT sites	1515	77%
STD clinic	165	8%
Institution [^]	84	4%
Hospital [#]	210	11%
Median CD4 (cells/ μ L) at diagnosis (IQR), n=1833	383	277–491.5

IQR – interquartile range; STD – sexually transmitted disease; CBO – community-based organization; VCT – voluntary counseling and testing

[^] entertainment sites, prisons, immigration sites, drug rehabilitation centers, blood transfusion centers, and partner service sites

[#] HIV testing for non-STD patients and patients undergoing surgery

Table II

Comparison of conditions at diagnosis between MSM linked (n=1661) and not linked (n=313) to care (CD4 test within 90 days after diagnosis) in Guangzhou, January 2008–September 2014

	<u>Linked frequency</u>	<u>%</u>	<u>Crude odds ratio</u>		<u>Adjusted odds ratio (aOR)&</u>	
			<u>OR</u>	<u>95% C.I.</u>	<u>aOR</u>	<u>95% C.I.</u>
Socio-demographics						
Median age (IQR) at diagnosis						
Not linked	29	(24–34)	ref		ref	
Linked	29	(24–35)	0.99	0.98–1.01	0.995	0.98–1.01
Employment status						
Unemployed	252	83%	ref		ref	
Employed	927	81%	0.84	0.60–1.17	0.78	0.55–1.10
Marriage						
Single, divorced, widowed	1362	86%	ref		ref	
Married	282	85%	0.94	0.67–1.31	0.91	0.65–1.27
Education level						
High school or above	1320	86%	ref		ref	
Below high school	341	78%	0.60	0.46–0.79 *	0.53	0.40–0.70 *
Guangzhou registered residence						
No	1233	88%	ref			
Yes	427	76%	0.44	0.35–0.57 *	/	
HIV/STD						
Previous HIV test before diagnosis						
No	688	89%	ref		ref	
Yes	137	92%	1.34	0.71–2.53	1.37	0.73–2.59
History of STDs						
No	595	86%	ref		ref	
Yes	170	83%	0.81	0.53–1.23	0.84	0.55–1.28
HIV testing sites						
CBOs and VCT sites	1310	90%	3.54	2.51–5.00 *	3.24	2.29–4.59 *

	<u>Linked</u> frequency	<u>%</u>	<u>Crude odds ratio</u>		<u>Adjusted odds ratio (aOR)^d</u>	
			<u>OR</u>	<u>95% C.I.</u>	<u>aOR</u>	<u>95% C.I.</u>
STD clinic	131	79%	1.54	0.95–2.50	1.44	0.89–2.34
Institution ^e	70	83%	2.00	1.05–3.82 [*]	1.69	0.88–3.26
Hospital [#]	150	71%	ref		ref	

^d adjusted by registered Guangzhou residence

IQR – interquartile range; STD – sexually transmitted disease; CBO – community-based organization; VCT – voluntary counseling and testing

^e entertainment sites, prisons, immigration sites, drug rehabilitation centers, blood transfusion centers, and partner service sites

[#] HIV testing for non-STD patients and patients undergoing surgery

^{*} Mann–Whitney U test was performed in SPSS to compare the age at diagnosis between MSM linked and not linked to care

^{*} p-value <0.05

Binary logistic generalized estimating equation (GEE) analyses of retention in care defined by 2 CD4 tests in the year

Table III

	pre-ART care model				ART care model			
	A) n=1783	B) n=1783	C) n=528	D) n=840	aOR	95%C.I.	aOR	95%C.I.
(intercept)	3.21	2.86–3.61 *	2.75	2.30–3.27 *	0.12	0.04–0.32 *	0.91	0.55–1.50
Time points[‡]								
Year one	1	1	/	/	1	/	1	/
Year two	0.24	0.2–0.28 *	0.24	0.21–0.29 *	1	0.31	0.25–0.40 *	
Year three	0.19	0.15–0.23 *	0.20	0.16–0.24 *	0.88	0.65–1.19	0.13	0.10–0.19 *
Year four	0.17	0.13–0.23 *	0.18	0.13–0.24 *	/	/	/	/
Year five	0.14	0.09–0.22 *	0.14	0.09–0.22 *	/	/	/	/
HIV testing sites								
CBOs and VCT sites	1	1	1	1	1	1	1	1
Hospital [#]	0.87	0.63–1.21	0.85	0.61–1.18	0.84	0.49–1.45	1.01	0.73–1.40
Institution [^]	0.70	0.48–1.04	0.72	0.48–1.07	1.05	0.54–2.07	1.76	1.04–2.97 *
STD clinic	0.64	0.47–0.88 *	0.63	0.46–0.87 *	0.56	0.26–1.18	0.55	0.37–0.81 *
Previous CD4 level[‡]								
200/μL	/	/	9.46	3.84–23.29 *	/	/	/	/
201–350/μL	/	/	5.49	2.32–13 *	/	/	/	/
351–500/μL	/	/	4.29	1.75–10.54 *	/	/	/	/
>500/μL	/	/	1	1	/	/	/	/
Age group at ART initiation								
25	1	1	1	1	1	1	1	1
25.1–35	/	/	1.28	0.79–2.07	/	/	/	/
>35	/	/	1.59	0.96–2.62	/	/	/	/
CD4 level at linkage								
200/μL	/	1.64	1.17–2.31 *	/	3.35	1.96–5.72 *	2.69	1.63–4.44 *
201–350/μL	/	1.29	1.02–1.61 *	/	2.69	1.63–4.44 *	2.69	1.63–4.44 *

	pre-ART care model			ART care model		
	A) n=1783	B) n=1783	C) n=528	D) n=840	aOR	95%C.I.
351–500/ μ L	aOR	95%C.I.	aOR	95%C.I.	aOR	95%C.I.
		1.12	0.92–1.37		1.79	1.07–3.01*
>500/ μ L		1			1	
Age group at linkage						
25					1	
25.1–35					1.17	0.88–1.57
>35	/	/	/	/	1.45	1.06–1.99*

aOR – adjusted odds ratio; STD – sexually transmitted diseases; CBO – community-based organization; VCT – voluntary counseling and testing

*time point is the year from linkage to care for pre-ART care models (Models A and B), and years from ART initiation for ART care models (Models C and D)

#HIV testing for non-STD patients and patients undergoing surgery

^entertainment sites, prisons, immigration sites, drug rehabilitation centers, blood transfusion centers, and partner service sites

ℳCD4 level of the time point. Minimum CD4 count was used for more than one CD4 test in the time point. For those not in care at the time point and without CD4 count, most recent CD4 count was imputed from available data from the previous year or most recent CD4 count known by the individual before loss to follow-up.

* p-value <0.05