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The Human Immunodeficiency Virus Care Continuum in China: 1985–2015

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Background. Human immunodeficiency virus (HIV) care continuum attrition is a major global public health challenge. Few studies have examined this problem in resource-limited settings. We aimed to assess cumulative, current, and historical achievement along China's HIV continuum of care.

Methods. A nationwide, serial cross-sectional study of all individuals with HIV infection diagnosed in China between 1 January 1985 and 31 December 2015 was conducted using data from China's HIV/AIDS information systems. Biennial estimates of the number of persons living with HIV were also used. We defined 7 steps in HIV care continuum as infected (estimated), diagnosed, linked, retained, enrolled, receiving antiretroviral therapy (ART), and virally suppressed. Cumulative, 30-year performance, and biennial performance during the most recent 10 years were examined.

Results. A total of 573 529 persons diagnosed with HIV infection were included. Cumulatively, 94% were linked, 88% were retained, 73% were enrolled, 67% were receiving ART, and 44% were suppressed. Greatest attrition was observed for adolescents, minorities, and those who reported injecting drug use as their route of infection. Improvement was observed from 2005 to 2015. As of the end of 2015, 68% among those infected were diagnosed, 67% among diagnosed were receiving ART, and 65% among those receiving ART were virally suppressed. After adjusting for those without viral load testing, the proportion suppressed increased to 89%.

Conclusions. Despite dramatic improvements, China faces serious challenges in achieving the Joint United Nations Programme on HIV/AIDS 90-90-90 targets, because of substantial attrition along its continuum of HIV care.

Keywords. HIV/AIDS; care continuum; antiretroviral therapy; viral suppression.

Since 1996, antiretroviral therapy (ART) has helped reduce mortality and morbidity rates among persons living with human immunodeficiency virus (PLHIV) [1, 2] and has acted in a "treatment as prevention" capacity at the population level, reducing the risk of transmission via sexual contact and injecting drug use [3–5]. Despite these benefits, only 37% of PLHIV worldwide had access to ART in 2013 [6]. Thus, in 2014, to encourage meaningful movement toward the end of the human immunodeficiency virus (HIV)/AIDS epidemic, the Joint United Nations Programme on HIV/AIDS (UNAIDS) published the "90-90-90 targets"—that is, 90% of PLHIV diagnosed, 90% of diagnosed PLHIV receiving ART, and 90% of PLHIV receiving ART virally suppressed [7].

This helped place renewed focus on what has become known as the HIV care continuum—a series of steps on the journey from HIV infection to viral suppression. To reap maximum benefit from ART, at both the individual and population levels, PLHIV must achieve the goal of each step in the continuum [8–10]. Although a broad range of studies has examined this issue, a preponderance has been conducted in high-income countries (HICs) [11–20], with smaller and more concentrated epidemics, relatively higher testing and treatment coverage, and generally better quality and consistency of care. Nevertheless, a majority of these studies found substantial leakage at multiple steps. The few studies conducted in low- and middle-income countries (LMICs) [21–26], describe even greater leakage.

Unfortunately, there is no one-size-fits-all solution to this problem—the unique attributes of the epidemic, health system, and population in each setting must be taken into account to successfully design and implement interventions aimed at ensuring that all PLHIV have their infection diagnosed and treated in a timely fashion and that they experience positive outcomes [9, 10, 15, 27]. To date, no comprehensive assessment of China's HIV care continuum has been undertaken. Therefore, we aimed to investigate the nationwide cumulative, current, and historical achievement of China's continuum of HIV care.

METHODS

The present study was a nationwide, serial cross-sectional study of all individuals with HIV infection diagnosed in China between 1 January 1985 and 31 December 2015.

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Data

China's laws on the prevention and treatment of infectious diseases designates HIV/AIDS as a class B notifiable infectious disease. Therefore, all medical units are required to report all new diagnoses of HIV infection to China's HIV/AIDS Comprehensive Response Information Management System (CRIMS) within 24 hours. CRIMS was established in 1985 and is a nationwide, real-time reporting system that is controlled and maintained by the National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention [28, 29]. In brief, CRIMS records include demographic information, diagnosis dates, patient-reported transmission routes, baseline and follow-up CD4 cell count dates and results, ART initiation dates, regimens, and follow-up records, including viral load (VL) testing dates and results and dates and causes of death [29]. We used data extracted from CRIMS on 30 June 2016.

Participants

All individuals who received a confirmed diagnosis of HIV infection in China between 1 January 1985 and 31 December 2015 were included. Individuals were then excluded if (1) they were no longer alive as of 31 December 2015, (2) they were not Chinese nationals, or (3) their records contained obvious errors (eg, missing or incorrect dates of diagnosis or ART initiation). Those who had died were excluded to be consistent with the definitions of the UNAIDS 20-20-20 targets, which uses only PLHIV in the denominator [7, 30], and those who were foreigners were excluded because they are not eligible for treatment in China's National Free ART Program. Participants were grouped according to the steps in the continuum achieved, and for each year that the estimated total number of PLHIV were available (biennially, 2005–2015) [31], participants were grouped by their achievement of care continuum steps in those years. All participants were included in the analyses.

Continuum

Table 1 describes China's continuum of HIV care in terms of 7 steps and includes definitions of all numerical tabulations (eg, number enrolled) and formulas for all calculations of proportions (eg, proportion receiving ART), showing numerator and denominator. To have achieved a particular step, an individual must have achieved all prior steps and met the criteria described

Table 1. Description of the Human Immunodeficiency Virus Care Continuum in China, Including Criteria for Achievement of Each Step

Step	Number Definition	Proportion Calculation
Step 1: infected	Total estimated number of individuals with HIV infection in China; beginning in 2005, a biennial estimation of the total number of PLHIV has been conducted by joint effort between UNAIDS, WHO, and China's Health and Family Planning Commission	…
Step 2: HIV infection diagnosed	Beginning in 1985, this is an annual tabulation of the total number of individuals with diagnosed HIV infection who were still alive at the end of the year	Proportion with HIV infection diagnosed = No. with HIV infection diagnosed/Estimated No. infected[a]
Step 3: linked	Beginning in 1985, this is an annual tabulation of all PLHIV who were linked to care and still alive at the end of the year; to be counted as liked to care, individuals with diagnosed HIV infection must have received ≥1 of the following services: (1) clinical consultation with public health physician to perform laboratory testing (eg, CD4 cell count, tuberculosis screening), (2) clinical diagnosis of advanced clinical disease (WHO Stage 3 or 4), or (3) receipt of HIV counseling	Proportion linked to care = No. linked/No. with HIV infection diagnosed[b]
Step 4: retained	Beginning in 1985, this is an annual tabulation of all PLHIV who were retained in care during the year and still alive at the end of the year; to be counted as retained in care, individuals who had HIV infection diagnosed and were linked to care must have received ≥1 follow-up consultation (defined as same services listed under step 3)	Proportion retained = No. retained/No. with HIV infection diagnosed[b]
Step 5: enrolled	Beginning in 2002, this is the annual tabulation of all PLHIV who also enrolled in ART and were still alive at the end of the year; to be counted as enrolled in ART, individuals who had HIV infection diagnosed and were linked and retained must have signed up for (ie, entered, or enrolled) treatment services in China's National Free ART Program	Proportion enrolled = No. enrolled/No. with HIV infection diagnosed[b]
Step 6: receiving ART	Beginning in 2002, annual tabulation of all PLHIV who were receiving ART during the year and were still alive at the end of the year; to be counted as receiving ART, individuals who had HIV infection diagnosed and were linked, retained, and enrolled must have initiated (ie, received prescriptions) and continued to receive ART (ie, did not drop out)	Proportion receiving ART = No. receiving ART/No. with HIV infection diagnosed[c]
Step 7: suppressed	Beginning in 2008, annual tabulation of all PLHIV who had achieved viral suppression during the year and were still alive at the end of the year; to be counted as virally suppressed, individuals who had HIV infection diagnosed and were linked, retained, enrolled, and receiving ART must have had a VL test and its result must have been <400 copies/mL	Proportion suppressed = No. suppressed/No. with HIV infection diagnosed[b] Proportion suppressed = No. suppressed/No. receiving ART[a,d]

Abbreviations: ART, antiretroviral therapy; HIV, human immunodeficiency virus; PLHIV, persons living with HIV; UNAIDS, Joint United Nations Programme on HIV/AIDS; VL, viral load; WHO, World Health Organization.

[a]Shown in Figure 1 only.

[b]Shown in Table 2 only.

[c]Shown in Table 2 and Figure 1.

[d]For the adjusted proportion suppressed, 2 adjustments were made to this denominator. The first adjusted denominator was the number receiving ART minus the number with no VL test results available. The second adjusted denominator was the number receiving ART minus the number who had been receiving ART for <6 months. Data not shown.

for that step. For example, to be included in those who achieved step 3 (linked), individuals must have received ≥1 HIV-related service after diagnosis, ever in their lifetime. For the analysis describing changes in the care continuum over time, individuals included as having achieved a particular step had to have met the criteria for that step in that year.

Analysis

First, characteristics of the whole study population (eg, all who achieved step 2: diagnosed) were tabulated. Demographic variables were categorized and presented as number and percentage, using the entire study population as the denominator. Percentages were calculated down the column (column percentage).

Second, all participants who achieved each subsequent step in the care continuum were tabulated and again presented as number and percentage. However, the denominator for this analysis was instead those who achieved step 2 (diagnosed). Percentages were calculated across the rows (row percentage). For each step, the denominator used to calculate the proportion achieving a later step was always those who achieved step 2.

Third, we grouped participants into those who achieved step 2 (diagnosed), step 6 (receiving ART), and step 7 (suppressed) in each of 6 years, 2005, 2007, 2009, 2011, 2013, and 2015, to examine changes in the HIV care continuum over time and to assess progress toward the 90-90-90 targets [7]. Numbers of participants achieving these steps were represented graphically as bars, and the proportion achieving the step is included above the bar. Proportions achieving step 2 (diagnosed) were calculated using the biennial estimates of the total number of PLHIV in China produced jointly by UNAIDS, World Health Organization, and China's Health and Family Planning Commission [31]. Proportions achieving step 6 (receiving ART) were calculated using the number of participants who achieved step 2 as the denominator. Likewise, the proportions achieving step 7 (suppressed) were calculated using the number of participants who achieved step 6 as the denominator.

Last, because achievement of step 7 (suppressed) is an important metric, as evidenced by its being the "third 90" [7], and is certainly an underestimation of the effectiveness of ART, we present 2 alternative calculations for 2015 data only, using adjusted denominators. Because even in HIC settings in 2016, time from diagnosis to viral suppression is still at least several months [32], our calculation of the proportion virally suppressed underestimates ART effectiveness because it includes, for example, those receiving ART only 1 month. In addition, national treatment guidelines in China require patients to have been receiving ART ≥6 months before they are eligible for VL testing. Therefore, for our first adjusted calculation, we have included only those receiving ART ≥6 months in the denominator. Similarly, because VL testing capacity and coverage remain low in China [33], many receiving ART had not undergone VL testing or had experienced delays in VL testing owing to its unavailability, which also may underestimate ART effectiveness. Therefore, for our second adjusted calculation, we have included in the denominator only those who had VL test results.

Ethics

This study was approved by the Institutional Review Board of the National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention. All individuals signed informed consent at the time of their entry into CRIMS that allowed the future use of their data for epidemiological study. No further informed consent was sought. All data were deidentified before use.

RESULTS

At the end of 2015, HIV infection had been diagnosed in a total of 780 368 patients in China. Among them, 185 429 (23.8%) had died, 21 347 were not Chinese nationals (2.7%), and 63 (<0.1%) had obvious errors in their records. Thus, a total of 573 529 (73.5%) PLHIV were included in our analysis.

Characteristics of Participants

As shown in Table 2, most participants were 20–39 years old (age 20–29 years, 30.4%; 30–39 years, 29.0%), male (71.6%), Han Chinese (76.0%), married or cohabitating (47.0%), and living in either southwestern (37.0%) or south-central China (33.2%). The most commonly reported route of HIV infection was heterosexual contact (58.1%), followed by homosexual contact (20.0%), injecting drug use (13.4%), and donation or receipt of blood products (5.1%).

Cumulative Performance, 1985–2015

Among all participants (those who achieved step 2: diagnosed), across the entire time frame from 1985 to 2015 combined, 93.6% also achieved step 3 (linked), 87.7% achieved step 4 (retained), 72.5% achieved step 5 (enrolled), 66.8% achieved step 6 (receiving ART), and 43.6% achieved step 7 (suppressed) (Table 2). Greatest attrition at step 3 (linked) occurred for adolescents (aged 10–19 years; 89.6%), minorities (92.2%), and those who reported their route of HIV infection as injecting drug use (85.6%). Greatest attrition at step 4 (retained) occurred for minorities (70.4%) and those who reported their route of HIV infection as injecting drug use (66.9%). All demographic groups experienced substantial attrition at step 5 (enrolled). Greatest attrition at this step was observed among adolescents (58.1%), minorities (68.0%), those who were single (63.7%), and reported their route of HIV infection as homosexual contact (72.9%). Greatest attrition at step 6 (receiving ART) occurred among minorities (57.6%) and those living in northwest China (54.6%). Finally, relatively smaller proportions of participants across all demographic groups achieved step 7 (suppressed). Lowest rates of suppression were among adolescents (29.1%), minorities

(36.5%), and those who reported injecting drug use (24.4%, Table 2).

Biennial Performance, 2005–2015

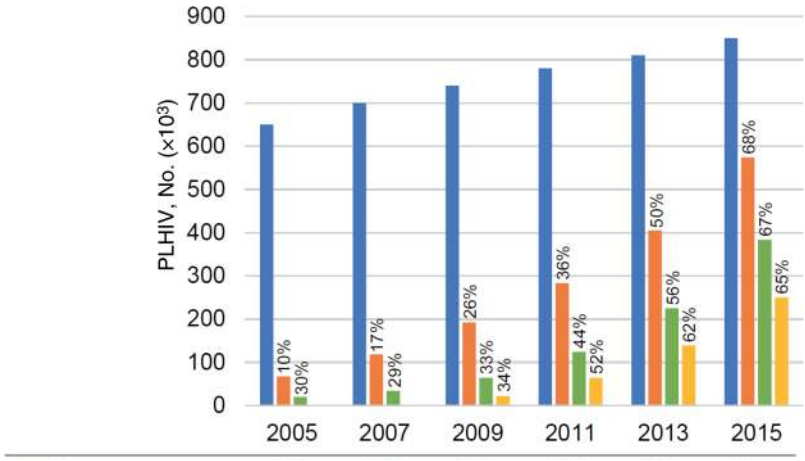
As shown in Figure 1, the total estimated number of PLHIV increased each year it was calculated [34]. However, the total number with infection diagnosed increased at a faster rate, such that the proportion with HIV infection diagnosed among all PLHIV increased from 10% in 2005 to 68% in 2015. Similarly, the proportion receiving ART among those with HIV infection diagnosed increased from 30% in 2005 to 67% in 2015. Finally, the proportion virally suppressed among those receiving ART also increased from 34% in 2009 to 65% in 2015.

Because the proportion who achieved viral suppression was almost certainly an underestimate owing to the numbers of PLHIV who did not undergo VL testing, we present 2 adjusted calculations for 2015 only. First, when those who had been receiving ART <6 months (n = 64 412) were removed from the total receiving ART (n = 382 854), the proportion suppressed increased to 78.6% (250 294 of 318 442) in 2015. Second, when those who have been receiving ART ≥6 months but have not yet had a VL test in the calendar year (n = 37 561) were also removed, the proportion suppressed increased to 89.1% (250 294 of 280 881) in 2015.

DISCUSSION

Cumulatively, over the 30-year period from 1985 to 2015, 94% of all PLHIV with infection diagnosed were linked to care, 88% were retained, 73% were enrolled in ART, 67% were receiving ART, and 44% were virally suppressed. Performance of China's continuum of HIV care improved over time, such that by the end of 2015, 68% of those infected had their infection diagnosed, 67% of those with HIV infection diagnosed were receiving ART, and 65% of those receiving ART had achieved viral suppression. Thus, although China can be credited for its substantial recent progress, it has not yet met the UNAIDS 90-90-90 targets [7].

Leakages observed at multiple steps in China's continuum of HIV cascade may be partly related to changes over time in China's HIV response, policies, and services. The most obvious example is the attrition observed in the pre-ART period (or failure to achieve the "receiving ART" step), which is at least partly due to CD4 cell count ART eligibility requirements. Before 2008, a CD4 cell count <200/μL was required for ART initiation. From 2008 to 2013, this requirement was relaxed to <350/μL, and then to <500/μL until 2015. Finally, in early 2016, the requirement was eliminated—all those with HIV infection, regardless of CD4 cell count, are now eligible for ART [35, 36]. This requirement served not only as a clinical barrier to many PLHIV, but also as a structural barrier, causing both delayed treatment initiation



	2005	2007	2009	2011	2013	2015
Infected	650	700	740	780	810	850
HIV infection diagnosed	67	118	192	283	405	574
Receiving ART	20	34	64	124	225	383
Receiving ART for ≥6 mo			54	95	186	322
VL tested			27	76	159	272
Virally suppressed			22	64	139	250

Figure 1. Biennial performance of China's continuum of human immunodeficiency virus (HIV) care, 2005–2015. Bars represent the total number of persons living with HIV who were infected (number estimated) and the numbers who had HIV infection diagnosed, were receiving antiretroviral therapy, and were virally suppressed. Percentages were calculated as the number achieving the step (numerator) divided by the number in the previous step (denominator). (See Table 1 for precise definitions of numbers and proportions represented here; for the proportion achieving viral suppression shown in the graph, unadjusted denominators were used.). Abbreviations: ART, antiretroviral therapy; PLHIV, persons living with HIV; VL, viral load.

Table 2. Cumulative Human Immunodeficiency Virus (HIV) Care Continuum Performance for Persons Living with Human Immunodeficiency Virus Diagnosed With HIV Infection in China, 1985–2015

Characteristic	Step 2: HIV Infection iagnosed, No. (Column %)[a]	No. (Row %)[b]				
		Step 3: Linked	Step 4: Retained	Step 5: Enrolled	Step 6: Receiving ART	Step 7: Suppressed
Overall	573 529 (100)	537 108 (93.6)	502 844 (87.7)	415 940 (72.5)	382 854 (66.8)	250 294 (43.6)
Age group, y						
<10	6470 (1.1)	6415 (99.1)	6171 (95.4)	5057 (75.2)	4727 (73.1)	3041 (47.0)
10–19	20 004 (3.5)	17 915 (89.6)	16 149 (80.7)	11 622 (58.1)	10 520 (52.6)	5820 (29.1)
20–29	174 103 (30.4)	159 189 (91.4)	144 680 (83.1)	113 245 (65.0)	103 057 (59.2)	65 618 (37.7)
30–39	166 074 (29.0)	155 311 (93.5)	143 827 (86.6)	121 568 (73.2)	111 170 (66.9)	76 533 (46.1)
40–49	105 458 (18.4)	100 837 (95.6)	96 627 (91.6)	83 312 (79.0)	78 029 (74.0)	52 452 (49.7)
50–59	55 499 (9.7)	53 698 (96.8)	52 509 (94.6)	45 876 (82.7)	43 307 (78.0)	28 157 (50.7)
≥60	45 897 (8.0)	43 740 (95.3)	42 878 (93.4)	35 257 (76.8)	32 042 (69.8)	18 672 (40.7)
Data missing	24 (<0.1)	3 (12.5)	3 (12.5)	3 (12.5)	2 (8.3)	1 (4.2)
Sex						
Male	410 722 (71.6)	383 517 (93.4)	357 489 (87.0)	291 146 (70.9)	268 010 (65.3)	169 531 (41.3)
Female	162 807 (28.4)	153 591 (94.3)	145 355 (89.3)	124 794 (76.7)	114 844 (70.5)	80 763 (49.6)
Ethnicity						
Han	435 615 (76.0)	409 900 (94.1)	388 265 (89.1)	322 095 (73.9)	303 424 (69.7)	200 010 (45.9)
Minorities	137 914 (24.0)	127 208 (92.2)	114 579 (83.1)	93 845 (68.0)	79 430 (57.6)	50 284 (36.5)
Marital status						
Single	184 267 (32.1)	169 916 (92.2)	154 675 (83.9)	117 348 (63.7)	107 717 (58.5)	65 301 (35.4)
Married/cohabitating	269 824 (47.0)	257 343 (95.4)	245 437 (91.0)	214 592 (79.5)	198 723 (73.6)	136 109 (50.4)
Divorced/widowed	110 867 (19.3)	105 376 (95.0)	99 053 (89.3)	80 979 (73.0)	73 789 (66.6)	47 125 (42.5)
Data missing	8571 (1.5)	4473 (52.2)	3679 (42.9)	3021 (35.2)	2625 (30.6)	1759 (20.5)
Geographic region[c]						
Southwest	212 488 (37.0)	194 596 (91.6)	177 443 (83.5)	144 390 (68.0)	130 532 (61.4)	82 052 (38.6)
South-central	190 690 (33.2)	182 335 (95.6)	172 110 (90.3)	148 157 (77.7)	137 856 (72.3)	99 388 (52.1)
East	70 914 (12.4)	68 042 (96.0)	66 543 (93.8)	55 515 (78.3)	53 285 (75.1)	32 127 (45.3)
Northwest	49 296 (8.6)	44 779 (90.8)	41 131 (83.4)	32 415 (65.8)	26 924 (54.6)	14 899 (30.2)
North	29 427 (5.1)	27 842 (94.6)	26 930 (91.5)	21 304 (72.4)	20 567 (69.9)	13 588 (46.2)
Northeast	20 714 (3.6)	19 514 (94.2)	18 687 (90.2)	14 159 (68.4)	13 690 (66.1)	8240 (39.8)
Route of HIV infection						
Injecting drug use	77 075 (13.4)	65 941 (85.6)	51 571 (66.9)	40 670 (52.8)	31 618 (41.0)	18 793 (24.4)
Blood products[d]	29 229 (5.1)	29 229 (100)	28 689 (98.2)	27 871 (95.4)	26 958 (92.2)	21 594 (73.9)
Heterosexual contact	333 350 (58.1)	317 031 (95.1)	302 725 (90.8)	252 214 (75.7)	232 991 (69.9)	153 636 (46.1)
Homosexual contact	114 656 (20.0)	110 212 (96.1)	106 381 (92.8)	83 613 (72.9)	80 807 (70.5)	48 971 (42.7)
Other/unknown	19 219 (3.4)	14 695 (76.5)	13 478 (70.1)	11 572 (60.2)	10 480 (54.5)	7300 (38.0)

Abbreviations: ART, antiretroviral therapy; HIV, human immunodeficiency virus.

[a]In this column, percentages are calculated down the column, with the total total number of participants in the study (N = 573 529) used as the denominator.

[b]In these columns, percentages are calculated across the rows, with the value in the "HIV Infection Diagnosed" column used as the denominator for all calculations in that row.

[c]For our definitions of geographic regions, Southwest includes the following: Yunnan Province, Sichuan Province, Guizhou Province, Chongqing Municipality, and Tibet Autonomous Region; South-central: Henan Province, Hubei Province, Hunan Province, Guangxi Zhuang Autonomous Region, Hainan Province, and Guangdong Province; East: Shandong Province, Jiangsu Province, Anhui Province, Zhejiang Province, Jiangxi Province, Fujian Province, and Shanghai Municipality; Northwest: Ningxia Hui Autonomous Region, Gansu Province, Qinghai Province, Xinjiang Uyghur Autonomous Region, and Shaanxi Province; North: Inner Mongolia Autonomous Region, Shanxi Province, Beijing Municipally, Hebei Province, and Tianjin Municipality; and Northeast: Heilongjiang Province, Jilin Province, and Liaoning Provinces.

[d]The "blood products" category included both those who became infected as donors through unsafe donation and those who became infected through receipt of contaminated blood products.

and pre-ART attrition. Streamlined testing and treatment initiation procedures have been examined in China and found to reduce the time from diagnosis to ART, increase the proportion successfully starting ART, and improve mortality rates [37]. We expect that with the removal of this barrier, the proportion of PLHIV with diagnosed infection receiving ART will rise.

Failure to achieve viral suppression is another example. Our finding that only 65% of those receiving ART had achieved viral suppression as of the end of 2015 may be initially viewed as surprising, given the well-accepted high efficacy of antiretroviral drugs even in real-world LMIC settings. However, some individuals included in our "receiving ART" denominator for the calculation of the proportion achieving viral suppression had been receiving ART for <6 months, during which time the full benefit may not yet have been experienced and patients are still ineligible for VL testing, according to national treatment guidelines.

After adjustment for this possibility (including only those receiving ART for ≥6 months in the denominator), the proportion suppressed increased from 65% to 79%. Furthermore, HIV

VL testing has only recently been scaled up in China. As of the end of 2014, a total of 167 laboratories covering all provinces and municipalities were qualified to carry out VL testing [33]. Thus, some of those receiving ART had not undergone VL testing, or had experienced a delay in VL testing, merely because of its unavailability. After adjustment for lack of VL test results, the proportion who achieved viral suppression in 2015 rose to 89%. A recent study in China showed that compared with standard once-annual VL testing, failure to undergo VL testing in the first year after ART initiation was associated with a higher mortality rate, and having 2 VL tests in the first year was associated with a lower mortality rate [38]. Therefore, as VL testing continues to be scaled up, and newer, faster, point-of-care technologies become available, VL testing uptake will increase, and perhaps the proportion achieving viral suppression will also increase.

Not surprisingly, leakage was also observed to be uneven across risk groups—adolescents (aged 10–19 years) and persons who inject drugs were most affected in our study. Globally, these groups have been known to struggle with a broad range of barriers all along the HIV care continuum [39, 40]. Clearly, more must be done to ensure that China's most vulnerable are given the assistance they need to achieve positive outcomes.

Despite these shortcomings, and its failure to achieve the UNAIDS 90-90-90 targets as of the end of 2015 [7], China has nevertheless shown enormous progress. At the end of 2009, only 1 year after the start of VL testing scale-up, China had already attained 26-33-34—that is, 26% of infected had HIV infection diagnosed, 33% of those with infection diagnosed were receiving ART, and 34% receiving ART were virally suppressed. Two years later, at the end of 2011, China had realized 36-44-52. And 4 years after that, as of the end of 2015, China achieved 68-67-65. With <3 years left before the 2020 deadline, China has a lot of work left to do. However, only 1 country has so far declared achievement of the 90-90-90 targets—Sweden, reporting 90-95-95, as of the end of 2015 [20]. Although Japan was not far behind, having reported 86-83-99, also at the end of 2015 [19], not all HICs are doing so well [12]. So far, there are relatively few reports from LMICs [21–26]. Although reports from these countries, like the present one from China, show that LMICs are lagging most HICs, comparisons across countries are very difficult to make.

Lack of agreement on the definitions of care continuum steps and criteria for meeting them precludes direct comparison. A range of methods have been used for estimating the total number of PLHIV. Most studies (ours included), but not all, include only the living in the number of PLHIV with HIV infection diagnosed. Linkage and retention have perhaps the least consensus among studies published thus far. Some studies defined the number receiving ART was according to prescriptions written, others (like ours) defined it according to drugs dispensed. The denominator for proportion of those receiving ART was sometimes all PLHIV with HIV infection diagnosed (like ours), but was very often only those eligible. Furthermore, viral suppression has been defined as anywhere from <50 to <1000 copies/mL. Typically, it is defined as <400 copies/mL in China (our study included), consistent with a majority of studies in LMICs, despite the World Health Organization guideline of <1000 copies/mL [27, 41–43]. A first step toward standardization of measurement was provided in the 2017 UNAIDS report on progress toward the 90-90-90 targets [30]. However, international guidance on a more granular level of detail would better facilitate sharing and application of lessons learned across the globe.

Our study had several limitations. First, its cross-sectional design prevented examination of causality. Second, we had to rely on estimates of the actual number of PLHIV [31], which lent some uncertainty to our measurement of the proportion of PLHIV with HIV infection diagnosed. Third, data on the route of HIV infection were self-reported, which may have been subject to social desirability or recall bias. Fourth, in our unadjusted analysis we assumed that all those who did not undergo VL testing had not achieved viral suppression, thereby probably misclassifying some individuals and underestimating the proportion who achieved viral suppression. However, we present 2 alternative calculations that attempt to adjust for the lack of VL data. Finally, although several recent studies indicate that the time it takes for individuals to achieve each step is a similarly important measure of continuum effectiveness [17, 21, 27, 44], we did not examine this outcome in our study. For example, it is possible that a study participant had HIV infection diagnosed in 1995 but was not linked until 1999, and perhaps did not attend a single follow-up visit, and thus was not "retained," until 2005. Clearly, this rate of movement through the care continuum is not ideal, and should be examined in a future study.

In conclusion, China has made remarkable progress toward the UNAIDS 90-90-90 targets over the past 10 years, having achieved proportions of 68% with HIV infection diagnosed, 67% receiving ART, and 65% virally suppressed, as of the end of 2015. This study should encourage policy makers to continue to support the fight against HIV. Redoubled efforts in prevention, testing mobilization, immediate ART for all those with diagnosed infection, continued scale-up of VL testing, and interventions to improve retention will help China make meaningful progress toward ending the HIV epidemic.

Notes

Author contributions. Y. Ma, Z. D., and Z. W. designed the study. Y. Ma, Z. D., and J. M. M. performed the analysis. Y. Ma, Z. D., J. M. M., and Z. W. interpreted the results and developed the initial draft. Y. Ma, W. G., Y. Mao, F. Z., Z. L., and Z. W. contributed to the design of original data collection and maintenance. All authors contributed to manuscript revisions and approved the final version for publication. The funding organization had no role in the development of study design, collection, analysis, and interpretation of data, the writing of the report, or the final decision to submit the manuscript for publication. The corresponding author had full access to all the data and had final responsibility for the decision to submit for publication.

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