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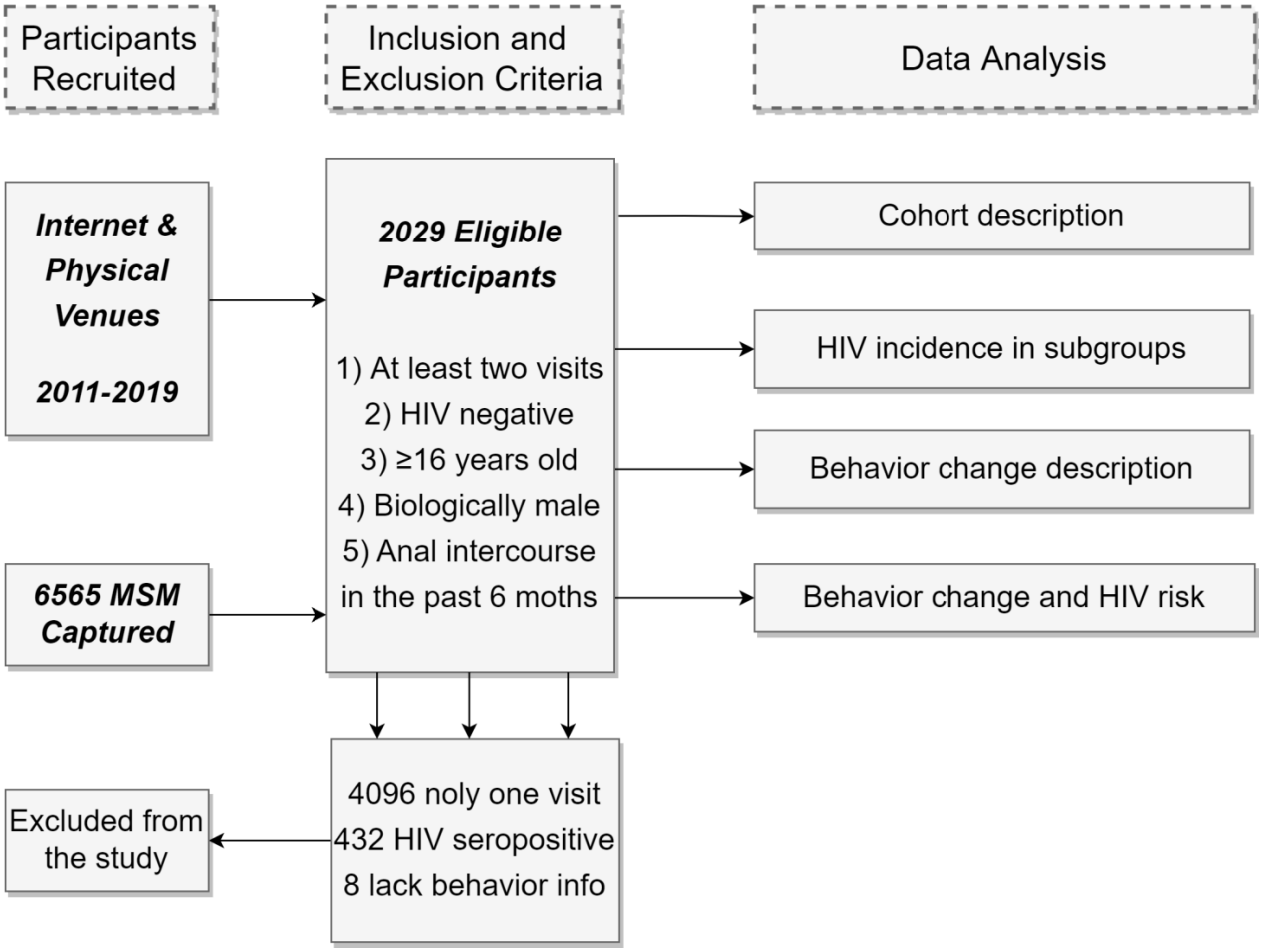


sFigure1. Flow diagram of the study

sTable1. Characteristics of excluded and included study participants at baseline

Variables at Baseline	Included (N=2029) N (%)	Excluded (N=4096) N (%)	*P*
Age			0.1555
<45	1504(74.13)	3098(75.63)	
45-60	464(22.87)	856(20.90)	
>60	61(3.01)	142(3.47)	
Marital status			0.0198
Married	947(46.67)	1783(43.53)	
Unmarried	1082(53.33)	2313(56.47)	
Education			0.6467
Below high school	56(2.76)	125(3.05)	
High school	1172(57.76)	2322(56.69)	
College or more	801(39.48)	1649(40.26)	
Residence time in Tianjin			0.0001
<3 months	405(19.96)	1154(28.17)	
3-7 months	39(1.92)	125(3.05)	
7-12 months	41(2.02)	85(2.08)	
1-2 years	86(4.24)	166(4.05)	
>2 years	1458(71.86)	2566(62.65)	
Condom use in last anal sex			0.1283
Yes	1550(76.39)	3056(74.61)	
No	479(23.61)	1040(23.39)	
Frequency of condom use during anal sex[ab]			0.6946
Consistent use	785(38.69)	1606(39.21)	
Inconsistent use	1244(61.31)	2490(60.79)	
Number of Sexual partners[b]			0.4535
<10	1709(84.23)	3480(84.96)	
More than 10	320(15.77)	616(15.04)	
STI[b]			0.7909
Yes	68(3.35)	132(3.22)	
No	1961(96.65)	3963(96.78)	
Inject drugs[b]			0.7625
Yes	22(1.08)	41(1.00)	
No	2007(98.92)	4053(99.00)	
Accept health service[c]			0.0001
Yes	938(46.23)	1681(41.04)	
No	1091(53.77)	2415(58.96)	
MSW[db]			0.0369
Yes	102(5.03)	159(3.88)	
No	1927(94.97)	3936(96.12)	

Abbreviations: STI, sexually transmitted infections; MSW, male sex workers.

[a] The frequency of condom use during anal sex in the past 6 months was divided into two categories, consistent use (When engaging in anal intercourse, condoms were used in more than 80% of cases and condoms were used throughout the sex) and inconsistent use (other cases).

[b] In the past 6 months.

[c] Health service represented whether participants had accepted any HIV related health service (HIV testing, condom distribution, HIV risk reducing consult, peer education or HIV infection risk assessment) in the past 12 months.

[d] MSW stands for male sex workers. It represented if the participants have been obtained money or goods through sexual activity.

sTable2. Univariate and multivariate cox proportional hazard model with time-varying covariates for HIV infection risk

Variables	Univariate cox regression analysis			Multivariate cox regression analysis[e]		
	HR	95%CI	*P* value	HR	95%CI	*P* value
Age						
<45	REF					
45-60	1.14	0.78-1.69	0.4819			
>60	0.94	0.38-2.32	0.8956			
Marital status						
Married	REF			REF		
Unmarried	4.73	2.90-7.71	0.0001	4.72	2.86-7.78	0.0001
Education						
Below high school	REF			REF		
High school	0.51	0.24-1.06	0.0719	0.93	0.43-2.01	0.7619
College or more	0.29	0.13-0.63	0.0018	0.47	0.20-1.07	0.0574
Residence time in Tianjin						
<3 months	REF			REF		
3-7 months	0.52	0.12-2.19	0.3804	0.66	0.16-2.83	0.5718
7-12 months	1.71	0.72-4.05	0.2195	1.14	0.48-2.78	0.7572
1-2 years	0.27	0.06-1.14	0.0770	0.27	0.06-1.13	0.0727
>2 years	0.50	0.34-0.74	0.0005	0.68	0.46-1.07	0.0748
Condom use in last anal sex						
Yes	REF			REF		
No	12.39	8.53-17.99	0.0001	5.10	3.19-8.13	0.0001
Frequency of condom use during anal sex[ab]						
Consistent use	REF			REF		
Inconsistent use	10.13	6.14-16.69	0.0001	3.66	1.97-6.82	0.0001
Number of Sexual partners[b]						
<10	REF			REF		
More than 10	1.33	0.93-1.92	0.1173	1.53	1.05-2.24	0.0266
STI[b]						
Yes	REF					
No	0.88	0.36-2.15	0.7831			
Inject drugs[b]						
Yes	REF					
No	1.81	0.25-13.01	0.5512			
Accept health service[c]						
Yes	REF			REF		
No	1.55	0.96-2.49	0.0687	1.20	0.74-1.94	0.4501
MSW[db]						
Yes	REF			REF		
No	0.66	0.34-1.27	0.2183	1.39	0.71-2.72	0.3340

Abbreviation: STI, sexually transmitted infections; MSW, male sex workers; HR, hazard ratio; CI: confidence interval; REF, reference level.

[a] The frequency of condom use during anal sex in the past 6 months was divided into two categories, consistent use (When engaging in anal intercourse, condoms were used in more than 80% of cases and condoms were used throughout the sex) and inconsistent use (other cases).

[b] In the past 6 months.

[c] Health service represented whether participants had accepted any HIV related health service (HIV testing, condom distribution, HIV risk reducing consult, peer education or HIV infection risk assessment) in the past 12 months.

[d] MSW stands for male sex workers. It represented if the participants have been obtained money or goods through sexual activity.

[e] Multivariate cox regression analysis included marital status, education, residence time in Tianjin, condom use during last sex, condom use during

anal sex, number of sexual partners, health service utilization, MSW.

sTable3. Definition of sexual behavior indicator levels

Variables	Ideal level	Risky level
Condom use in last anal sex	Yes	No
Frequency of condom use during anal sex	Consistent use	Inconsistent use
Number of sexual partners	<10	More than 10

sTable4. Total number of follow-up times among MSM in Tianjin from 2011-2019

Number of Follow-Up Times[a]	**Number of MSM** (%)	**Cumulative Percentage** (%)
2	832 (41.01)	41.01
3	378 (18.63)	59.64
4	240 (11.83)	71.46
5	142 (7.00)	78.46
6	111 (5.47)	83.93
7	67 (3.30)	87.24
8	56 (2.76)	90.00
9	25 (1.23)	91.23
10	33 (1.63)	92.85
>10	145 (7.15)	100.00
Total	2029 (100.00)	

[a] Represented the total number of follow-ups for each participant within the period from first enrollment to the last follow-up. Mean: 4.39 times; Standard Deviation: 3.96; Median: 3 times; P_{25}: 2 times; P_{75}: 5 times.

sTable5. HIV Incidence rates by year

Year	Number of MSM	HIV seroconversion	Incidence Rate (95%CI)[a]
2012[b]	454	8	2.86 (1.59-5.14)
2013	589	20	4.57 (3.31-6.31)
2014	702	18	3.43 (2.35-4.98)
2015	794	27	4.65 (3.53-6.12)
2016	860	16	2.50 (1.63-3.83)
2017	823	12	2.13 (1.29-3.53)
2018	776	10	2.27 (1.32-3.93)
2019	518	16	5.51 (3.97-7.66)

[a] When calculating the incidence rate, numerator was the number of HIV infection in each year and denominator was the sum of total actual survival time of each participant in this year.

[b] The first case of HIV seroconversion occurred in 2012, though the study started in 2011.

sTable6. HIV incidence rate among age subgroups

Age subgroup	Number of MSM	HIV seroconversion	Incidence Rate (95%CI)
<45	1504	85	3.83 (3.24-4.52)
45-60	464	37	2.81 (2.14-3.69)
>60	61	5	2.08 (0.95-4.55)

sTable7. Incidence rates for HIV infection among MSM with different follow-up times

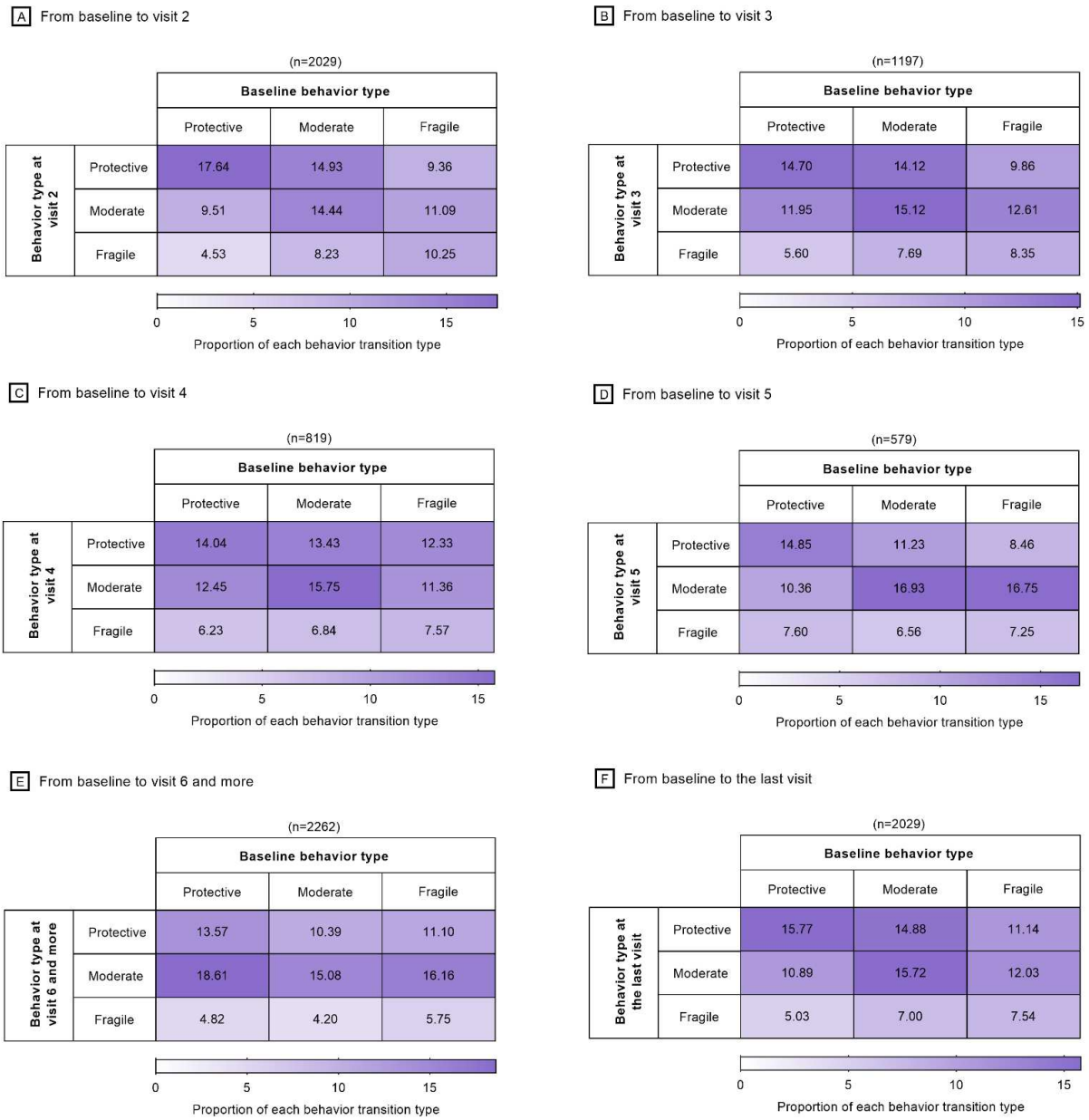
Behavior transition type		Incidence Rate Per 100 Person-Years (95%CI)			Total
		Baseline			
		Protective	Moderate	Fragile	
2 Times[a]	Protective	1.73 (0.44-6.83)	0 (0.00-0.00)	5.6 (2.39-13.12)	4.88 (3.65-6.53)
	Moderate	1.05 (0.15-7.38)	1.51 (0.38-5.97)	0.8 (0.11-5.63)	
	Fragile	10.27 (4.06-25.99)	14.07 (7.92-24.99)	16.97 (11.14-25.85)	
3 Times	Protective	0 (0.00-0.00)	0 (0.00-0.00)	0 (0.00-0.00)	4.49 (3.06-6.59)
	Moderate	3.18 (0.81-12.44)	0 (0.00-0.00)	5.04 (1.67-15.18)	
	Fragile	13.83 (6.58-29.07)	21.07 (10.91-40.69)	14.73 (7.43-29.19)	
4 Times	Protective	0 (0.00-0.00)	0 (0.00-0.00)	0 (0.00-0.00)	2.89 (1.72-4.84)
	Moderate	1.52 (0.22-10.63)	1.16 (0.17-8.14)	0 (0.00-0.00)	
	Fragile	15.24 (5.38-43.19)	19.03 (9.77-37.06)	9.45 (2.53-35.33)	
5 Times	Protective	0 (0.00-0.00)	0 (0.00-0.00)	0 (0.00-0.00)	3.21 (1.74-5.91)
	Moderate	7.24 (1.91-27.51)	0 (0.00-0.00)	4.97 (1.29-19.19)	
	Fragile	7.86 (2.08-29.73)	22.69 (8.39-61.37)	6.92 (1.04-45.85)	
6 times And more	Protective	0 (0.00-0.00)	0.52 (0.07-3.67)	0.85 (0.21-3.38)	2.27 (1.64-3.15)
	Moderate	2.15 (0.90-5.12)	0.44 (0.06-3.11)	0.41 (0.06-2.9)	
	Fragile	16.08 (9.11-28.37)	9.92 (4.64-21.2)	13.68 (7.46-25.1)	
Overall	Protective	0.37 (0.09-1.48)	0.19 (0.03-1.35)	1.37 (0.66-2.86)	3.36 (2.83-3.99)
	Moderate	2.27 (1.27-4.07)	0.69 (0.26-1.83)	1.39 (0.67-2.9)	
	Fragile	13.18 (9.15-18.99)	15.37 (11.23-21.04)	14.51 (10.77-19.55)	
Total		3.14 (2.30-4.29)	2.92 (2.13-3.99)	4.02 (3.07-5.26)	

[a] 2 times represented the participants whose number of total follow-up times was 2, and so on. Participants were divided into subgroups according to their number of total follow-up times. The calculation of HIV incidence rate was done within each subgroup.

sTable8. Behavior transition type from baseline to each visit

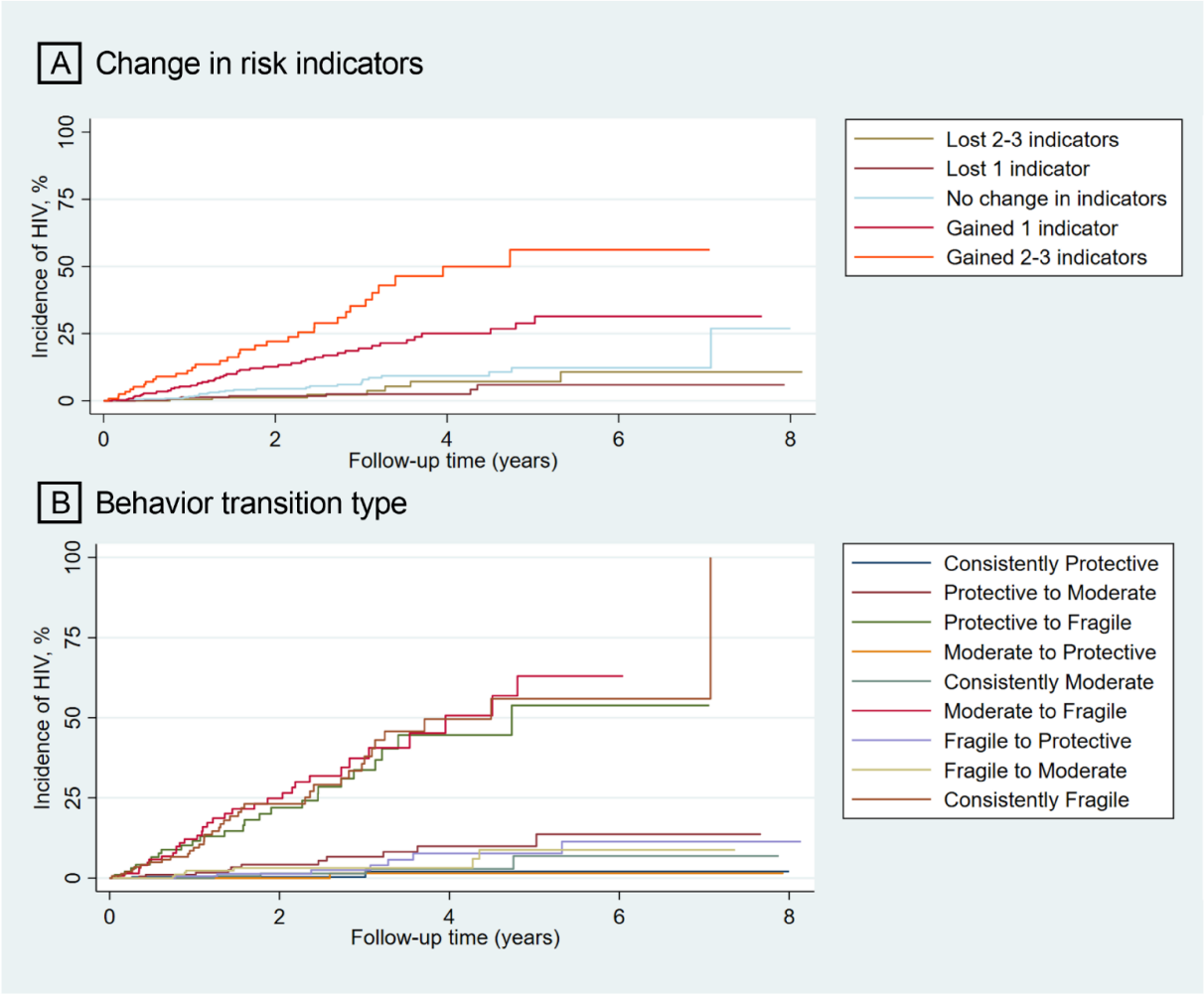
Behavior transition type in each visit[a] **N (%)**		**Baseline**			Total
		Protective	Moderate	Fragile	
2nd	Protective	358 (17.64)	303 (14.93)	190 (9.36)	851 (41.94)
	Moderate	193 (9.51)	293 (14.44)	225 (11.09)	711 (35.04)
	Fragile	92 (4.53)	167 (8.23)	208 (10.25)	467 (23.02)
3rd	Protective	176 (14.70)	169 (14.12)	118 (9.86)	463 (38.68)
	Moderate	143 (11.95)	181 (15.12)	151 (12.61)	475 (39.68)
	Fragile	67 (5.60)	92 (7.69)	100 (8.35)	259 (21.64)
4th	Protective	115 (14.04)	110 (13.43)	101 (12.33)	326 (39.80)
	Moderate	102 (12.45)	129 (15.75)	93 (11.36)	324 (39.56)
	Fragile	51 (6.23)	56 (6.84)	62 (7.57)	169 (20.63)
5th	Protective	86 (14.85)	65 (11.23)	49 (8.46)	200 (34.54)
	Moderate	60 (10.36)	98 (16.93)	97 (16.75)	255 (44.04)
	Fragile	44 (7.60)	38 (6.56)	42 (7.25)	124 (21.42)
6th And More	Protective	307 (13.57)	235 (10.39)	251 (11.10)	793 (35.06)
	Moderate	421 (18.61)	341 (15.08)	373 (16.16)	1135 (50.18)
	Fragile	109 (4.82)	92 (4.20)	130 (5.75)	334 (14.77)
Total		643 (31.69)	763 (37.60)	623 (30.70)	8915 (100.00)

[a] listed the number (proportion) of each behavior type in each visit.



sFigure2. Heatmap of percentage of each behavior transition type in each visit

Figure legends 1: Values and colors indicated the percentage of each behavior transition type in each visit (for example, in Figure 1A, 17.64 represented the percentage of “protective” to “protective” was 17.64% from baseline to visit2). A lighter color indicates that the percentage was lower for MSM in that subgroup, whereas a darker color indicated a higher percentage in that subgroup.



sFigure3. Kaplan-Meier curves of incident HIV among different Behavior changes

sTable9. OR and 95% CI for behavior transition-type of “fragile” or “moderate” in the last follow-up stratified by the behavior type categories at baseline

Behavior changes	“Fragile” or “Moderate” at the last follow-up as the dependent variable, OR (95% CI)[a]		
	Protective at baseline	Moderate at baseline	Fragile at baseline
Per 1-time increase in the total follow-up times	1.02 (0.98-1.06)	0.99 (0.95-1.03)	0.95 (0.91-0.99)
Age			
<45	REF	REF	REF
45-60	0.57 (0.37-0.87)	0.45 (0.29-0.68)	0.52 (0.35-0.78)
>60	0.48 (0.16-1.39)	0.23 (0.10-0.54)	0.71 (0.25-2.05)
Residence time in Tianjin			
<3 months	REF	REF	REF
3-7 months	0.51 (0.11-2.32)	1.31 (0.40-4.30)	3.54 (0.75-16.63)
7-12 months	1.06 (0.36-3.12)	1.53 (0.30-7.78)	1.76 (0.53-5.86)
1-2 years	1.93 (0.75-4.97)	0.89 (0.40-1.96)	1.88 (0.72-4.85)
>2 years	0.92 (0.59-1.43)	0.65 (0.45-0.99)	1.10 (0.73-1.66)

Abbreviation: OR, odds ratio; CI: confidence interval; REF, reference level.

[a] Multivariate logistic regression analysis included total follow-up times, age, marital status, education, residence time in Tianjin, health service utilization