

# Effectiveness of HIV Risk Reduction Interventions among Men who have Sex with Men in China: A Systematic Review and Meta-Analysis

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## Abstract

**Objective:** To evaluate the effect of risk reduction interventions on HIV knowledge, attitudes and behaviors among men who have sex with men (MSM) in China.

**Methods:** We performed a systematic review and meta-analysis of HIV risk reduction intervention studies among Chinese MSM. The summary difference of standardized mean differences (SMD) between both study arms or between pre- and post-intervention assessments were defined as the effect size (ES); ES was calculated using standard meta-analysis in random effects models.

**Results:** Thirty-four eligible studies were included in the analysis, including two randomized clinical trials (RCT), six quasi-experimental studies, six pre-and-post intervention studies, and twenty serial cross-sectional intervention studies. These studies showed an increase in consistent condom use with any male sexual partners (mean ES, 0.46; 95% confidence interval [CI], 0.35–0.56), with regular sexual partners (mean ES, 0.41; 95% CI, 0.18–0.63), and casual sexual partners (mean ES, 0.52; 95% CI, 0.24–0.79). The analysis of ten studies that measured the impact on uptake of HIV testing also showed a positive result (mean ES, 0.55; 95% CI, 0.38–0.71). The risk reduction interventions also improved HIV/AIDS-related knowledge (mean ES, 0.77; 95% CI, 0.60–0.94) and attitudes (mean ES, 1.35; 95% CI, 0.91–1.79), but did not reduce prevalence of HIV (mean ES, 0.23; 95% CI, 0.02–0.45) and syphilis infections (mean ES, –0.01; 95% CI, –0.19–0.17). There was significant heterogeneity among these studies.

**Conclusions:** On aggregate, HIV risk reduction interventions were effective in reducing risky behaviors and improving knowledge and attitudes among Chinese MSM, but were not associated with a change in the prevalence of HIV and syphilis. Future studies should use incidence as definitive study outcome.

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## Introduction

Men who have sex with men (MSM) have become one of main subgroup populations at high risk of HIV infection in China in the past decade [1]. Chinese MSM tend to live in large- or middle-size cities rather than in small towns and rural areas for numerous considerations, e.g., there are more job opportunities; it is easier to find sexual partners; there are more socially tolerant environments which also keep some MSM away from their family members and

acquaintances in their hometowns. MSM have lived in situations of repression, negative feedback, and discrimination and stigma. They often are poorly informed as to their sexual risks; a desire for intimacy and sexual fulfillment tends to outweigh the possible consequences of unprotected sex and the risks associated with it. Risky behaviors can occur in the context of an increasing number of MSM with HIV infection, some in acute stages of infection with very high HIV viral loads. The twin-epidemic of HIV and of STI

can increase HIV viral expression and break down the integrity of mucosal surfaces and can further recruit HIV target cells to the infected area. HIV has spread quickly among Chinese MSM particularly in urban areas [2,3,4]; a national survey in 61 cities in years 2008 and 2009 showed 4.9% prevalence rate [5]. It is an urgent need to find effective intervention approaches to respond to the emerging epidemic among MSM in China as well as in other areas of the world [6].

Attitudes towards sex and sexual behaviors in China have evolved over thousands of years, but have advanced rapidly in recent years, reflecting cultural input consequent to industrialization and Western cultural norms and values in the past 30 years. Now people in China tend to be more tolerant towards homosexuality which has begun to be considered as a legitimate lifestyle choice. Although Chinese government has prioritized HIV prevention programs for MSM population, these programs often do not involve gay community and their community based organizations (CBOs), and therefore, their impact may be limited [7]. Unprotected sex and frequent change of sexual partners are prevalent among Chinese MSM, particularly among young MSM [8], and abuse of alcohol and club drugs further increase unprotected sex in a group of MSM [9,10,11] and put MSM at higher risk of contracting and transmitting HIV.

Two recently published meta-analyses evaluated the efficacy of HIV prevention intervention among MSM in China, suggesting that interventions may increase condom use, uptake of HIV testing, and HIV-related knowledge [12,13]. There were numerous more recent intervention studies evaluating the efficacy on HIV-related behaviors, attitudes, and knowledge in China [14,15,16,17,18]. Hence, we conducted an updated systematic review and meta-analysis to evaluate the effects of HIV risk reduction interventions on knowledge, attitudes, behaviors and disease prevalence among Chinese MSM.

## Results

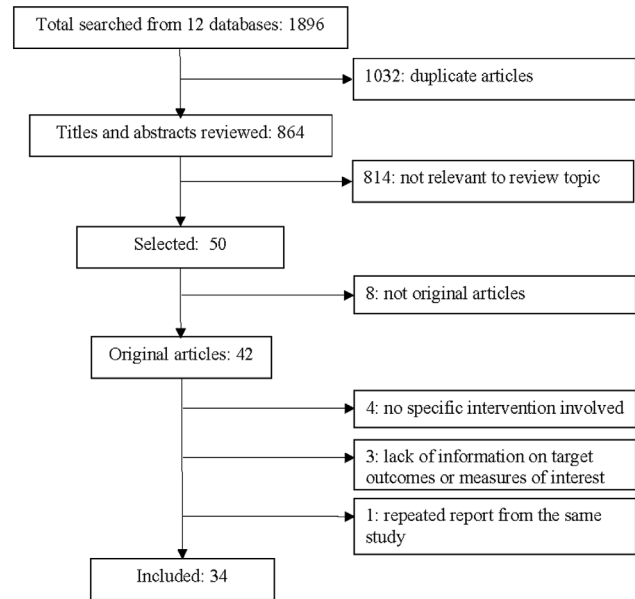
### Results from Literature Search

Our search yielded 1896 entries from twelve electronic databases (Figure 1); 864 titles and abstracts were reviewed and 1032 duplicates were removed. We excluded 814 citations because they did not meet one or more of the inclusion criteria. Out of 50 potential relevant papers for full text reviewing, 16 were further excluded because of not original article (i.e., editorial, comment, or review;  $k=8$ ), no specific intervention involved ( $k=4$ ), lack of information on target outcomes ( $k=3$ ), and repeated report from the same study ( $k=1$ ). The excluded articles are listed in Appendix S1. We included 34 studies in our systematic review.

Of 34 studies, study design included: two RCT [14,19], six quasi-experimental studies [15,17,20,21,22,23], six self-pre-and-post intervention studies without control groups [18,24,25,26,27,28], and twenty serial cross-sectional studies (Table 1). A large variation of rigor scores was noted, ranging from 0 to 8, with a mean score of 2.5. One study had a rigor score of zero [29], nineteen had a score of one, and only five had a score of  $\geq 6$  [14,19,20,22,23] (Table 2).

### Consistent Condom Use

A variety of condom use outcomes were reported, e.g., in anal sex with regular, casual, and/or mixed sexual partners and were measured during various recall periods, e.g., during last sexual encounter, in the past month, and/or the past six months (Table 3). The overall effectiveness of risk reduction interventions on consistent condom use with any sexual partners during anal intercourse is presented in Figure 2. Twenty five studies reported a



**Figure 1. Flow diagram of the literature search process<sup>1</sup>.** <sup>1</sup> Twelve databases included: 1) AMED; 2) BNI; 3) EMBASE; 4) CNKI; 5) CQVIP; 6) EconLit; 7) ERIC; 8) Medline; 9) PsycINFO; 10) Scopus; 11) ISI Web of Science; 12) Wanfang Data. doi:10.1371/journal.pone.0072747.g001

positive association between interventions and consistent condom use, and 17 had statistical significance. Meta-analysis of these 25 studies showed that risk reduction intervention increased consistent condom use (mean ES: 0.46; 95% CI: 0.35, 0.56;  $P<0.01$ ). Large heterogeneity was observed among these studies ( $I^2=87.2\%$ ;  $P<0.01$ ). The funnel plot show significant evidence of publication bias (Kendall tau = 0.31;  $P=0.03$ ; Egger's  $t$  value = 3.86;  $P<0.01$ ).

The effectiveness was also shown in subgroup analyses by: (1) type of sexual partners (2) recall period, (3) number of study sites, (4) venue of recruiting participants, (5) type of risk reduction intervention, (6) study design, (7) sample size at baseline, and (8) rigor score (Table 4). In standardized deleted residual analysis, four studies [24,27,30,31] were identified as outliers (standardized deleted residual = 3.40 [24], 2.02 [27], 2.05 [30], -2.23 [31]). Further sensitivity analyses were used to evaluate the stability of summary effect size in the meta-analysis by excluding the outlier studies. Summary effect sizes were not changed after these exclusions (Table 4).

Six studies presented separately the proportions of consistent condom use with regular and casual sexual partners during anal intercourse. The effect sizes in the meta-analysis were similar with regular sexual partners (mean ES, 0.41; 95% CI, 0.18–0.63), and with casual sexual partners (mean ES, 0.52; 95% CI, 0.24–0.79; Figure 3).

### Uptake of HIV Testing

Of ten studies evaluating uptake of HIV testing eight reported an increased proportion of taking HIV testing while two did not [19,32]. Meta-analysis of ten studies showed a marked increase in taking HIV testing post intervention (mean ES, 0.55; 95% CI, 0.38–0.71;  $P<0.01$ ). Substantial heterogeneity was found across these six studies ( $I^2=83.8\%$ ,  $P<0.01$ ; Figure 4).

**Table 1.** Characteristics of HIV intervention prevention studies among Chinese men who have sex with men.

| Publication              | City (trial period)                | Study participants |   | Description of interventions   |                                   | Study design | Follow-up (months) | Drop-out (%) |            |
|--------------------------|------------------------------------|--------------------|---|--|-----------------------------------|--------------|--------------------|--------------|------------|
|                          |                                    | Recruitment        | No. of participants (age mean, age range)                   | Intervention   |                                   |              |                    |              | Comparison |
|                          |                                    |                    |   | Intervention   | Comparison                        |              |                    |              |            |
| Gao et al. [20], 2005    | Chengdu (N/A)                      | EBS, RDS           | 135→135 <sup>A</sup> , 140→140 <sup>B</sup><br>(N/A, 16–46) | A: self-facilitate peer-led intervention; B: social-facilitate peer-led intervention | No specific                       | QES          | 5                  | 0            |            |
| Song et al. [24], 2005   | Shenzhen (N/A)                     | EBS                | 109→71 (24, 16–46)  | Multi-way intervention   | N/A                               | SPIS         | 0                  | 35           |            |
| Wang et al. [21], 2005   | Chengdu (N/A)                      | RDS                | 20→150 (N/A, 16–42)   | Multi-way intervention   | No specific                       | QES          | 5                  | 14           |            |
| Xu et al. [29], 2006     | Chengdu & Kunming (2005)           | EBS                | 48→48 (32, 18–69)   | Multi-way intervention   | N/A                               | SCIS         | 60                 | N/A          |            |
| Gao et al. [22], 2007    | Chengdu (N/A)                      | EBS, RDS           | 80→80 (25, 17–50)   | Peer-led intervention  | No described                      | QES          | 5                  | 0            |            |
| Lau et al. [19], 2008    | Hong Kong (N/A)                    | EBS, WDS           | 238→140 (N/A, 18–41+)                                       | Internet-based intervention  | Educational materials distributed | RCT          | 6                  | 41           |            |
| Liu et al. [58], 2008    | Chongqing (2006–2007)              | EBS                | 180→207 (23, N/A)   | Multi-way intervention   | N/A                               | SCIS         | 12                 | N/A          |            |
| Wang et al. [33], 2008   | Mianyang (2006–2007)               | RDS                | 201→200 (24, 16–57)   | Peer-led intervention  | N/A                               | SCIS         | 6                  | N/A          |            |
| Zhu et al. [25], 2008    | Hefei, Wuhu & Fuyang (N/A)         | PDR                | 218→170 (24, 18–61)   | Peer-led intervention  | N/A                               | SPIS         | 3                  | 22           |            |
| Cao et al. [59], 2009    | Shenyang, Chengdu & Nanjing (2007) | EBS                | 484→553 (21, 16–45)   | Multi-way intervention   | N/A                               | SCIS         | 6                  | N/A          |            |
| Feng et al. [60], 2009   | Chongqing (2006–2007)              | RDS                | 1000→772 (28, ≥18)  | Multi-way intervention   | N/A                               | SCIS         | 12                 | N/A          |            |
| Wang M et al. [61], 2009 | Wuhan (2006)                       | SBS                | 222→224 (N/A, 15–24)  | Multi-way intervention   | N/A                               | SCIS         | 6                  | N/A          |            |
| Wang Y et al. [62], 2009 | Mianyang (2006–2008)               | RDS                | 201→200→203 (24, 16–57)                                     | Peer-led intervention  | N/A                               | SCIS         | 24                 | N/A          |            |
| Xiu et al. [63], 2009    | Qingdao (2007–2008)                | EBS                | 216→199 (27, 18–50)   | Multi-way intervention   | N/A                               | SCIS         | N/A                | N/A          |            |
| Xu et al. [32], 2009     | Wuhan (2007–2008)                  | EBS                | 253→154 (27, 15–61)   | Multi-way intervention   | N/A                               | SCIS         | 6                  | N/A          |            |
| Zeng et al. [64], 2009   | 18 cities (2006–2008)              | RDS, WDS           | 5178→5460 (26, ≥18)   | Multi-way intervention   | N/A                               | SCIS         | 24                 | N/A          |            |
| Zhang et al. [23], 2009  | Mianyang & Yibin (2007)            | PDS                | 200→200 (N/A, 18–35+)                                       | Peer-led intervention  | Routine HIV intervention          | QES          | 6                  | 0            |            |
| Ding et al. [34], 2010   | Chongqing (2006–2008)              | SBS                | 1000→1044→743 (27, 18–68)/N/A                               | Multi-way intervention   | N/A                               | SCIS         | 24                 | N/A          |            |
| He et al. [26], 2010     | Wuhu (2006–2008)                   | RDS                | 360→306 (23, 15–48)   | Multi-way intervention   | N/A                               | SPIS         | 24                 | 15           |            |
| Ma et al. [65], 2010     | Xiamen (2008–2009)                 | RDS                | 98→140→154 (25, N/A)  | Multi-way intervention   | N/A                               | SCIS         | 14                 | N/A          |            |
| Meng et al. [27], 2010   | Pulan (2009)                       | SBS                | 62→62 (28, 19–49)   | Peer-led intervention  | N/A                               | SPIS         | 10                 | 0            |            |
| Nong et al. [66], 2010   | Nanning (2007–2008)                | EBS                | 230→452→452 (25, N/A)                                       | Multi-way intervention   | N/A                               | SCIS         | 12                 | N/A          |            |
| Zhang et al. [30], 2010  | Guilin (2008–2009)                 | EBS                | 315→346 (28, 18–51+)  | Multi-way intervention   | N/A                               | SCIS         | 12                 | N/A          |            |
| Li et al. [35], 2011     | Nanjing (2008–2010)                | SBS                | 606→616→400 (28, ≥18)                                       | Multi-way intervention   | N/A                               | SCIS         | 24                 | N/A          |            |

**Table 1. Cont.**

| Publication              | City (trial period)          | Study participants |                                  | No. of participants (age mean, age range) |            | Description of interventions  |                                   | Study design | Follow-up (months) | Drop-out (%) |
|--------------------------|------------------------------|--------------------|----------------------------------|---|------------|-------------------------------|-----------------------------------|--------------|--------------------|--------------|
|                          |                              | Recruitment        | Intervention                     | Intervention                              | Comparison | Intervention                  | Comparison                        |              |                    |              |
| Qu et al. [67], 2011     | Hohhot & Baotou (2008–2009)  | SBS                | 706→767 (27, 18–63)              | N/A                                       | N/A        | Peer-led intervention         | N/A                               | SCIS         | 12                 | N/A          |
| Wang F et al. [68], 2011 | Yingtian (2009–2010)         | PDS                | 135→134 (27, N/A)                | N/A                                       | N/A        | Multi-way intervention        | N/A                               | SCIS         | 12                 | N/A          |
| Wang L et al. [69], 2011 | N/A (2008–2010)              | SBS                | 500→496 (23, ≥18)                | N/A                                       | N/A        | HIV testing intervention      | N/A                               | SCIS         | 24                 | N/A          |
| Wang Y et al. [28], 2011 | Nanchang (2006–2007)         | EBS                | 101→101 (N/A, N/A)               | N/A                                       | N/A        | Peer-led intervention         | N/A                               | SPIS         | 12                 | 0            |
| Wu et al. [31], 2011     | Wuhu (2009–2010)             | SBS                | 244→179 (20, 18–25)              | N/A                                       | N/A        | Multi-way intervention        | N/A                               | SCIS         | 6                  | N/A          |
| Hao et al. [14], 2012    | Nanjing (2008–2009)          | RDS                | 149→100 (28, 18–73)              | 146→111 (28, 18–73)                       |            | Enhanced voluntary counseling | Standard voluntary counseling     | RCT          | 6                  | 28           |
| Tan et al. [15], 2012    | Shenzhen (2009–2010)         | EBS                | 111→120 (28, N/A)                | 105→98 (26, N/A)                          |            | IEC intervention              | Educational materials distributed | QES          | 12                 | N/A          |
| Wang et al. [16], 2012   | Harbin (2006–2010)           | SBS                | 400→419→451→450→413 (N/A, 18–79) | N/A                                       | N/A        | Multi-way intervention        | N/A                               | SCIS         | 48                 | N/A          |
| Duan et al. [17], 2013   | Mianyang & Yibin (2006–2008) | PDS                | 200→200 (N/A, ≥18)               | 200→200 (N/A, ≥18)                        |            | Peer-led intervention         | Routine HIV intervention          | QES          | 12                 | N/A          |
| Guo et al. [18], 2013    | Langfang (2007)              | WDS, PDS, EBS      | 233→200 (N/A, ≥18)               | N/A                                       | N/A        | HIV testing intervention      | N/A                               | SPIS         | 3                  | 14           |

**NOTE:** EBS: establishment-based sampling; RDS: respondent-driven sampling; PDS: peer-driven sampling; WDS: web-driven sampling; SBS: snowball sampling; IEC: information, education, communication; QES: quasi-experimental study; SCIS: serial cross-sectional intervention studies; SPIS: self-pre-and-post intervention studies without comparison group; RCT: randomized control trial; N/A: Not available. doi:10.1371/journal.pone.0072747.t001

**Table 2.** Quality assessment of study design (rigor score\*).

| Publication              | Cohort (a) | With control group (b) | Pre/post intervention (c) | Random assignment (d) | Random selection for assessment (e) | Sample size > 100 (f) | Follow-up ≥ 80% (g) | Comparable socio-demographics between study arms (h) | Comparable outcome measures at baseline (i) | Total |
|--------------------------|------------|------------------------|---------------------------|-----------------------|-------------------------------------|-----------------------|---------------------|--|---|-------|
| Gao et al. [20], 2005    | 1          | 1                      | 1                         | 0                     | 0                                   | 1                     | 1                   | 0.5  | 1   | 6.5   |
| Song et al. [24], 2005   | 1          | 0                      | 1                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 3     |
| Wang et al. [21], 2005   | 1          | 1                      | 1                         | 0                     | 0                                   | 1                     | 1                   | 0.5  | 0   | 5.5   |
| Xu et al. [29], 2006     | 0          | 0                      | 0                         | 0                     | 0                                   | 0                     | 0                   | 0  | 0   | 0     |
| Gao et al. [22], 2007    | 1          | 1                      | 1                         | 0                     | 0                                   | 1                     | 1                   | 1  | 1   | 7     |
| Lau et al. [19], 2008    | 1          | 1                      | 1                         | 1                     | 1                                   | 1                     | 0                   | 1  | 1   | 8     |
| Liu et al. [58], 2008    | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang et al. [33], 2008   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Zhu et al. [25], 2008    | 1          | 0                      | 1                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 3     |
| Cao et al. [59], 2009    | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Feng et al. [60], 2009   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang M et al. [61], 2009 | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang Y et al. [62], 2009 | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Xiu et al. [63], 2009    | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Xu et al. [32], 2009     | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Zeng et al. [64], 2009   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Zhang et al. [23], 2009  | 1          | 1                      | 1                         | 0                     | 0                                   | 1                     | 1                   | 0  | 1   | 6     |
| Ding et al. [34], 2010   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| He et al. [26], 2010     | 1          | 0                      | 1                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 3     |
| Ma et al. [65], 2010     | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Meng et al. [27], 2010   | 1          | 0                      | 1                         | 0                     | 0                                   | 0                     | 1                   | 0  | 0   | 3     |
| Nong et al. [66], 2010   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Zhang et al. [30], 2010  | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Li et al. [35], 2011     | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Qu et al. [67], 2011     | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang F et al. [68], 2011 | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang L et al. [69], 2011 | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Wang Y et al. [28], 2011 | 1          | 0                      | 1                         | 0                     | 0                                   | 1                     | 1                   | 0  | 0   | 4     |
| Wu et al. [31], 2011     | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |
| Hao et al. [14], 2012    | 1          | 1                      | 1                         | 1                     | 1                                   | 1                     | 0                   | 1  | 1   | 8     |
| Tan et al. [15], 2012    | 0          | 1                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 1  | 1   | 4     |
| Wang et al. [16], 2012   | 0          | 0                      | 0                         | 0                     | 0                                   | 1                     | 0                   | 0  | 0   | 1     |

**Table 2. Cont.**

| Publication            | Cohort (a) | With control group (b) | Pre/post intervention (c) | Random assignment (d) | Random selection for assessment (e) | Sample size > 100 (f) | Follow-up ≥ 80% (g) | Comparable socio-demographics between study arms (h) | Comparable outcome measures at baseline (i) | Total |
|------------------------|------------|------------------------|---------------------------|-----------------------|-------------------------------------|-----------------------|---------------------|--|---|-------|
| Duan et al. [17], 2013 | 0          | 1                      | 0                         | 0                     | 1                                   | 1                     | 0                   | 0  | 0   | 2     |
| Guo et al. [18], 2013  | 1          | 0                      | 1                         | 0                     | 1                                   | 1                     | 1                   | 0  | 0   | 4     |

\*One point score for meeting each of the following items (if data were not available in the articles for any item, 0.5 was recorded):  
 (a) was a prospective cohort,  
 (b) used a comparison arm,  
 (c) collected pre and post intervention data,  
 (d) used random assignment of participants to study arms,  
 (e) did random sampling for assessments,  
 (f) sample size > 100,  
 (g) follow-up rate ≥ 80%,  
 (h) had a comparison group with comparable socio-demographics such as age, education, race, employment, income, marital status and others [score "1" if >50% variables were comparable between study arms, and '0' if not], and  
 (i) had a comparison arm with comparable outcome measures at baseline between study arms.  
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**HIV/AIDS-related Knowledge and Attitudes**

Of 21 studies reported HIV/AIDS knowledge outcome, 20 showed statistically significant increase, while 4 reported no statistically different change [28,33,34,35] (Figure 5). Meta-analysis found a significant positive effect size (mean ES, 0.77; 95% CI, 0.60–0.94;  $P < 0.01$ ). Large statistical heterogeneity was observed ( $I^2 = 90.2\%$ ;  $P < 0.01$ ).

Only three studies evaluated AIDS-related attitudes [20,21,22], and all found improvement of AIDS-related attitudes. The summary ES was 1.35 (95% CI, 0.91, 1.79;  $P < 0.01$ ), but large heterogeneity was noted ( $I^2 = 63.6\%$ ,  $P = 0.04$ ).

**HIV and Syphilis Infections**

Ten serial cross-sectional studies assessed HIV/STI outcomes. Six studies had no summary effect on syphilis prevalence (mean ES, -0.01; 95% CI, -0.19, 0.17;  $P = 0.93$ ), and ten studies had a positive overall effect on increasing HIV prevalence (mean ES, 0.23; 95% CI, 0.02, 0.45;  $P = 0.03$ ). Large statistical heterogeneity was observed for two outcomes (Figure 6).

**Discussion**

Our systematic review and meta-analysis evaluate the effectiveness of behavioral interventions on the HIV-related behaviors, knowledge and attitudes, as well as prevalence of HIV/STI among MSM in China. Compared to two previous meta-analytic reviews involving 16 [12] and 22 [13] individual studies in China, respectively, our review included 34 studies with four intervention study designs. Our meta-analysis confirmed previous reviews on increasing consistent condom use, HIV/AIDS knowledge [13], and uptake of HIV testing [12,13]. Our review also evaluated the effect on HIV and syphilis prevalence, but showed no positive effect.

Consistent condom use is seen as the most relevant HIV-related behavior to evaluate effectiveness of interventions among MSM. Our meta-analysis found that a variety of behavioral interventions conducted in China were associated with a significant increase in consistent condom use in anal intercourse. The positive effect was consistent in different study designs and by different measurement periods. However, HIV prevalence among MSM in China increased from 0.6% in 2003 to 7.4% in 2009 from a systematic review and meta-analysis [4]. The possible reasons for this contradiction might be: i) consistent condom use is a poor surrogate index of HIV risk because social desirability bias exists among MSM with consequent over-reporting of condom use; ii) prevention and control measures are not tailored to the needs and context of MSM communities, overestimating their effectiveness; iii) positive reports of program effectiveness might be easier to publish in peer-reviewed journals, resulting in a positive publication bias.

Unprotected anal intercourse (UAI) with casual sexual partners is known as an important route of HIV acquisition for MSM. Recent research has indicated that higher levels of UAI may be associated with one's level of perceived familiarity with casual sexual partners [36]. Likewise, UAI with regular sexual partners has increasingly attracted attention in recent years [37,38]. It is notable that behavioral interventions significantly increased consistent condom use during anal intercourse both with casual (41% increase) and regular sexual partners (52% increase) in our subgroup meta-analyses, involving 12 individual studies. Our stratified analyses by number of study sites, venue of recruiting participants, type of risk reduction interventions, sample size at baseline, and rigor score of study design also found significant increases of consistent condom use during anal sex in these specific

**Table 3.** Behavioral, biomedical, and knowledge outcomes of HIV intervention studies among Chinese MSM.

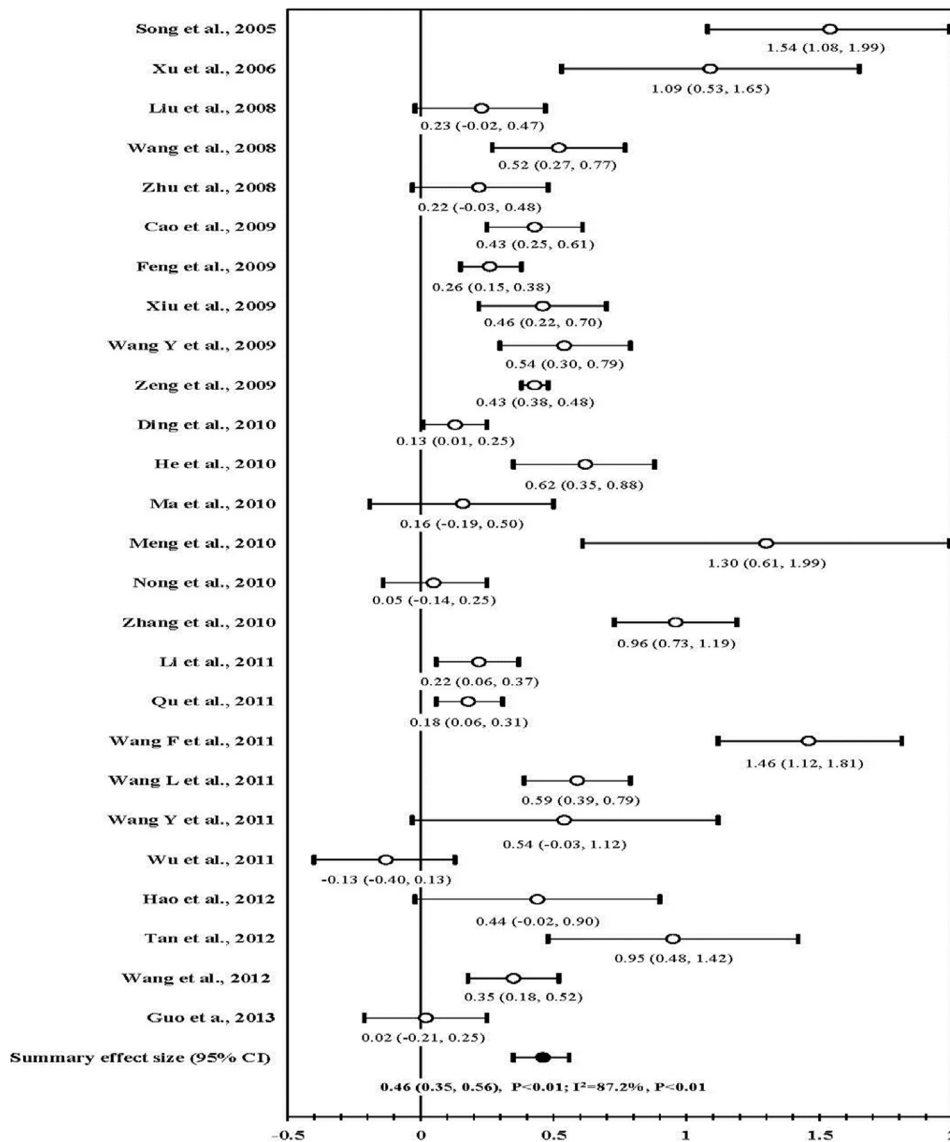
| Publication              | Consistent condom use (%)  |   |                    | Uptake of HIV testing (%)    |                              |     | HIV/AIDS-related knowledge and attitudes (%) |   |                                 | HIV/STI prevalence (%)            |                             |     |
|--------------------------|--|---|--------------------|------------------------------|------------------------------|-----|--|---|---------------------------------|-----------------------------------|-----------------------------|-----|
|                          | IG   | CG  | AI                 | IG                           | CG                           | AI  | IG   | CG  | AI                              | IG                                | CG                          | AI  |
| Gao et al. [20], 2005*   | AI with CP <sup>PM6</sup> 4.6→66.6<br>AI with RP <sup>PM6</sup> 4.1→46.8 | 3.7→51.1<br>4.1→26.5  | 3.8→4.5<br>3.4→4.2 | N/A                          | N/A                          | N/A | Knowledge 11.1→76.3<br>Attitude 10.7→58.6    | 11.0→11.7<br>15.1→16.5                    | Attitude 16.3→67.4<br>14.2→61.4 | N/A                               | N/A                         | N/A |
| Song et al. [24], 2005   | AI <sup>PM6</sup> 11.9→63.0  | N/A   | N/A                | N/A                          | N/A                          | N/A | Knowledge 60.7→84.2                          | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Wang et al. [21], 2005   | AI with RP 10.5→35.5<br>6.5→49.7   | AI with CP 6.8→6.2<br>with CP 3.1→5.3   | AI                 | N/A                          | N/A                          | N/A | Knowledge 31.0→71.8<br>Attitude 34.1→68.5    | Knowledge 32.3→32.5<br>Attitude 32.4→31.2 | N/A                             | N/A                               | N/A                         | N/A |
| Xu et al. [29], 2006     | AI <sup>PM1</sup> 18.8→58.3  | N/A   | N/A                | N/A                          | N/A                          | N/A | Knowledge 16.7→90.8                          | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Gao et al. [22], 2007    | AI with CP 4.3→76.8<br>3.1→46.2  | AI with RP 2.9→4.2<br>with RP 3.2→4.8   | AI                 | N/A                          | N/A                          | N/A | Knowledge 11.3→86.3<br>Attitude 16.3→87.5    | Knowledge 10.8→11.2<br>Attitude 15.0→16.2 | N/A                             | N/A                               | N/A                         | N/A |
| Lau et al. [19], 2008    | AI with CP <sup>PM6</sup> 63.0→60.0<br>RP <sup>PM6</sup> 37.3→42.9       | AI with AI 49.1→61.1<br>AI with RP <sup>PM6</sup> 30.8→39.3                                     | AI                 | VCT <sup>PM6</sup> 20.7→15.7 | VCT <sup>PM6</sup> 10.7→12.1 | N/A | Knowledge 88.6→93.6                          | Knowledge 87.9→94.3                       | STDP <sup>PM6</sup> 5.7→2.9     | N/A                               | STDP <sup>PM6</sup> 2.1→4.3 | N/A |
| Liu et al. [58], 2008    | AI <sup>PM6</sup> 40.9→50.2  | AI <sup>PM0</sup> 64.3→75.8   | N/A                | 18.3→58.0                    | N/A                          | N/A | Knowledge 35.6→65.2                          | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Wang et al. [33], 2008   | AI <sup>PM6</sup> 31.5→52.0  | N/A   | N/A                | 26.9→45.5                    | N/A                          | N/A | Knowledge 68.6→76.6                          | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Zhu et al. [25], 2008    | AI <sup>PM0</sup> 56.4→65.2<br>46.2→52.5                                 | AI with CP <sup>PM0</sup> 48.4→60.9   | N/A                | N/A                          | N/A                          | N/A | Knowledge** 14.7(2.59)<br>→16.95(1.81)       | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Cao et al. [59], 2009    | AI <sup>PM3</sup> 71.7→83.7  | AI <sup>PM0</sup> 86.5→90.4   | N/A                | 69.6→70.5                    | N/A                          | N/A | Knowledge 62.7→91.9                          | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Feng et al. [60], 2009   | AI <sup>PM0&amp;PM6</sup> 56.4→65.5                                      | 31.8→41.9   | N/A                | N/A                          | N/A                          | N/A | Knowledge 74.3→82.4                          | N/A                                       | N/A                             | Syphilis 9.3→7.3<br>10.4→10.8     | HIVN/A                      | N/A |
| Wang M et al. [61], 2009 | AI with CP <sup>PM1</sup> 25.2→25.6                                      | AI with RP <sup>PM1</sup> 15.3→23.4   | N/A                | N/A                          | N/A                          | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Wang Y et al. [62], 2009 | AI <sup>PM6</sup> 31.5→41.3<br>30.3→47.1<br>23.7→38.7                    | AI with CP <sup>PM6</sup> 52.9<br>AI with RP <sup>PM6</sup> 57.8<br>AI <sup>PM0</sup> 54.0→73.1 | N/A                | N/A                          | N/A                          | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Xiu et al. [63], 2009    | AI <sup>PM6</sup> 45.3→63.8  | N/A   | N/A                | N/A                          | N/A                          | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Xu et al. [32], 2009     | AI with CP <sup>PM6</sup> 40.3→39.0<br>CP <sup>PM0</sup> 50.2→70.6       | AI with RP <sup>PM6</sup> 37.7→56.6   | N/A                | 37.9→36.4                    | N/A                          | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Zeng et al. [64], 2009   | AI <sup>PM0&amp;PM6</sup> 58.0→76.7                                      | 28.2→44.5   | N/A                | 18.8→39.1                    | N/A                          | N/A | Knowledge 76.0→90.5                          | N/A                                       | N/A                             | HIV 2.3→5.0                       | N/A                         | N/A |
| Zhang et al. [23], 2009  | AI with CP <sup>PM0</sup> 80.5→89.0<br>RP <sup>PM0</sup> 67.0→72.0       | AI with AI 82.5→81.0<br>AI with RP <sup>PM0</sup> 70.5→75.0                                     | N/A                | 9.0→22.0                     | 24.5→24.0                    | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |
| Ding et al. [34], 2010   | AI <sup>PM6</sup> 31.8→36.2<br>56.4→61.2                                 | AI <sup>PM0</sup> 36.2→36.7<br>64.4   | N/A                | 18.9→35.2                    | 32.0                         | N/A | Knowledge 90.0→89.5<br>→90.7                 | N/A                                       | N/A                             | HIV 10.4→12.5<br>Syphilis 9.3→8.5 | N/A                         | N/A |
| He et al. [26], 2010     | AI 9.7→22.9<br>14.7→41.2   | RP <sup>PM1</sup> 13.3→25.5   | N/A                | N/A                          | N/A                          | N/A | N/A  | N/A                                       | N/A                             | N/A                               | N/A                         | N/A |

**Table 3. Cont.**

| Publication              | Consistent condom use (%)   |  | Uptake of HIV testing (%) |           | HIV/AIDS-related knowledge and attitudes (%) |                                | HIV/STI prevalence (%)                                      |     |
|--------------------------|---|--|---------------------------|-----------|--|--------------------------------|---|-----|
|                          | IG  | CG   | IG                        | CG        | IG   | CG                             | IG  | CG  |
| Ma et al. [65], 2010     | AI <sup>PMO</sup> 71.7→66.7→76.6  | N/A  | 32.7→42.1→59.1            | N/A       | Knowledge 43.9→45.9→59.7                     | N/A                            | HIV 2.0→1.4→2.6<br>Syphilis 9.2→4.3→10.4<br>HCV 1.0→0.7→0.7 | N/A |
| Meng et al. [27], 2010   | AI <sup>PM1</sup> 6.45→37.1 AI <sup>PMO</sup> 27.4→77.4   | N/A  | N/A                       | N/A       | N/A  | N/A                            | N/A   | N/A |
| Nong et al. [66], 2010   | AI <sup>PM6</sup> 43.0→34.6→45.2 AI <sup>PMO</sup> 72.2→64.4→75.1   | N/A  | 28.3→38.7→44.7            | N/A       | N/A  | N/A                            | HIV 0.87→1.99→2.43<br>Syphilis 10.43→8.18→11.28             | N/A |
| Zhang et al. [30], 2010  | AI <sup>PM6</sup> 15.1→46.4   | N/A  | 17.8→55.2                 | N/A       | Knowledge 30.2→37.9                          | N/A                            | HIV 1.59→2.02   | N/A |
| Li et al. [35], 2011     | AI <sup>PM6</sup> 41.9→56.8→50.8 AI <sup>PMO</sup> 57.8→67.5→64.0 AI with CP <sup>PM6</sup> 64.7→36.4→65.8 AI with RP <sup>PM6</sup> 47.5→45.6→40.1 | N/A  | N/A                       | N/A       | Knowledge 97.0→97.4→98.8                     | N/A                            | HIV 4.0→2.1→2.8<br>Syphilis 11.4→7.5→7.8                    | N/A |
| Qu et al. [67], 2011     | AI <sup>PM6</sup> 38.0→45.3 AI <sup>PMO</sup> 81.4→82.5   | N/A  | N/A                       | N/A       | Knowledge 70.7→81.7                          | N/A                            | HIV 1.7→1.7   | N/A |
| Wang F et al. [68], 2011 | AI <sup>PM6</sup> 23.7→77.6 AI <sup>PMO</sup> 49.6→89.6   | N/A  | N/A                       | N/A       | Knowledge 63.0→95.5                          | N/A                            | N/A   | N/A |
| Wang L et al. [69], 2011 | AI <sup>PM6</sup> 12.5→27.5 AI <sup>PMO</sup> 58.9→75.8   | N/A  | 44.4→65.2                 | N/A       | Knowledge 56.8→87.0                          | N/A                            | HIV 6.2→5.6   | N/A |
| Wang Y et al. [28], 2011 | AI 84.8→93.2  | N/A  | N/A                       | N/A       | Knowledge 81.1→88.2                          | N/A                            | N/A   | N/A |
| Wu et al. [31], 2011     | AI <sup>PM6</sup> 29.4→25.0 AI <sup>PMO</sup> 56.5→67.9   | N/A  | N/A                       | N/A       | Knowledge 81.8→92.0                          | N/A                            | N/A   | N/A |
| Hao et al. [14], 2012    | AI <sup>PM6</sup> 28.1→51.6 AI with CP <sup>PM6</sup> 48.9→63.2 AI with RP <sup>PM6</sup> 22.2→47.8   | AI <sup>PM6</sup> 27.4→33.3 AI with CP <sup>PM6</sup> 46.7→47.5 AI with RP <sup>PM6</sup> 21.4→31.1  | N/A                       | N/A       | N/A  | N/A                            | N/A   | N/A |
| Tan et al. [15], 2012    | AI <sup>PM6</sup> 39.2→61.6 AI <sup>PMO</sup> 73.0→85.0   | AI <sup>PM6</sup> 42.9→33.3 AI <sup>PMO</sup> 64.0→65.3  | 69.4→90.8                 | 52.4→56.1 | Knowledge 73.0→91.7                          | Knowledge 66.7→68.4            | N/A   | N/A |
| Wang et al. [16], 2012   | AI <sup>PM6</sup> 38.7→36.3→41.8→44.1→52.9  | N/A  | 26.2→31.0→37.0→56.4→47.2  | N/A       | N/A  | N/A                            | HIV 1.0→2.9→3.5→5.1→7.5<br>Syphilis 9.2→15.5→14.4→22.4→15.7 | N/A |
| Duan et al. [17], 2013   | AI with CP <sup>PM6</sup> 32.1→58.4 AI with RP <sup>PM6</sup> 23.7→42.5 AI with CP <sup>PMO</sup> 5.7→18.2 AI with RP <sup>PMO</sup> 51.7→78.0      | AI with CP <sup>PM6</sup> 36.4→30.2 AI with RP <sup>PM6</sup> 30.3→21.6 AI with CP <sup>PMO</sup> 18.1→5.8 AI with RP <sup>PMO</sup> 58.5→41.1 | N/A                       | N/A       | Knowledge** 15.1(2.3)→12.4(3.3)              | Knowledge** 9.9(3.0)→11.6(3.6) | N/A   | N/A |
| Guo et al. [18], 2013    | AI <sup>PM3</sup> 50.7→51.5   | N/A  | N/A                       | N/A       | N/A  | N/A                            | N/A   | N/A |

**NOTE:** MSM: men who have sex with men; IG: intervention group; CG: comparison group; AI: anal intercourse; CP: casual partners; RP: regular partners; VCT: voluntary counseling and testing; \*Gao et al. [20], 2005 conducted 2 independent intervention patterns with the same control group, including self-facilitate peer-led intervention and social-facilitate peer-led intervention; \*\*Knowledge scores as score mean (standard deviation); doi:10.1371/journal.pone.0072747.t003





**Figure 2. Forest plot of effect size: the impact of behavioral interventions on consistent condom use during anal intercourses with any male sexual partners among MSM in China.**  
doi:10.1371/journal.pone.0072747.g002

subgroups. The evidence base currently provides general support for intervention approaches, and the efforts to better understand mechanisms of intervention effects and confirm positive effects in high rigor designs should be prioritized.

Client-initiated HIV testing and counseling, known as voluntary counseling and testing (VCT), and provider-initiated HIV testing and counseling in health facilities have helped millions of people learn their HIV status, but global coverage of HIV testing and counseling programs remains low, especially in China. Low levels of HIV prevalence and high levels of stigma and discrimination against people living with HIV/AIDS are disincentives for VCT [39,40]. Many studies have confirmed intervention effects of VCT promotion [41,42,43], but this significant effect may wane over time since the intervention [41]. Eight of ten studies from China reported positive effects on seeking HIV testing, continuing 6- to 48-months after intervention. In our meta-analysis, a 55% increase in HIV test seeking was associated with the behavioral interven-

tions, though one study from Hong Kong showed 29% decrease at 6 months after internet-based intervention [19]. Far more work is needed in China to identify the effectiveness of different interventions on various outcomes over time.

Correct HIV-related knowledge and positive attitudes toward HIV/AIDS have been used to evaluate the interventions among MSM, especially in China. Inconsistent scales for quantitative measurement of HIV-related knowledge and attitudes present substantial challenges for estimating overall effectiveness. Combining the individual studies using meta-analysis suggested a 77% increase of HIV-related knowledge involving 21 Chinese studies, and a 135% increase of HIV-related positive attitudes in three Chinese studies [20,21,22].

It is challenging and costly to measure incidence of HIV or other STD, particularly over a meaningful and substantial time period. To our knowledge, only one meta-analysis among two studies has been done and shown 80% reduction of STI

**Table 4.** Subgroup and sensitivity analyses of consistent condom use with any sexual partners during anal intercourse.

| Subgroup  | No. of studies (k) | Combined ES (95% CI) | P-value | Heterogeneity  |         |
|---|--------------------|----------------------|---------|----------------|---------|
|   |                    |                      |         | I <sup>2</sup> | P-value |
| Recall period on consistent condom use (months) |                    |                      |         |                |         |
| Last sex  | 16                 | 0.42 (0.28, 0.56)    | <0.01   | 89.6%          | <0.01   |
| Past 6 months                                   | 19                 | 0.48 (0.35, 0.60)    | <0.01   | 89.5%          | <0.01   |
| Number of study sites                           |                    |                      |         |                |         |
| One   | 20                 | 0.51 (0.34, 0.67)    | <0.01   | 88.8%          | <0.01   |
| Multiple  | 6                  | 0.35 (0.22, 0.48)    | <0.01   | 80.3%          | <0.01   |
| Venue of recruiting participants                |                    |                      |         |                |         |
| Establishment-based                             | 10                 | 0.59 (0.32, 0.85)    | <0.01   | 89.2%          | <0.01   |
| Other   | 16                 | 0.40 (0.28, 0.52)    | <0.01   | 86.4%          | 0.01    |
| Type of risk reduction interventions            |                    |                      |         |                |         |
| Peer-led  | 6                  | 0.44 (0.22, 0.67)    | <0.01   | 73.9%          | 0.01    |
| Multi-way                                       | 20                 | 0.46 (0.33, 0.59)    | <0.01   | 89.1%          | <0.01   |
| Study design                                    |                    |                      |         |                |         |
| Randomized clinical evaluation                  | 1                  | 0.44 (-0.02, 0.90)   | -       | -              | -       |
| Quasi-experimental evaluation                   | 1                  | 0.95 (0.48, 1.42)    | -       | -              | -       |
| Self-pre-and-post intervention evaluation       | 6                  | 0.66 (0.23, 1.09)    | <0.01   | 89.0%          | <0.01   |
| Serial cross-sectional evaluation               | 18                 | 0.40 (0.29, 0.52)    | <0.01   | 88.1%          | <0.01   |
| Sample size at baseline                         |                    |                      |         |                |         |
| ≤300  | 17                 | 0.55 (0.34, 0.76)    | <0.01   | 87.5%          | <0.01   |
| >300  | 9                  | 0.38 (0.26, 0.50)    | <0.01   | 88.2%          | <0.01   |
| Rigor score                                     |                    |                      |         |                |         |
| 1   | 18                 | 0.40 (0.29, 0.52)    | <0.01   | 88.1%          | <0.01   |
| >1  | 8                  | 0.66 (0.32, 1.01)    | <0.01   | 86.1%          | <0.01   |
| <b>Sensitivity analyses</b>                     |                    |                      |         |                |         |
| Song et al. [24], 2005 excluded                 | 25                 | 0.42 (0.32, 0.52)    | <0.01   | 85.9%          | <0.01   |
| Meng et al. [27], 2010 excluded                 | 25                 | 0.44 (0.33, 0.55)    | <0.01   | 87.3%          | <0.01   |
| Zhang et al. [30], 2010 excluded                | 25                 | 0.43 (0.32, 0.53)    | <0.01   | 85.8%          | <0.01   |
| Wu et al. [31], 2011 excluded                   | 25                 | 0.48 (0.37, 0.58)    | <0.01   | 86.7%          | <0.01   |

**NOTE:** ES: effect size; CI: confidence interval.  
doi:10.1371/journal.pone.0072747.t004

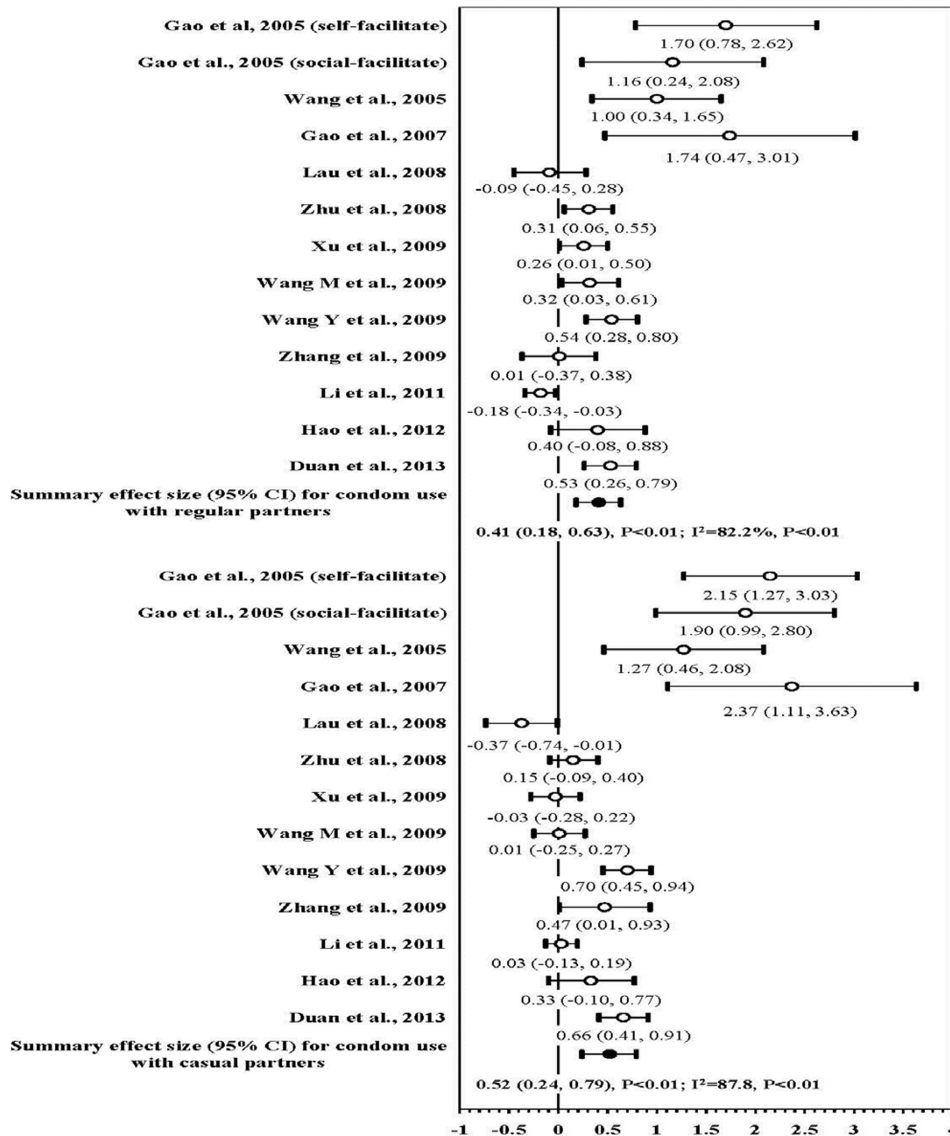
acquisition (chlamydia or gonorrhoea) among people living with HIV/AIDS [44,45,46]. Our study failed to observe reduction of HIV and syphilis infections among Chinese MSM by synthesizing the findings from ten serial cross-sectional studies that measured one or both infections, though various behavioral interventions were performed in some selected cities, though a 40% increase of consistent condom use was observed in the subgroup analysis of serial cross-sectional studies. The similar finding from a recent meta-analytic review showed that HIV prevalence among MSM has substantially increased from 2001–2009 across all Chinese regions [2]. More comprehensive behavioral and biomedical interventions are needed to control this ongoing disaster.

**Strengths and Limitations**

The strength of our study is our thoroughness and methodological rigor of the meta-analysis for risk reduction interventions among Chinese MSM. Our elucidation of the impact of behavioral interventions on behavior and knowledge is useful in

identifying ongoing research and service needs. Our analyses adjusted baseline data between study arms in evaluating the effect of interventions and combined continuous and categorical outcomes of targeted outcomes, something done rarely in other reviews.

Our meta-analysis has limitations as well. All studies used self-reported behaviors, knowledge and attitudes as the outcomes of interest, which might be subject to social desirability bias. Second, no comparison group was included in pre-and-post studies and non-randomization designs represented most of the included studies, contributing a large portion of heterogeneity and reducing the power of analysis. Third, major publication bias in the formal evaluations was found. Positive outcomes might be easier to be accepted by journals. Finally, although 12 databases were searched for the reviews and extensive check for completeness by cross-referencing were employed, we cannot exclude having missed a relevant study.



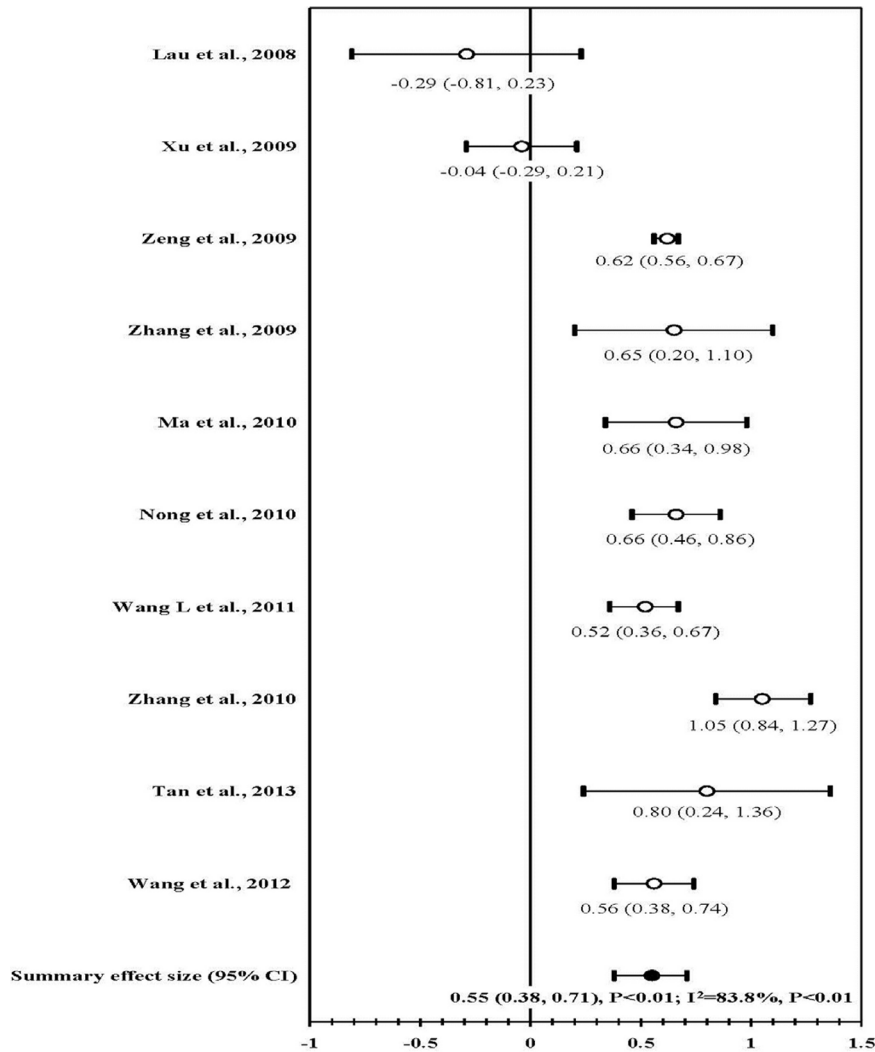
**Figure 3. Forest plot of effect size: the impact of behavioral interventions on consistent condom use during anal intercourses among MSM in China by types of sexual partners.**  
doi:10.1371/journal.pone.0072747.g003

**Methods**

**Literature Search and Study Selection**

A literature search was conducted to identify studies evaluating the effectiveness of HIV risk reduction interventions among MSM in China. Twelve electronic databases were searched for publications in peer-reviewed journals through May 2013, including AMED (Allied and Complementary Medicine Database, Ovid Technologies, Inc., New York), British Nursing Index (Ovid Technologies, Inc., New York), CNKI (Tongfang Knowledge Network Technology Co., Ltd., Beijing, China), CQVIP (Chongqing VIP Information Co., Ltd., Chongqing, China), EMBASE (Elsevier, Amsterdam, The Netherlands), EconLit (The American Economic Association, New York), ERIC (Education Resources Information Centre, Institute of Education Sciences of the U.S. Department of Education, Washington), Ovid Medline (Ovid Technologies, Inc., New York), PsycINFO (American Psycholog-

ical Association, Washington), Scopus (Elsevier, Amsterdam, The Netherlands), Wanfang Data (Chinese Ministry of Science & Technology, Beijing, China), and Web of Science (Thomson Scientific Technical Support, New York). The following combination of key words was used in literature search: (men who have sex with men OR MSM OR homosexual men OR gay men OR bisexual men OR transgender women OR money boy) AND (HIV OR AIDS OR sexually transmitted infections OR sexually transmitted diseases) AND (intervention OR randomized clinical trial OR treatment OR prevention OR adherence OR compliance). All publications were exported to an Endnote file (Endnote X4, Thomson Reuters, San Francisco, CA), and duplicates were deleted. The title and abstract of each paper were independently reviewed by two authors (Liu Y, and Dahiya K) to determine its relevance to the topic. Then, full texts were reviewed whether the paper assessed impacts of risk reduction intervention on HIV-related outcomes among MSM in China. Cross-referencing by



**Figure 4. Forest plot of effect size: the impact of behavioral interventions on uptake of HIV testing among MSM in China.**  
doi:10.1371/journal.pone.0072747.g004

checking the cited references in the included papers was also performed as an additional tool to identify relevant publications.

### Inclusion Criteria

Studies that met the following criteria were included in this meta-analysis: 1) studies evaluating the effectiveness of HIV risk reduction interventions among MSM, including randomized clinical trials (RCTs), quasi-experimental studies, pre-and-post intervention studies without control groups, and serial cross-sectional intervention studies; 2) studies conducted in China; 3) studies reporting HIV-related knowledge, attitudes and behaviors, as well as prevalence of HIV or other sexually transmitted infections (STIs); 4) published in English or Chinese. Duplication of human samples of included studies was evaluated by two authors and these samples were only used once in our analyses.

### Data Extraction

Data extraction was independently done by two authors (Liu Y, and Dahiya K) using a standardized form including items on lead author, publication year, study city, venue of recruiting partici-

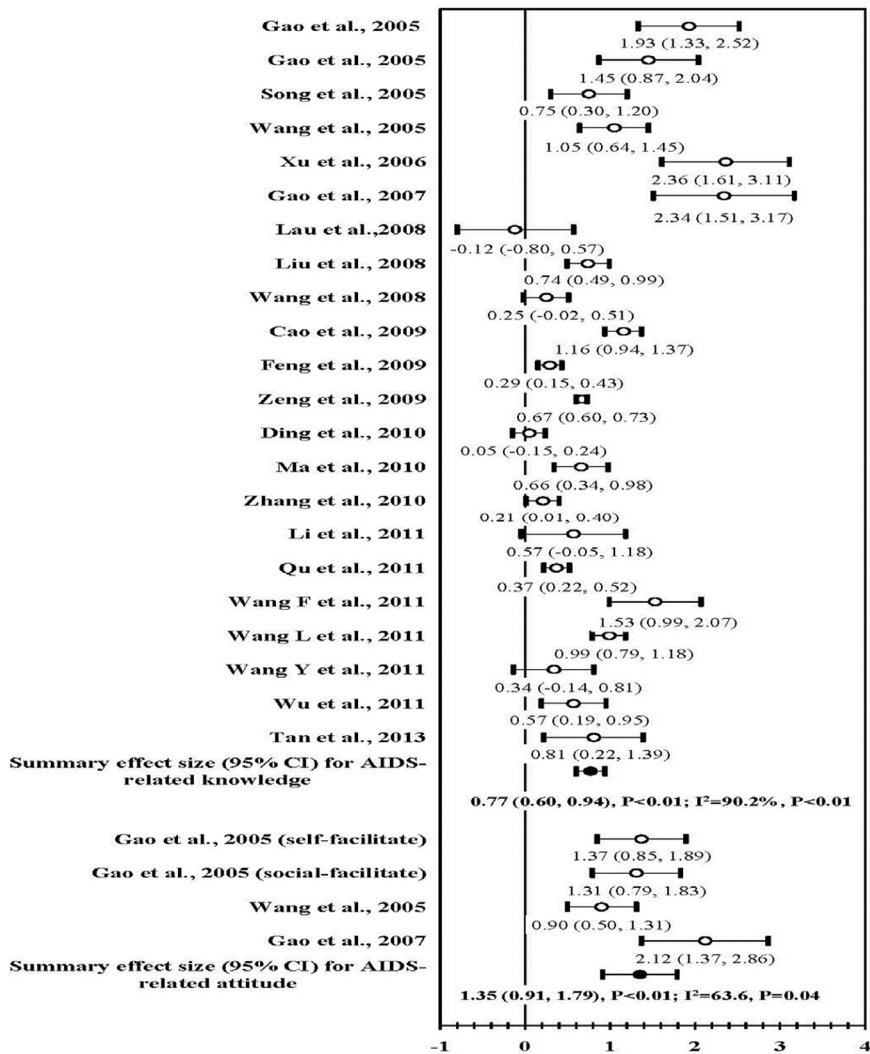
pants, study design, demographic characteristics of study groups, characteristics of sex partners (regular or casual), description of intervention and comparison, duration of follow-up, drop-out rate, proportion or mean frequency of HIV-related outcomes at different follow-up time points, and rigor score of study design. Any disagreements between two data extractors were discussed with the team until a consensus was reached.

### Rigor Score

The rigor of study design for each study was assessed using an 8-item scale, as used in other reviews [47,48] plus an additional item of sample size with a cut-off value of  $>100$  representing good statistical power. The scale is additive, with 1 point for each item. Therefore, the rigor score ranges from 0 to 9, with a higher value representing better study design.

### Statistical Methods

We focused on six main outcomes in our meta-analysis: (1) consistent condom use, (2) uptake of HIV testing, (3) HIV-related knowledge, (4) HIV-related attitudes, (5) HIV infection, and (6)



**Figure 5. Forest plot of effect size: the impact of behavioral interventions on HIV/AIDS-related knowledge and attitude among MSM in China.**

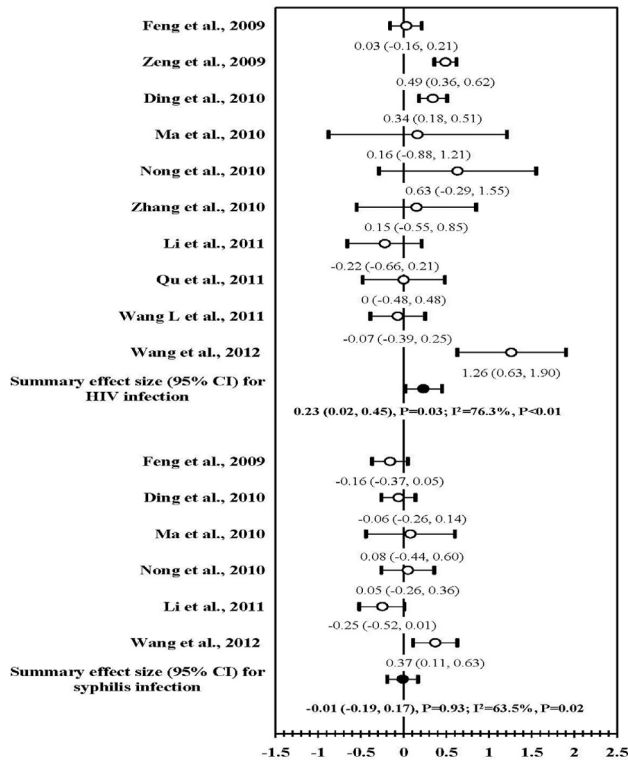
doi:10.1371/journal.pone.0072747.g005

syphilis infection. For studies with multiple intervention arms [20], the effect sizes were calculated using the same comparison arm. When some studies had multiple measurements at different follow-up time points, the last follow-up assessment was used in the meta-analysis for estimating the overall effect size. When such outcome variables were not explicitly reported, they were derived from data provided in the paper or were secured from the authors when possible.

Effect size was calculated on the basis of targeted outcomes from the baseline and latest follow-up assessments between study arms (or self-pre-and-post intervention studies without control arms, or serial cross-sectional intervention studies). Standard mean differences (SMDs) and 95% confidence intervals (CIs) were used to estimate the effectiveness of risk reduction interventions. When studies reported dichotomous outcomes, we transformed odds ratios into SMDs using Cox transformation [49,50]. SMD in each study arm was calculated as a fraction of dividing the difference of two means at follow-up and baseline by the pooled standard

deviation (SD) of these two means [51]. The difference of SMDs from the intervention and comparison arms was used for meta-analysis. As the study arms might not be comparable at baseline, even in RCTs, we used Becker's strategy to adjust for the reported difference between arms at baseline when calculating SMDs; for pre-and-post intervention studies without a comparison arm and for serial cross-sectional intervention studies, we assumed the value for the comparison arm was zero [51]. An SMD difference >0 indicated an increase in the given outcome in the intervention group relative to the control group. Random effects models were derived using the DerSimonian-Laird method [52,53] to establish overall effect sizes. Random effects estimates allowed for variation of true effects across studies [54].

We assessed heterogeneities by  $I^2$  statistics [55], and identified outliers by standardized deleted residuals analyses. The funnel plot, Begg and Mazumdar rank correlation test, and Egger's test of the intercept were employed to assess publication bias [56].



**Figure 6. Forest plot of effect size: the impact of behavioral interventions on HIV and syphilis prevalence among MSM in China.**

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We conducted pre-planned subgroup analyses to examine consistent condom use during anal intercourse by type of sexual partners (regular vs. casual), length of recall period on consistent

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condom use (last sex vs. last 6 months), number of study site (one vs. multiple cities), venue of recruiting participants (establishment-based vs. other), type of risk reduction interventions (peer-led vs. other), study design (randomized clinical trial evaluation vs. quasi-experimental evaluation vs. self-pre-and-post intervention evaluation without control groups vs. serial cross-sectional intervention evaluation), sample size at baseline ( $\leq 300$  vs.  $> 300$ ), and rigor score (1 vs.  $> 1$ ). We conducted sensitivity analyses to determine the stability of intervention effects by evaluating whether the overall effect size was sensitive to inclusion of each individual study. The R/S plus software version 2.15.1 was used for the meta-analyses [57].

## Conclusions

Our analysis suggested that available behavioral interventions can increase consistent condom use during anal sex, regardless of type of sexual partners, encourage successfully seeking of HIV testing, increase HIV-related knowledge and improve attitudes. But these interventions have had limited impacts on HIV or syphilis infection per se. Well-designed intervention studies are needed to explore the effectiveness of a variety of MSM-focused behavioral intervention programs in China.

## Supporting Information

Appendix S1

(DOCX)

Checklist S1 PRISMA 2009 Checklist.

(DOC)

## Author Contributions

Conceived and designed the experiments: YHR YMS SHV HZQ LY. Performed the experiments: HYL YL KD WSF LZ JTM LY. Analyzed the data: HYL LY. Contributed reagents/materials/analysis tools: HYL LZ JTM LY. Wrote the paper: HYL SHV HZQ LY.

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