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Prevalence of passive smoking in the community population aged 15 and above in China: a systematic review and meta-analysis

Running head: Prevalence and distribution of passive smoking in China

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ABSTRACT

Objectives: To estimate the prevalence and distribution of passive smoking in the community population aged 15 and above in China.

Design: A meta-analysis of cross-sectional studies reported the prevalence of passive smoking in China, and a series of subgroup, trend, and sensitivity analyses for conducting this study.

Data source: 46 studies, with 381,580 non-smokers, published between 1997 and 2015 included in a meta-analysis estimating the prevalence and distribution of passive smoking in China.

Results: The pooled prevalence of passive smoking was 48.7% (95%CI: 44.8-52.5) and relatively stable from 1995 to 2013. The prevalence in subgroups of sex, area, age, and time varied from 35.1% (95%CI: 31.8-38.3) in the elderly (≥60) to 48.6% (95%CI: 42.9-54.2) in urban areas. The prevalence was lower in the elderly (≥60) than in persons aged 15-59 (OR 1.61, 95%CI: 1.44-1.81). However, the difference did not show significance between female and male in both areas (OR: 1.27, 95%CI 0.93-1.74 and OR: 1.14, 95%CI 0.82-1.58, respectively). Additionally, a remarkably increasing trend was found among males from 1995 to 2010, but more studies are needed to confirm this finding (Egger's test, p=0.002).

Conclusions: The high and stable prevalence of passive smoking in China arouses increasing national concern regarding specific research and tobacco control. Urban residents and the labour force are more vulnerable to exposure.

Strengths and limitations of this study

1. The study is the first Meta-analysis of the prevalence and distribution of passive smoking in the community population aged 15 and above in China.
2. To reduce the limitation of meta-analysis of prevalence, strict inclusion and exclusion criteria were developed and a series of subgroup, trend, and sensitivity analyses were performed.
3. The result of prevalence and distribution of passive smoking in the community population aged 15 and above may be meaningful for targeted public tobacco control policies in China.
4. More specific studies on tobacco exposure are needed, especially on male non-smokers.

INTRODUCTION

Active smoking is an undeniable factor in multiple chronic diseases and all–cause mortality.[1-2]Pertinent studies showed that 1 in 2 middle-aged or older smokers and 2 in 3 younger smokers die from smoking.[3-5] Meanwhile, studies examined the causal relationships between passive smoking and lung cancer, coronary heart disease, respiratory diseases, and several adverse health effects in infants and children. [1] The economic burden of passive smoking is substantial and is deemed to be one of the primary risk factors in global disease burden.[6-8]Fortunately, it can be prevented, and a growing body of tobacco control interventions has been explored.[9-11]

Currently, most studies focus on smoking. However, few of them were specific investigations in passive smoking, which was typically as part of surveys on active smoking or a social demographic characteristic examined in health behaviour studies. Additionally, several specific studies, even in the national level, reported a wide range of prevalence of passive smoking in China. And we cannot obtain the tendency of passive smoking with time. In other words, it is difficult to determine the extent and seriousness of the epidemiology of passive smoking in china.

Hence, we performed a systematic review and meta-analysis to estimate the prevalence of passive smoking in the community population aged 15 years and above in China and examined the prevalence of passive smoking by sex, area, age and survey years. The synthesis of these data would be helpful in determining the susceptible population or susceptible areas to establish and implement targeted public policies based on the effects of previous tobacco control efforts.

METHODS

We performed this analysis in accordance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE)[12] guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[13] (when generating the flow diagram).

Search strategy

We searched Medline, PUBMED, EMBASE, the Chinese Biological Medical Literature database (CBM), the Chinese Wanfang database, the Chinese National Knowledge Infrastructure (CNKI) and the Chongqing VIP database using the term "(tobacco smoke pollution or passive smoking or second hand smoke or environmental tobacco smoke) and (cross-sectional study or descriptive research or survey or epidemiology)" to identify studies on the prevalence of passive smoking among Chinese adults (aged≥15 years) published from the start of the database to January 2015. We also manually searched relevant annual investigation reports and reference lists to ensure the integrity of the electronic search results.

Selection criteria

Inclusion criteria

Passive smoke exposure was defined as a non-smoker being exposed to another person's tobacco smoke for at least 15 minutes daily for more than 1 day per week. [14] Studies had to meet the following criteria for inclusion: (1) sample of community

non-smokers aged 15 years and above; (2) cross-sectional study or surveillance of the prevalence of passive smoking in China; (3) census or random sampling survey as the investigation type.

Exclusion criteria

We excluded studies if the definition of passive smoking was unclear, the data were incomplete and could not be obtained from the authors, or the literature was repetitively published. In particular, we checked whether data used in provincial studies had already been utilised in national studies, and if so, we excluded the provincial study.

Data extraction and assessment of risk of bias

Two reviewers independently extracted the following information: first author, year of publication, participant characteristics (geographical location, sex, age and sample size), study methods (time of survey, type of survey, method of random sampling, and definition and measurement of passive smoking). Disagreements were discussed to reach consensus. Additionally, publication bias was evaluated by Egger's test. [15]

Statistical analysis

As the sample size of non-smokers was sufficient, reaching close to 0.5 of prevalence in all studies, we used the crude data to pool the overall prevalence estimates. [16 17] Additionally, the random effects model with the D-L method was used to calculate the

pooled estimates and 95% confidence intervals (CIs) due to the high heterogeneity between studies (I^2>75%).[18-20]

In the subgroup analysis, we calculated the prevalence of passive smoking by sex (male and female), area (urban and rural), and age (15-60 and ≥60 years old), and differences were determined by calculating odds ratios (ORs). Moreover, a series of trend analyses were performed by sex, area and age. Additionally, due to the wide range of sample sizes of the included studies, we excluded national health surveys and divided the non-national studies into two groups (sample size≥1000 and <1000) for the sensitivity analyses. We performed all meta-analyses using Stata version 12.0 with the command metan and used Review Manager 5.3 to calculate ORs. Additionally, the trend figures were graphed in Excel 2010.

RESULTS

Our search yielded 1722 studies from the CNKI, 103 from the CBM, 133 from the Wanfang database, and 45 from the VIP. We also identified 194 records in PUBMED, 63 in Medline, and 9 in EMBASE. Six additional records were identified by a manual search of publicly available data. After removing duplicates, 1,650 studies remained. We screened the titles and abstracts of these studies and excluded 1,449 records due to inappropriate study types. Then, 201 full-text articles were assessed for eligibility, and 46 studies, with 381,580 non-smokers, published between 1997 and 2015 on data obtained from 1995 to 2013 were finally included **(Figure 1)**.

Descriptions of studies

Among these eligible studies, 17 studies [21-37] were special investigations of passive smoking, and the remaining studies were mainly parts of investigations on smoking behaviour. Additionally, 6 studies [31-32 36 38-40]were conducted at the national level, while the remaining studies were performed at the provincial level. Hence, the sample sizes were quite variable, ranging from 136[41] to 126142[40] participants. The multistage method of random sampling was primarily employed, except in 5 studies[21 42-45] that used the cluster method and 2 studies[46 47] that used the stratified method. The area of study also varied, with 12 studies[21 25 27 34 35 37 42 43 47-50] examining urban areas, 11 studies[23 26 30 33 44-46 51-54] examining rural areas, and the remaining studies examining both urban and rural areas, nine[29 31 32 40 54-58] of which could be stratified for further subgroup analyses. Nearly all studies reported data for both sexes, but female participants dominated, ranging from 61%[42] to 100%[25 34 35] of the study populations. Most study populations covered the full spectrum of adulthood, except for two studies that focused on persons 35 years of age[43] and 40 years of age[25] and one study[21] that only examined persons 60 years of age and above **(Table 1)**. Additionally, passive smoking was measured by self-report in all studies, and the estimated publication bias was nonsignificant (Egger's test, p=0.493).

Overall prevalence of passive smoking

A total 173,622 non-smokers had been exposed to passive smoke. Estimates of the prevalence of passive smoking ranged from 28.7% to 86.4% **(Figure 2)**, with high heterogeneity (χ^2=25612.75, p<0.001; I^2=99.8%). The pooled prevalence was 48.7%

(95%CI: 44.8-52.5) and increased smoothly over the survey years **(Figure 3)**, from 43.4% (95%CI: 30.2-56.5) in 1995-1999 to 51.6% (95%CI: 35.6-67.6) in 2005-2007 **(Table 2)**.

Subgroup and trend analysis

We collected and stratified the eligible studies by sex, area, and age for further subgroup analyses **(Table 1).** The results are presented in **Table 3**.

Thirty-nine studies[21-24 26-33 36-40 42 43 45-64]reported data for both sexes and 3 studies[25 34-35] only for females including a total of 271,307 females and 94,424 males in the subgroup analyses. Additionally, we excluded the data of one study[65] that only included 5 male non-smokers. The pooled prevalence of passive smoking among females and males were 47.8% (95%CI: 43.9-51.6) and 43.4% (95%CI: 38.9-48.0), respectively. However, the difference calculated using the data of the 39 studies was not statistically significant (OR 1.19, 95%CI: 0.99-1.43). Additionally, the pooled prevalence of passive smoking among females changed radically over the survey years, and that among males remarkably increased from 1995 to 2010 and then decreased slightly in recent years **(Figure 3a).** The highest prevalence of passive smoking among females and males were found in 2003-2004 [52.8% (95%CI: 43.1-62.6)] and 2007-2009 [48.4% (95%CI: 38.5-58.3)], respectively **(Table 2)**. However, the estimated public bias indicated that more studies were necessary to accurately pool the prevalence of passive smoking among males (Egger's test, p=0.002).

Twenty-one studies[21 25 27 29 31-32 34-35 37 40 42-43 47-50 54-58] reported data for urban areas. These studies included a total 123,369 non-smokers, 55,905 of whom were exposed to second hand smoke, resulting in a pooled prevalence of 48.6% (95%CI: 42.9-54.2). 20 studies[23 26 28-33 40 44-46 51-58] reported data for rural areas. A total of 192,375 non-smokers were included in these studies, 86,824 of whom were exposed to second hand smoke, resulting in a pooled prevalence of 43.5% (95%CI: 37.5-49.5). We did not estimate the difference in the prevalence of passive smoking between urban and rural areas because of the small number of studies[29 31-32 40 54-58] (n=9) that examined both areas. However, the prevalence of passive smoking was higher in urban areas than in rural areas for all 9 of those studies, and the prevalence in both areas showed upward trends in 2002-2013 (**Figure 3b**). Additionally, we conducted a comparison of the sexes by area **(Figure 4)**; no significant difference was found between the sexes in either area (OR 1.27, 95%CI: 0.93-1.74 and OR 1.14, 95%CI: 0.82-1.58, respectively).

The participants in the 46 included studies were divided into two age groups, with 60 years of age utilised as the cutoff between groups to simplify the data analysis. A high prevalence was found in the 15-59-year-old group compared to the ≥60-year-old group (OR 1.61, 95%CI: 1.44-1.81). The pooled prevalence for the two groups were 47.1% (95%CI: 43.2-50.9) and 35.1% (95%CI: 31.8-38.3), respectively. Additionally, the prevalence in the 15-59-year-old group increased markedly from 1995-1999 [29.4% (95%CI: 27.9-31.0)] to 2002-2004 [48.5% (95%CI: 40.0-57.0)] and then became relatively stable, while the prevalence in the ≥60-year-old group was

relatively stable throughout the study period (**Figure 3c**).

Sensitivity Analysis

The results of four sensitivity analyses did not materially alter the pooled prevalence (**Table 4**). And compared with all included studies, the absolute change in estimated prevalence ranged from 3.1% to 4.8%. Additionally, the heterogeneity of all analyses was substantial (I^2>98%).

DISCUSSION

Our meta-analysis of the prevalence of passive smoking in the community population aged 15 and above in China identified 46 studies and 381,580 non-smokers. The pooled overall prevalence of passive smoking was 48.7% (95% CI: 44.8-52.5) and remained high throughout the study period. Compared with the estimated prevalence of passive smoking in other developing countries, that in China is at an intermediate level;[66] however, it is much higher than that in the United States, where the prevalence of adult (>20) non-smokers exposed to passive smoke was 48.0% (42.6%~53.4%) in 1999~2000 and decreased to 21.3% (18.6%~24.0%) in 2011-2012.[67] This finding indicates that we have not yet met the commitment to the Framework Convention on Tobacco Control and that we need to further accelerate the process of legislation and implementation of tobacco control.

The prevalence of passive smoking in China varies by sex, area, and age group. Specifically, previous studies showed that females were more likely to be exposed to

passive smoke due to the high proportion and rate of smoking among Chinese men and women's difficulty in avoiding exposure in the social environment present at the time of those studies, where women held a weak position in the family and workplace. [39] However, our trend and subgroup analyses revealed a remarkable increase in the prevalence of passive smoking among males especially from 1995 to 2010 and, found that the difference in the overall prevalence and the prevalence in both urban and rural areas between females and males were nonsignificant. This result may be valuable from a public health point of view, as it suggests that we should attach more importance to male non-smokers because they have a greater likelihood of passive smoking in the workplace and in public areas. [66]

Additionally, the prevalence of passive smoking in urban areas was higher than that in rural areas throughout the study period, and an upward trend was found in both areas from 1995 to 2013. However, a previous meta-analysis on the prevalence of passive smoking in China obtained opposing results, indicating that the prevalence of passive smoking was greater in rural areas than in urban areas. [68] This divergence may be due to the following reasons: our meta-analysis used more strict criteria and included 30 studies published in 2010-2015 that were not included in the previous meta-analysis; passive smoking was measured by self-report in all eligible studies, and the much greater health consciousness in urban areas could have led to more self-reports of passive smoking; [69] and people in urban areas may be more likely to be exposed to passive smoke in the workplace and during social interactions. Hence, tobacco control policies should continue to focus on urban populations.

The age analysis showed that people aged 15-59 were 61% more likely to be exposed to second hand smoke than those aged ≥60. The possible explanations for this finding are that the elderly have retired and are more concerned about health and that some elderly persons quit smoking or reduced tobacco exposure on account of multiple chronic diseases and the advice of doctors.[70] Additionally, the high prevalence of passive smoking among people aged 15-59, which was stable for nearly a decade, suggests that more attention should be paid to tobacco exposure in the labour force population.

We did not limit our meta-analysis to studies in mainland China; however, no studies on special administrative regions were included. Second, although we developed strict inclusion and exclusion criteria and performed a series of subgroup, trend, and sensitivity analyses, the heterogeneity between studies was substantial, possibly due to characteristics that could not be collected from the eligible studies, such as age by sex, education level, ethnicity, and passive source. Future studies are needed to more closely examine these features. In addition, high heterogeneity is common in meta-analyses of observational studies.[12]Another limitation of our meta-analysis is that we did not include pregnant women or children (<15 years of age), whose health is more seriously affected by passive smoking. [1]

In conclusion, in this meta-analysis, the estimated prevalence of passive smoking in the community population aged 15 and above in China was 48.7% (95% CI: 44.8-52.5). Urban residents and the labour force population are more vulnerable to tobacco exposure. More attention should be placed on male non-smokers' tobacco

exposure. Currently, specific studies regarding passive smoking in Chinese populations are insufficient, and the high and stable prevalence of passive smoking in China requires nationwide concern and effective cessation interventions.

Table 1 Characteristics and stratified data of the included studies

First author and year published	Survey year	Type (special investigation / contains relative data)	Locations	Methods of random sampling	Female ,%	Age	Subgroup					
							Male	Female	15-59	≥60	Urban	Rural
Yang et al. (2015)[21]	2010	Special	Province	Cluster	64	60-95	130/668	417/1203	..	547/1871	547/1871	..
Chinese CDC (2014)[38]	2010	Relative	National	Multistage	66	≥60	1434/5085	3306/9923	..	4470/15008	..	..
Cai, L. et al. (2014)[26]	2010	Special	Province	Multistage	77	≥18	1031/2699	3859/8892	3655/8447	1235/3144	..	4890/11591
Chen et al. (2014)[25]	2008-2010	Special	Province	Multistage	100	45-65	..	12730/27874	11457/25033	1273/2843	12730/27874	..
Chen et al. (2014)[59]	2013	Relative	Province	Multistage	68	15-69	64/179	189/371	..	..	..	..
Li et al. (2014)[24]	2011	Special	Province	Multistage	71	≥18	162/227	345/549	..	..	..	..

Li et al. (2014)[23]	2011	Special	Province	Multistage	75	≥18	266/717	856/2124	758/1897	190/483	..	1122/2841
Qi et al. (2014)[22]	2012	Special	Province	Multistage	77	15-74	1110/3055	4297/10177	4692/11185	169/623	..	..
Wang et al. (2014)[56]	2011	Relative	Province	Multistage	65	≥18	1905/4045	4090/7411	5238/9786	661/1670	1855/3291	4420/7486
Yan et al. (2014)[55]	2012	Relative	Province	Multistage	67	15-69	140/522	417/1044	..	..	321/700	373/866
Li, S.J et al. (2013)[51]	2011	Relative	Province	Multistage	81	≥18	230/558	1070/2279	2813/3629	..	..	1300/2837
Fan et al. (2013)[61]	2010	Relative	Province	Multistage	71	15-69	107/166	202/417	..	..	..	..
Li et al. (2013)[41]	2012	Relative	Province	Multistage	..	15-69	..	..	..	..	..	..
Liu et al. (2013)[27]	2012	Special	Province	Multistage	65	≥15	113/262	233/491	322/653	-	346/753	..
Wu et al. (2013)[60]	2010	Relative	Province	Multistage	66	≥18	69/144	141/285	182/366	28/63	..	..
Zhang et al. (2013)[28]	2010	Special	Province	Multistage	67	l5-69	413/1293	1171/2901	1525/3967	59/227	..	1584/4194
Cai, L. et al. (2012)[30]	2010	Special	Province	Multistage	78	≥18	901/1289	3469/4567	..	775/1194	..	4370/5856
Feng et al. (2012)[49]	2010	Relative	Province	Multistage	66	≥15	156/257	295/508	403/687	..	551/765	..
Han et al. (2012)[53]	..	Relative	Province	Multistage	88	≥18	26/104	309/794	..	..	..	335/898

Huang et al. (2012)[48]	2010	Relative	Province	Multistage	68	15-65	50/103	77/221	..	..	127/324	..
Li et al. (2012)[43]	2010	Relative	Province	Cluster	62	35-86	35/84	62/138	..	..	97/222	..
Sun et al. (2012)[46]	2010	Relative	Province	Stratified	81	≥18	76/183	248/748	266/589	58/159	..	324/931
Wang et al. (2012)[62]	2010	Relative	Province	Multistage	74	15-69	131/415	501/1159	464/1122	27/93	..	..
Wang et al. (2012)[52]	2010	Relative	Province	Multistage	68	≥15	582/1521	1258/3197	1605/3914	235/804	..	1840/4718
Wei et al. (2012)[42]	2010	Relative	Province	Cluster	61	≥15	99/220	134/345	..	..	233/565	..
Xu et al. (2012)[29]	2010	Special	Province	Multistage	69	≥15	293/467	613/1047	..	..	513/821	420/806
Feng et al. (2011)[65]	2010	Relative	Province	Multistage	99	≥18	1/5	243/440	..	..	..	..
Meng et al. (2011)[57]	2007	Relative	Province	Multistage	66	15-69	254/853	519/1647	..	..	417/1118	356/1380
Chinese CDC (2010)[31]	2007	Relative	National	Multistage	72	15-69	3632/9879	10546/26145	12116/ 69768	1384/4659	5470/14341	8708/21683
SATS china (2010)[39]	2010	Special	National	Multistage	69	≥15	2045/2760	4514/6305	..	..	..	..
Chinese CDC	2004	Special	National	Multistage	79	18-69	1501/4842	6016/	6243/	612/2519	3047/8809	4470/

(2009)[32]								17747	17929			13780
Chen et al. (2009)[63]	2007	Relative	Province	Multistage	77	15-69	207/585	727/1950	..	..	..	..
Zhou et al. (2009)[47]	2008	Relative	Province	Stratified	79	≥15	107/135	457/518	..	..	564/653	..
Wang et al. (2008)[33]	2004	Special	Province	Multistage	71	18-69	646/2358	1673/5784	2022/7079	211/1063	..	2391/8142
Jiang et al. (2007)[44]	2004-2005	Relative	Province	Cluster	..	≥18	..	..	..	..	..	11037/15110
Su et al. (2007)[50]	2006	Relative	Province	Multistage	74	≥18	519/727	730/2068	1240/2523	81/272	1249/2795	..
Wang et al. (2007)[58]	2004	Relative	Province	Multistage	64	15-69	792/2100	1641/3699	..	..	1268/3054	1222/2244
Han et al. (2006)[35]	2002	Special	Province	Multistage	100	15-94	..	2886/3500	..	..	2886/3500	..
Huang et al. (2006)[45]	2002	Relative	Province	Cluster	93	≥40	298/354	3895/5300	1559/2201	500/1192	..	3393/5654
Ying et al. (2006)[34]	2002	Special	Province	Multistage	100	15-86	..	814/1000	619/753	81/110	814/1000	..
Zhang et al. (2006)[54]	2002	Relative	Province	Multistage	69	≥15	437/2184	1823/4899	1908/5789	310/1242	1768/3850	1441/3764
Ma et al. (county	2002	Relative	National	Multistage	70	≥15	9957/38167	47946/87975	43136/	6108/21021	29236/47792	56699/

team)(2006)[40]									102170			89991
Yang et al. (2005)[36]	2002	Special	National	Multistage	74	15-69	1323/2780	4169/7635	..	..	..	..
Yao et al. (2002)[37]	1999	Special	Province	Unclear	66	≥18	292/1244	750/2389	992/3369	70/264	1042/3633	..
Wen et al. (1999)[71]	1996	Relative	Province	Multistage	..	≥15	..	..	..	..	..	..
Lin et al. (1997)[64]	1995	Relative	Province	Multistage	75	15-69	468/1193	1537/3641	..	..	..	..

Table 2 Trends in the pooled prevalence of passive smoking by sex, area and age in the community population aged 15 and above in China: 1995-2013

Survey year	1995-1999	2002-2004	2005-2007	2008-2010	2011-2013
Prevalence% (95%CI)					
overall	43.4(30.2-56.5)	50.9(42.2-59.6)	51.6(35.6-67.6)	47.3(41.7-52.9)	50.4(44.7-56.2)
male	31.3(15.9-46.8)	39.0(30.6-47.4)	43.3(28.0-58.6)	48.4(38.5-58.3)	42.4(35.7-48.8)
female	36.8(26.2-47.4)	52.8(43.1-62.6)	36.2(32.1-40.3)	49.2(41.9-56.5)	48.1(42.8-53.5)
urban	28.7(27.2-30.2)	53.6(39.5-67.6)	40.1(35.5-44.6)	51.3(39.3-63.2)	46.5(31.9-61.0)
rural	..	40.1(31.4-48.8)	33.0(18.9-47.1)	47.1(33.1-61.0)	42.8(37.1-48.5)
15-59	29.4(27.9-31.0)	48.5(40.0-57.0)	44.9(36.6-53.1)	49.0(40.7-57.3)	46.2(38.7-53.6)
≥60	26.5(21.2-31.8)	34.1(28.1-40.1)	29.7(28.4-31.0)	38.6(31.8-45.4)	32.8(24.9-40.7)
No. studies (sample**)**					
overall	3(9065)	9(190324)	5(32005)	19(115141)	9(34147)
male	2(2437)	7(52785)	4(12044)	17(17489)	8(9565)
female	2(6030)	9(137539)	4(31810)	19(70688)	8(24446)
urban	1(3633)	6(63112)	3(18254)	8(33043)	3(5327)
rural	..	6(116797)	2(23063)	6(28035)	4(14126)
15-59	1(3369)	6(135921)	2(32291)	9(47754)	4(23521)
≥60	1(264)	6(27147)	2(4931)	11(25429)	4(2799)

Table 3 Pooled prevalence of passive smoking by sex, area, and age in the community population aged 15 and above in China

Subgroup	No. studies	Prevalence %(95%CI)	Heterogeneity χ^2	*P*	I^2,%	Egger's test t	*P*
Sex							
male	39	43.4(38.9-48.0)	7386.26	<0.001	99.5	3.29	0.002
female	43	47.8(43.9-51.6)	16726.46	<0.001	99.7	-0.39	0.701
Area							
rural	20	43.5(37.5-49.5)	12889.39	<0.001	99.9	-0.41	0.688
urban	21	48.6(42.9-54.2)	7321.31	<0.001	99.7	0.54	0.596
Age							
≥60	24	35.1(31.8-38.3)	1378.78	<0.001	98.3	1.44	0.164
15-59	22	47.1(43.2-50.9)	6681.43	<0.001	99.7	1.17	0.257

Table 4 Sensitivity analyses of prevalence of passive smoking in China

Outcome	No. Studies	No. Non-smokers	Prevalence %(95%CI)	I^2, %
All included studies	46	381,580	48.7(44.8-52.5)	99.8
National survey	6	219,243	45.6(36.8-54.3)	99.9
Non-national survey				
non-national survey (sample size≥1000)	25	153,709	46.6(40.3-52.9)	99.9
non-national survey (sample size<1000)	15	8,628	53.5(44.5-62.4)	98.8
overall	40	162,337	49.1(44.1-54.1)	99.8

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Competing interests: None.

Contributors: Shanshan Yang conceived and Jing Zeng designed the research. Jing Zeng and Shanshan Yang conducted the systematic review. Yao He, Lei Wu, Jianhua Wang, Yiyan Wang, Di Zhang and Bin Jiang interpreted the data. Jing Zeng performed statistical analysis. Yao He and Miao Liu handled supervision. Jing Zeng and Shanshan Yang drafted the manuscript.

Provenance and peer review: Not commissioned; externally peer reviewed.

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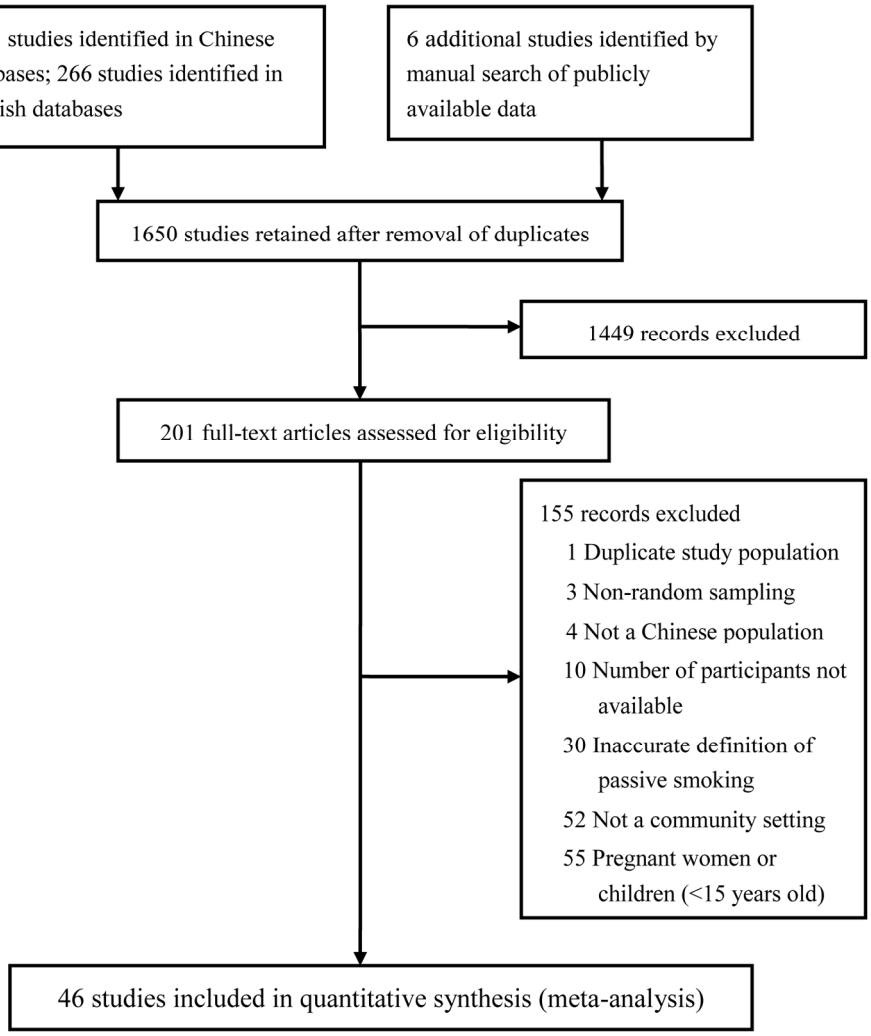
Figure 1 Study selection flow diagram

Figure 2 Forest plot of the pooled prevalence and confidence intervals of passive smoking in the community population aged 15 and above in China

Figure 3 Trends in the pooled prevalence of passive smoking by sex, area and age in the community population aged 15 and above in China: 1995-2013

Figure 4 The risk of passive smoking between sexes and areas in the community population aged 15 and above in China



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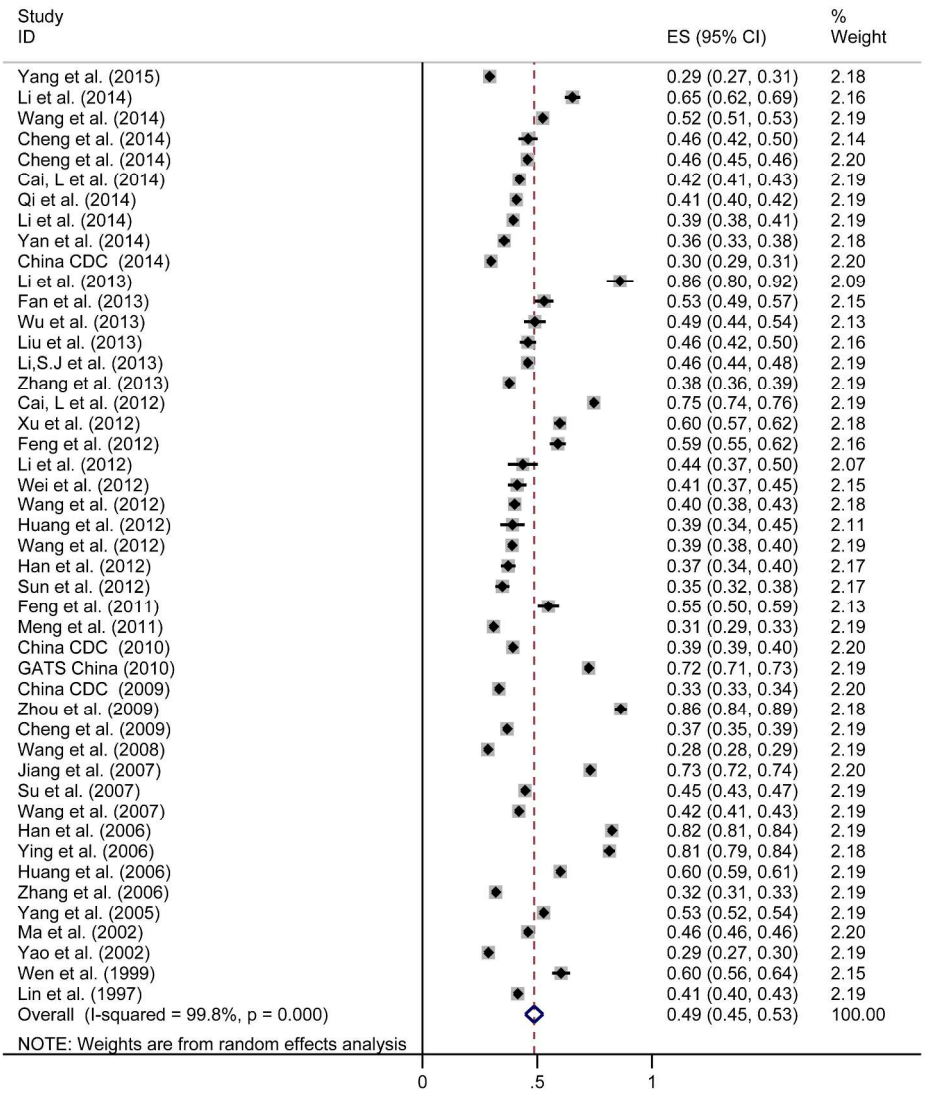

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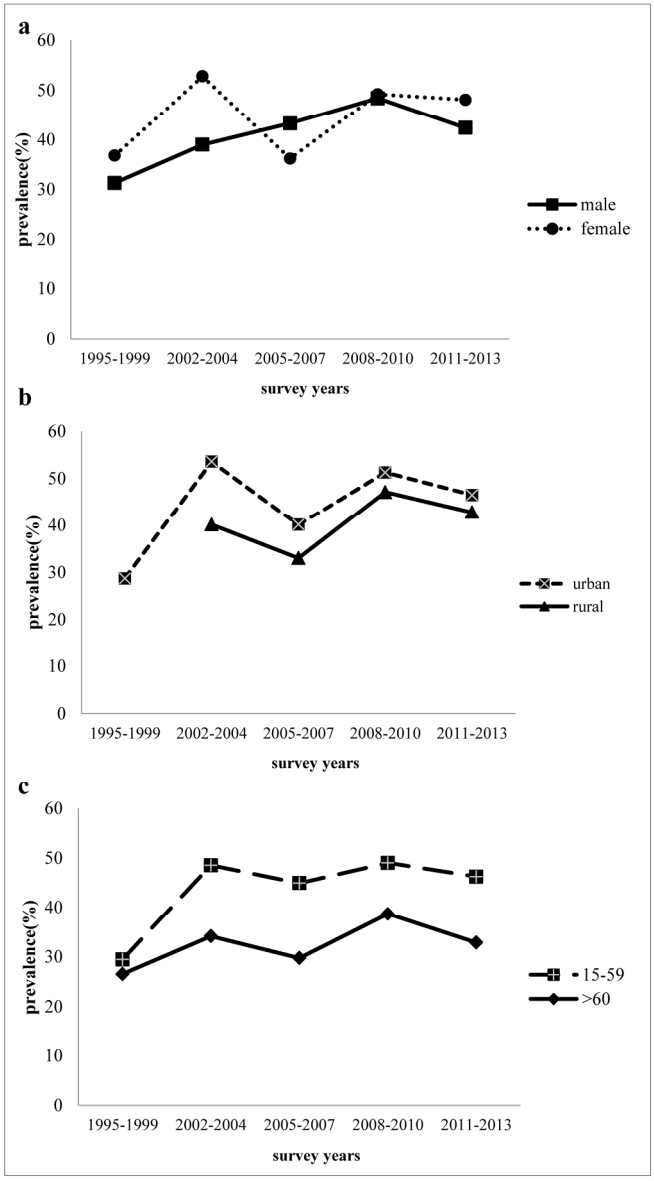

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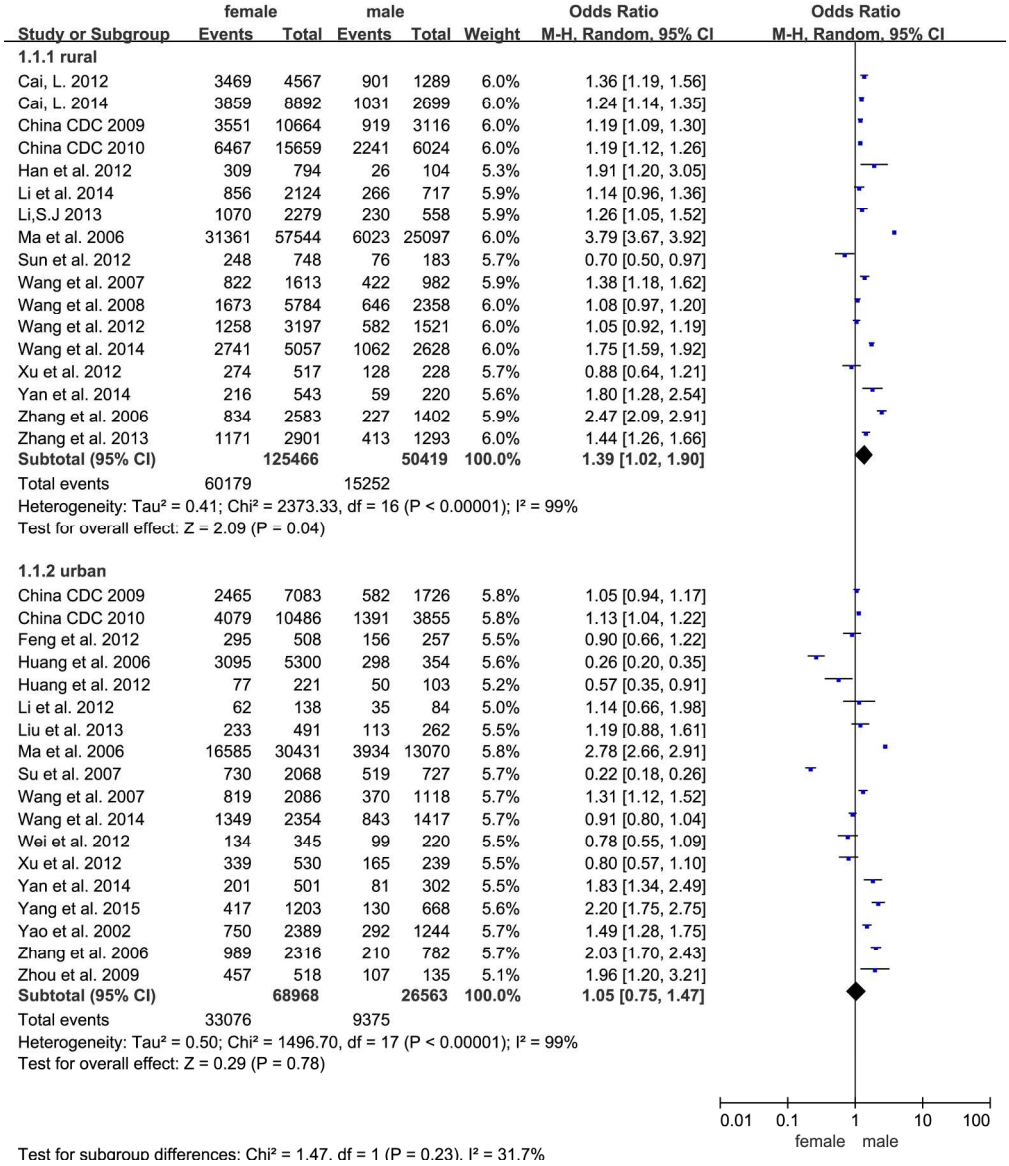

195x227mm (300 x 300 DPI)

MOOSE Checklist

Prevalence of passive smoking in the community population aged 15 and above in China: a systematic review and meta-analysis

Jing Zeng, [1, 2, #] Shanshan Yang, [1, 2, 5, #] Lei Wu, [1, 2] Jianhua Wang, [1, 2] Yiyan Wang, [1, 2] Miao Liu, [1, 2] Di Zhang, [1, 2] Bin Jiang, [4] Yao He, [1, 2, 3, *]

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Criteria		Brief description of how the criteria were handled in the meta-analysis
Reporting of background should include		
√	Problem definition	Passive smoking is casually linked to several chronic diseases, and is deemed to one of primary risk factors for global disease burden. However, effective interventions can control its harm to health. The accurate epidemiology of passive smoking is meaningful for targeted public policies. We aimed to estimate the prevalence and distribution of passive smoking in the community population aged 15 and above of China.
√	Hypothesis statement	The epidemiology of passive smoking in China is severe and requires national concerns regarding specific research and tobacco control.

√	Description of study outcomes	Prevalence and distribution of passive smoking in China.
√	Type of exposure or intervention used	Passive smoking
√	Type of study designs used	We included cross-sectional studies about the prevalence of passive smoking in the community population aged 15 years and above in China.
√	Study population	The community population aged 15 and above in China.
Reporting of search strategy should include		
√	Qualifications of searchers	The credentials of all authors are indicated in the author list.
√	Search strategy, including time period included in the synthesis and keywords	Time: the start of the database to January 2015 Term "(tobacco smoke pollution or passive smoking or second hand smoke or environmental tobacco smoke) and (cross-sectional study or descriptive research or survey or epidemiology)"
√	Databases and registries searched	Medline, PUBMED, EMBASE, and four representative Chinese databases.
√	Search software used, name and version, including special features	We did not employ search software. EndNote(X7) and NoteExpress (version 3) was used to merge retrieved citations and eliminate duplications.
√	Use of hand searching	We hand-searched relevant annual investigation reports and reference lists.
√	List of citations located and those excluded, including justifications	Details of the literature search process are outlined in the flow chart. The citation list is available upon request.
√	Method of addressing articles published in languages other than English	We placed no restrictions on language. However, we included the study reported the prevalence of passive smoking in China, so authors are almost Chinese writhing in English or Chinese.
√	Method of handling abstracts and unpublished studies	If eligible, we would contact with the authors.
√	Description of any contact with authors	We contacted with some authors who had conducted investigation on the prevalence of passive smoking to gain relative data for analysis.
Reporting of methods should include		
√	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Detailed inclusion and exclusion criteria were described in the methods section.
√	Rationale for the selection and coding of data	Data extracted from each of the studies was the following information: first author, year of publication, participant characteristics (geographical location, sex, age and sample size), study methods (time of survey, type of survey, method of random sampling, and definition and measurement of passive smoking).

√	Assessment of confounding	Assessed publication bias using Egger's test. And conducted subgroup and sensitivity analyses to restrict the possible confounders such as sex, age, area, and sample size.
√	Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	Conducted subgroup analyses and calculated the prevalence of passive smoking by sex, area, and age. And excluded national health surveys and divided the non-national studies by sample size for the sensitivity analyses.
√	Assessment of heterogeneity	Heterogeneity of the studies was explored with the I^2 index, which assesses not only heterogeneity in a meta-analysis but also the extent of that heterogeneity.
√	Description of statistical methods in sufficient detail to be replicated	Description of methods of meta-analyses, subgroup analyses, and sensitivity analyses and assessment of publication bias are detailed in the methods.
√	Provision of appropriate tables and graphics	The detailing of the searching terms was not complicated and written in the section of search strategy; searching database and outcomes was presented in the flow chart.
Reporting of results should include		
√	Graph summarizing individual study estimates and overall estimate	Figure 1
√	Table giving descriptive information for each study included	Table 1
√	Results of sensitivity testing	Table 4
√	Indication of statistical uncertainty of findings	95% confidence intervals were presented with all summary estimates, I^2 values and results of sensitivity analyses
Reporting of discussion should include		
√	Quantitative assessment of bias	The result of Egger's test indicated that there was no publication bias except for male nonsmokers' tobacco exposure. Subgroup and sensitivity analyses indicated the high heterogeneity was due to most common biases in observational studies.
√	Justification for exclusion	Considering the commonly high heterogeneity in meta-analyses of observational studies, we developed strict exclusion criteria. In particular, we checked whether data used in provincial studies had already been utilized in national studies, and if so, we excluded the provincial study.
√	Assessment of quality of included studies	We developed strict inclusion and exclusion criteria and performed a series of subgroup, trend, and sensitivity analyses We discussed the results and potential reasons

		for the observed heterogeneity.
Reporting of conclusions should include		
√	Consideration of alternative explanations for observed results	We noted that the high and stable prevalence of passive smoking in China may be due to the lack of nationwide concern and effective cessation interventions. Hence, we need more concern and actions.
√	Generalization of the conclusions	The estimated prevalence of passive smoking in the community population aged 15 and above in China was 48.7% (95% CI: 44.8-52.5). Urban residents and the labor force population are more vulnerable to tobacco exposure. We noted the lack of studies in male non-smokers' tobacco exposure.
√	Guidelines for future research	We recommend future studies on specific studies regarding passive smoking in Chinese populations, especially on male non-smokers' tobacco exposure.
√	Disclosure of funding source	See Funding.

BMJ Open

Prevalence of passive smoking in the community population aged 15 and older in China: a systematic review and meta-analysis

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Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, passive smoking, Chinese, meta-analysis

Prevalence of passive smoking in the community population aged 15 and older in China: A systematic review and meta-analysis

Running head: Prevalence and distribution of passive smoking in China

Jing Zeng, [1, 2, #] Shanshan Yang, [1, 2, 5, #] Lei Wu, [1, 2] Jianhua Wang, [1, 2] Yiyan Wang, [1, 2] Miao Liu, [1, 2] Di Zhang, [1, 2] Bin Jiang, [4] Yao He, [1, 2, 3,*]

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Key words: passive smoking, epidemiology, Chinese, meta-analysis

Text word count: 3384

ABSTRACT

Objectives: To estimate the prevalence and distribution of passive smoking in the community population aged 15 and older in China.

Design: A meta-analysis of cross-sectional studies reporting the prevalence of passive smoking in China and a series of subgroup, trend, and sensitivity analyses were conducted in this study.

Data source: The meta-analysis, which included 46 studies with 381,580 non-smokers, estimated the prevalence and distribution of passive smoking in China. All studies were published between 1997 and 2015.

Results: The pooled prevalence of passive smoking was 48.7% (95%CI: 44.8-52.5) and was relatively stable from 1995 to 2013. The prevalence in the subgroups of gender, area, age, and time varied from 35.1% (95%CI: 31.8-38.3) in the elderly (≥60 years) to 48.6% (95%CI: 42.9-54.2) in urban areas. The prevalence was lower in the elderly (≥60 years) than in those between 15 and 59 years (OR 1.61, 95%CI: 1.44-1.81). The difference between females and males in both urban and rural areas was not statistically significant (OR: 1.27, 95%CI 0.93- 1.74 and OR: 1.14, 95%CI 0.82-1.58, respectively). In addition, a significantly increasing trend was found among males from 2002 to 2010. Heterogeneity was high in all pooled estimates (I^2>98%, p<0.001).

Conclusions: The high and stable prevalence of passive smoking in China is raising increasing national concern regarding specific research and tobacco control programs. Attention should be focused on young, middle-aged and male non-smokers regardless

of region.

Strengths and limitations of this study

1. The study is the first meta-analysis of the prevalence and distribution of passive smoking in the community population aged 15 and older in China.
2. To reduce the limitations of the meta-analysis regarding prevalence, strict inclusion and exclusion criteria were developed, and a series of subgroup, trend, and sensitivity analyses were performed.
3. The high and stable prevalence of passive smoking in China is increasing national interest in specific research and tobacco control programs.
4. The prevalence and distribution of passive smoking in the community population aged 15 and older indicate that targeted public tobacco control policies are needed in China.

INTRODUCTION

The economic burden of tobacco use, including both active and passive smoking, is substantial and is deemed to be one of the primary contributors to the global disease burden. [1-3]Relevant studies have examined the causal relationships between passive smoking and lung cancer, coronary heart disease, respiratory diseases, and multiple adverse health effects in infants and children. [4] Tobacco use is also a leading risk factor for premature mortality and disability from non-communicable diseases in China. [5] In China, 300 billion smokers and 740 billion non-smokers are exposed to second-hand smoke (SHS)[6], and 16.5% of all deaths (1.4 million) in 2010 were attributed to SHS exposure[7]. SHS exposure could result in approximately 3 million deaths per year by 2050 if effective interventions for tobacco control are not implemented. [8]

Previous studies have indicated that public smoking bans are effective ways to reduce exposure to SHS.[9] Approximately 44 countries have implemented smoking bans. China endorsed the WHO Framework Convention on Tobacco Control and stated that it was “determined to give priority to the right to protect public health” in 2003.[10] Many large cities have local regulations regarding tobacco control, but the effect has been less than expected.[11 12] China is the largest tobacco grower and consumer in the world. Chinese national legislators have actively commenced the process of national bans on smoking in public and work places since 2014.[5] However, because of significant interference, particularly from the tobacco industry, few effective legislative, executive, administrative or other measures designed to protect

all persons from exposure to tobacco smoke have been implemented at any governmental level. [10 13] The passive smoking problem in China is widespread and not taken seriously.[14 15] Few studies on smoking have focused specifically on passive smoking, with the passive smoking rate generally included in surveys on active smoking or as a social demographic characteristic in health behaviour studies. The passive smoking rate in China varies greatly among studies, ranging from 28% to 86%, independent of the time period of the study.[16 17] Even national-level studies conducted by different institutions in the same year reported a wide range in the passive smoking rate in China(39%-72%).[6 18] Accurate and scientific reports on passive smoking are needed to provide the government with information on the extent and seriousness of the epidemiology of passive smoking in China, to help evaluate the influence of passive smoking on health, and to provide data and evidence to support tobacco control policies in China.

Herein, we performed a systematic review and meta-analysis to estimate the prevalence of passive smoking in the community population aged 15 years and older in China and examined the prevalence of passive smoking by gender, area, age and survey years. The synthesis of these data would be helpful in determining susceptible populations and areas that could benefit from the establishment and implementation of targeted public policies based on the effects of previous tobacco control efforts.

METHODS

We performed this analysis in accordance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE)[19] guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[20] guidelines (when generating the flow diagram).

Search strategy

We searched Medline, PUBMED, EMBASE, the Chinese Biological Medical Literature database (CBM), the Chinese Wanfang database, the Chinese National Knowledge Infrastructure (CNKI) and the Chongqing VIP database using the terms "(tobacco smoke pollution or passive smoking or second hand smoke or environmental tobacco smoke) and (cross-sectional study or descriptive research or survey or epidemiology)" to identify studies on the prevalence of passive smoking among Chinese adults (aged ≥15 years) published from inception to January 2015. We also manually searched relevant annual investigation reports and reference lists to ensure the integrity of the electronic search results. See the online supplementary information for the search strategy.

Selection criteria

Inclusion criteria

Passive smoke exposure was defined as a non-smoker being exposed to another person's tobacco smoke for at least 15 minutes daily for more than 1 day per week.[21]

Studies had to meet the following criteria for inclusion: (1) a sample of community non-smokers aged 15 years and older; (2) a cross-sectional study or surveillance of the prevalence of passive smoking in China; and (3) census or random sampling survey as the investigation type.

Exclusion criteria

We excluded studies if the definition of passive smoking was unclear, the data were incomplete and could not be obtained from the authors, or the study data had been published previously. In particular, we verified whether data used in provincial studies had already been utilised in national studies; if so, we excluded the provincial study.

Data extraction and quality assessment

Two reviewers independently extracted data and assessed the quality of each eligible study. Disagreements were discussed to reach consensus. The standardised extraction form included the following information: first author, year of publication, participant characteristics (geographical location, gender, age and sample size) and study methods (time of survey, type of survey, method of random sampling, and definition and measurement of passive smoking).

The Agency for Healthcare Research and Quality (ARHQ) methodology checklist, STROBE statement[22] and Patricia L. Loney's methodological scoring system[23] were integrated into nine items used to evaluate the methodological quality of the studies. Quality scoring for studies was not performed because it was not

possible to weigh different items. However, the tool suggested by the Cochrane Collaboration was used to present the overall quality of the included studies. Each item was assessed as 'low risk', 'unclear risk' or 'high risk'. The evaluation items were as follows:

- Setting: State the research sites, times and places of data collection.
- Selection: Enrol a random sample or a whole population.
- Sample: Use an adequate sample size (>300 subjects).
- Criteria: List inclusion and exclusion criteria for test and control subjects or refer to previous publications.
- Variables: List all outcomes, exposures and potential confounders.
- Measurements: Define each variable of interest or provide details of the methods of assessment.
- Bias: Describe how confounding was assessed and/or controlled.
- Response and completeness: Summarize response rates and completeness of data collection.
- Characteristics: Describe the characteristics of the study subjects.

Statistical analysis

As the sample size of non-smokers was sufficient, reaching a prevalence of approximately 0.5 in all studies, we used the raw data to pool the overall prevalence estimates.[24 25]In addition, the random effects model with the D-L method was used to calculate the pooled estimates and 95% confidence intervals (CIs) due to the high

heterogeneity among studies (I^2>75%).[26-28] Publication bias was evaluated by Egger's test. If bias existed, the 'trim and fill' method was used to adjust for the publication bias.

In the subgroup analyses, we calculated the prevalence of passive smoking by gender (male and female), area (urban and rural), and age (15-60 and ≥60 years old), and differences were determined by calculating odds ratios (ORs). To observe the relatively continuous and long-term trends of prevalence in passive smoking, trend analyses were performed by gender, area and age using the studies that conducted surveys between 2002 and 2013. In addition, due to the wide range of sample sizes of the included studies, we excluded national health surveys and divided the non-national studies into two groups (sample sizes ≥1000 and <1000) for the sensitivity analyses. We performed all meta-analyses using Stata version 12.0 with the command metan. The trend figures were graphed in Excel 2010.

RESULTS

Our search yielded 1722 studies from the CNKI, 103 from the CBM, 133 from the Wanfang database, and 45 from the VIP. We also identified 194 records in PUBMED, 63 in Medline, and 9 in EMBASE. Six additional records were identified through a manual search of publicly available data. After removing duplicates, 1,650 studies remained. We screened the titles and abstracts of these studies and excluded 1,449 records due to inappropriate study types. The remaining 201 full-text articles were assessed for eligibility, and 46 studies with 381,580 non-smokers published between

1997 and 2015 on data obtained from 1995 to 2013 were finally included **(Figure 1)**. The quality of all eligible studies was moderate and acceptable. Of the eligible studies, 24 were rated low risk in all nine items, while high-risk ratings mainly related to the response rate (5/46) and bias (4/46). A risk of bias graph and summary are available in online supplementary Figure S1.

Descriptions of studies

Among the eligible studies, 17[6 15 17 29-42] were special investigations of passive smoking, and the remaining studies were generally part of broader investigations on smoking behaviour. In addition, 6 studies[6 18 38 41 43 44] were conducted at the national level, and the remaining studies were conducted at the provincial level. Therefore, the sample sizes varied greatly, ranging from 136[45] to 126,142 [44] participants. The multistage method of random sampling was primarily employed, although 5 studies[15 46-49] used the cluster method and 2[16 50] used the stratified method. The area of study also varied, with 12 studies[15 16 32 34 39 40 42 46 47 51-53] examining urban areas, 11[17 30 33 35 37 48 49 53-56] examining rural areas, and the remainder examining both urban and rural areas; nine[18 36 38 44 57-61] of these latter studies could be stratified for further subgroup analyses. Nearly all studies reported data for both genders, but female participants were more common, comprising between 61%[46] to 100%[32 39 40] of the study populations. Most study populations covered the full spectrum of adulthood except for two that focused on persons 35 years of age and older[47] and 45 years of age and older[32] and one[15] that only examined persons 60 years of age and older **(Table 1)**.

Passive smoking was measured by self-reporting in all studies, and the estimated publication bias was not significant (Egger's test, p=0.493).

Overall prevalence of passive smoking

A total of 173,622 non-smokers had been exposed to passive smoke. Estimates of the prevalence of passive smoking ranged from 28.7% to 86.4% **(Figure 2)** with high heterogeneity (χ^2=25,612.75, p<0.001; I^2=99.8%). The pooled prevalence was 48.7% (95%CI: 44.8-52.5) and increased at an even rate over the survey years from 43.4% (95%CI: 30.2-56.5) in the 1995-1999 period to 51.6% (95%CI: 35.6-67.6) in the 2005-2007 period **(Table S1)**.

Subgroup and trend analyses

We collected and stratified the eligible studies by gender, area, and age for further subgroup analyses **(Table 1).** The results are presented in **Table 2**.

Thirty-nine studies reported data for both genders, and 3 studies[32 39 40] reported data only for females, so we included a total of 271,307 females and 94,424 males in the subgroup analyses. We excluded the data from one study[62] that only included 5 male non-smokers. The pooled prevalence of passive smoking among females and males were 47.8% (95%CI: 43.9-51.6) and 43.4% (95%CI: 38.9-48.0), respectively. However, the difference calculated using the data of the 39 studies was not statistically significant (OR 1.19, 95%CI: 0.99-1.43). In addition, the pooled prevalence of passive smoking among females changed significantly over the survey

years, whereas among males it increased significantly from 2002 to 2010 and has decreased slightly in recent years **(Figure 3).** The highest prevalence of passive smoking among females and males were between 2002 and 2004 [52.8% (95%CI: 43.1-62.6)] and between 2008 and 2010 [48.4% (95%CI: 38.5-58.3)], respectively **(Table S1)**. However, the estimated public bias indicated that more studies are necessary to accurately pool the prevalence of passive smoking among males (Egger's test, p=0.002).

Twenty-one studies reported data for urban areas. These studies included a total of 123,369 non-smokers, 55,905 of whom were exposed to second-hand smoke. This resulted in a pooled prevalence of 48.6% (95%CI: 42.9-54.2). Twenty studies reported data for rural areas. A total of 192,375 non-smokers were included in these studies, 86,824 of whom were exposed to second-hand smoke, resulting in a pooled prevalence of 43.5% (95%CI: 37.5-49.5). We did not estimate the difference in the prevalence of passive smoking between urban and rural areas because of the small number of studies (n=9) that examined both areas. However, the prevalence of passive smoking was higher in urban areas than in rural areas for all those studies, and the prevalence in both areas showed an upward trend, particularly from 2005 to 2013 (**Figure 3**). We also conducted a comparison of gender by area **(Figure 4)**; no significant difference was found between genders in either urban or rural areas (OR 1.27, 95%CI: 0.93-1.74 and OR 1.14, 95%CI: 0.82-1.58, respectively).

The participants in the 46 included studies were divided into two age groups, with 60 years of age designated the cutoff between groups to simplify the data

analysis. A higher prevalence was found in the 15 to 59-year-old group than in the ≥60-year-old group (OR 1.61, 95%CI: 1.44-1.81). The pooled prevalence for the two groups were 47.1% (95%CI: 43.2-50.9) and 35.1% (95%CI: 31.8-38.3), respectively, and the difference remained constant throughout the survey years (**Figure 3**).

Sensitivity analysis

The results of four sensitivity analyses did not significant alter the pooled prevalence (**Table 3**). When all included studies were compared, the absolute change in estimated prevalence ranged from 3.1% to 4.8%. The results of the 'trim and fill' method indicated that the pooled prevalence of males was moderate despite the existent publication bias (Egger's test, p=0.002) (Figure S2). The heterogeneity of all analyses was substantial (I^2>98%).

DISCUSSION

Our meta-analysis of the prevalence of passive smoking in the community population aged 15 and older in China identified 46 studies and 381,580 non-smokers. The pooled overall prevalence of passive smoking was 48.7% (95% CI: 44.8-52.5) and remained high throughout the study period. Compared with the estimated prevalence of passive smoking in other developing countries, China is at an intermediate level; [63] however, passive smoking in China is much more common than in the United States, where the prevalence of adult (>20 years) non-smokers exposed to passive smoke was 48.0% (42.6%~53.4%) between 1999 and 2000 and decreased to 21.3%

(18.6%~24.0%) between 2011 and 2012.[64]This finding indicates that China has not yet met its commitment to the Framework Convention on Tobacco Control and that we need to further accelerate the process of legislation and the implementation of tobacco control.

The prevalence of passive smoking in China varies by gender, area, and age group. Specifically, previous studies showed that females were more likely to be exposed to passive smoke due to the high proportion and rate of smoking among Chinese men and to women's difficulty in avoiding exposure because of the social environment that existed at the time of those studies, in which women held a weak position in the family and workplace.[6] However, our trend and subgroup analyses revealed a remarkable increase in the prevalence of passive smoking among males, particularly from 2002 to 2010, and found that the differences in the overall prevalence and the prevalence in both urban and rural areas between females and males were not significant. This result may be valuable from a public health standpoint as it suggests that although tobacco exposure of females in China is a source of major concern, attention should also be given to male non-smokers, who have a greater likelihood of passive smoking in the workplace and in public areas.[63]

The prevalence of passive smoking in urban areas was higher than in rural areas throughout the survey years, and an upward trend was found in both areas from 2002 to 2013. However, a previous meta-analysis on the prevalence of passive smoking in China obtained the opposite results, indicating that the prevalence of passive smoking was greater in rural areas than in urban areas.[65]Several factors may have contributed

to this divergence. First, our meta-analysis used stricter criteria and included 30 studies published between 2010 and 2015 that were not included in the previous meta-analysis. Second, people in urban areas may be more likely to be exposed to passive smoke in the workplace and during social interactions. Third, passive smoking was measured by self-reporting in all eligible studies. The much greater health consciousness in urban areas could have led to more self-reports of passive smoking[66], and the prevalence may have been underestimated in rural areas. With the trend of urbanization and the massive annual migration to urban areas in China for jobs, tobacco control policies should focus on both populations.

The age analysis showed that people aged 15-59 were 61% more likely to be exposed to second-hand smoke than those aged ≥60. The possible explanation for this finding is that the retired elderly are more concerned about health, and some have quit smoking or intentionally reduced tobacco exposure because of multiple chronic diseases and on the advice of their doctors.[67] In addition, the high prevalence of passive smoking among people aged 15-59, which was stable for nearly a decade, suggests that more attention should be paid to tobacco exposure in young and middle-aged non-smokers.

There are some limitations in this meta-analysis. First, the heterogeneity between studies was substantial despite the strict inclusion and exclusion criteria. Subgroup, trend, and sensitivity analyses were performed to explore the high heterogeneity but with no conclusive results. Therefore, the more conservative random effects meta-analysis model was used. The high heterogeneity might have been due to the

confounding effects of the variations in geographical distribution of the eligible studies, and these could not be extracted based on characteristics such as age in different genders, education level, ethnicity, and passive source because many of the included studies reported passive smoking as an additional outcome. Second, no studies on special administrative regions were included, which limits the representativeness and significance of these findings. Third, most eligible studies were written in Chinese, which makes it difficult for non-Chinese readers to review the original materials. Finally, pregnant women and children (<15 years old), whose health is more seriously affected by passive smoking, were not included in the review.

4

CONCLUSION

Tobacco control has been difficult to implement since China committed to the Framework Convention on Tobacco Control. This meta-analysis summarises the prevalence and distribution of passive smoking in the community population aged 15 and older in China to help inform public policy. Young and middle-aged populations, regardless of region, are vulnerable to exposure. Although women have been the primary focus to date, attention should also be given to male non-smoker. The existing studies specially regarding passive smoking in China are insufficient, and the high and stable prevalence of passive smoking over the past decade requires a nationwide focus and effective cessation interventions.

Table 1 Characteristics and stratified data of the included studies

First author and year published	Survey year	Type (special investigation / contains relative data)	Location	Methods of random sampling	Female (%)	Age	Subgroup					
							Male	Female	15-59	≥60	Urban	Rural
Yang et al. (2015)[15]	2010	Special	Province	Cluster	64	60-95	130/668	417/1203	..	547/1871	547/1871	..
Chinese CDC (2014)[4338]	2010	Relative	National	Multistage	66	≥60	1434/5085	3306/9923	..	4470/15,008	..	..
Cai, L. et al. (2014)[33]	2010	Special	Province	Multistage	77	≥18	1031/2699	3859/8892	3655/8447	1235/3144	..	4890/11,591
Chen et al.(a) (2014)[32]	2008-2010	Special	Province	Multistage	100	45-65	..	12,730/27,874	11,457/25,033	1273/2843	12,730/27,874	..
Chen et al.(b)	2013	Relative	Province	Multistage	68	15-69	64/179	189/371	..	..	..	..

(2014)[68]												
Li et al.(a) (2014)[31]	2011	Special	Province	Multistage	71	≥18	162/227	345/549	..	..	..	..
Li et al.(b) (2014)[30]	2011	Special	Province	Multistage	75	≥18	266/717	856/2124	758/1897	190/483	..	1122/2841
Li et al. (2014)[29]	2012	Special	Province	Multistage	77	15-74	1110/3055	4297/10,177	4692/11,185	169/623	..	..
Wang et al. (2014)[58]	2011	Relative	Province	Multistage	65	≥18	1905/4045	4090/7411	5238/9786	661/1670	1855/3291	4420/7486
Yan et al. (2014)[57]	2012	Relative	Province	Multistage	67	15-69	140/522	417/1044	..	..	321/700	373/866
Li, S.J et al. (2013)[54]	2011	Relative	Province	Multistage	81	≥18	230/558	1070/2279	2813/3629	..	..	1300/2837
Yan et al. (2013)[69]	2010	Relative	Province	Multistage	71	15-69	107/166	202/417	..	..	..	..
Li et al. (2013)[45]	2012	Relative	Province	Multistage	..	15-69	..	..	..	..	..	..
Liu et al. (2013)[34]	2012	Special	Province	Multistage	65	≥15	113/262	233/491	322/653	-	346/753	..
Wu et al. (2013)[70]	2010	Relative	Province	Multistage	66	≥18	69/144	141/285	182/366	28/63	..	..
Zhang et al. (2013)[35]	2010	Special	Province	Multistage	67	15-69	413/1293	1171/2901	1525/3967	59/227	..	1584/4194
Cai, L. et al. (2012)[37]	2010	Special	Province	Multistage	78	≥18	901/1289	3469/4567	..	775/1194	..	4370/5856

Feng et al. (2012)[52]	2010	Relative	Province	Multistage	66	≥15	156/257	295/508	403/687	..	551/765	..
Han et al. (2012)[56]	..	Relative	Province	Multistage	88	≥18	26/104	309/794	..	..	..	335/898
Huang et al. (2012)[51]	2010	Relative	Province	Multistage	68	15-65	50/103	77/221	..	..	127/324	..
Li et al. (2012)[47]	2010	Relative	Province	Cluster	62	35-86	35/84	62/138	..	..	97/222	..
Sun et al. (2012)[50]	2010	Relative	Province	Stratified	81	≥18	76/183	248/748	266/589	58/159	..	324/931
Wang et al.(a) (2012)[71]	2010	Relative	Province	Multistage	74	15-69	131/415	501/1159	464/1122	27/93	..	..
Wang et al.(b) (2012)[55]	2010	Relative	Province	Multistage	68	≥15	582/1521	1258/3197	1605/3914	235/804	..	1840/4718
Wei et al. (2012)[46]	2010	Relative	Province	Cluster	61	≥15	99/220	134/345	..	..	233/565	..
Xu et al. (2012)[36]	2010	Special	Province	Multistage	69	≥15	293/467	613/1047	..	..	513/821	420/806
Zeng et al. (2011)[62]	2010	Relative	Province	Multistage	99	≥18	1/5	243/440	..	..	..	..
Meng et al. (2011)[59]	2007	Relative	Province	Multistage	66	15-69	254/853	519/1647	..	..	417/1118	356/1380

Chinese CDC (2010)[18]	2007	Relative	National	Multistage	72	15-69	3632/9879	10,546/26,145	12,116/ 69,768	1384/4659	5470/14,341	8708/21,683
GATS China (2010)[6]	2010	Special	National	Multistage	69	≥15	2045/2760	4514/6305	..	..	..	..
Chinese CDC (2009)[38]	2004	Special	National	Multistage	79	18-69	1501/4842	6016/ 17,747	6243/ 17,929	612/2519	3047/8809	4470/ 13,780
Chen et al. (2009)[72]	2007	Relative	Province	Multistage	77	15-69	207/585	727/1950	..	..	..	..
Zhou et al. (2009)[16]	2008	Relative	Province	Stratified	79	≥15	107/135	457/518	..	..	564/653	..
Wang et al. (2008)[17]	2004	Special	Province	Multistage	71	18-69	646/2358	1673/5784	2022/7079	211/1063	..	2391/8142
Jiang et al. (2007)[48]	2004-2005	Relative	Province	Cluster	..	≥18	..	..	..	..	..	11,037/ 15,110
Su et al. (2007)[53]	2006	Relative	Province	Multistage	74	≥18	519/727	730/2068	1240/2523	81/272	1249/2795	..
Wang et al. (2007)[60]	2004	Relative	Province	Multistage	64	15-69	792/2100	1641/3699	..	..	1268/3054	1222/2244
Han et al. (2006)[40]	2002	Special	Province	Multistage	100	15-94	..	2886/3500	..	..	2886/3500	..

Huang et al. (2006)[49]	2002	Relative	Province	Cluster	93	≥40	298/354	3895/5300	1559/2201	500/1192	..	3393/5654
Ning et al. (2006)[39]	2002	Special	Province	Multistage	100	15-86	..	814/1000	619/753	81/110	814/1000	..
Zhang et al. (2006)[61]	2002	Relative	Province	Multistage	69	≥15	437/2184	1823/4899	1908/5789	310/1242	1768/3850	1441/3764
Xia et al. (county team)(2006)[44]	2002	Relative	National	Multistage	70	≥15	9957/38,167	47,946/87,975	43,136/ 102,170	6108/21,021	29,236/47,792	56,699/ 89,991
Wang et al. (2005)[41]	2002	Special	National	Multistage	74	15-69	1323/2780	4169/7635	..	..	..	..
Yao et al. (2002)[42]	1999	Special	Province	Unclear	66	≥18	292/1244	750/2389	992/3369	70/264	1042/3633	..
Wen et al. (1999)[73]	1996	Relative	Province	Multistage	..	≥15	..	..	..	..	..	..
Lin et al. (1997)[74]	1995	Relative	Province	Multistage	75	15-69	468/1193	1537/3641	..	..	..	..

Table 2 Pooled prevalence of passive smoking by gender, area, and age in the community population aged 15 and older in China

Subgroup	No. studies	Prevalence %(95%CI)	Heterogeneity χ^2	*P*	I^2,%	Egger's test t	*P*
Gender							
male	39	43.4(38.9-48.0)	7386.26	<0.001	99.5	3.29	0.002
female	43	47.8(43.9-51.6)	16,726.46	<0.001	99.7	-0.39	0.701
Area							
rural	20	43.5(37.5-49.5)	12,889.39	<0.001	99.9	-0.41	0.688
urban	21	48.6(42.9-54.2)	7321.31	<0.001	99.7	0.54	0.596
Age							
≥60	24	35.1(31.8-38.3)	1378.78	<0.001	98.3	1.44	0.164
15-59	22	47.1(43.2-50.9)	6681.43	<0.001	99.7	1.17	0.257

Table 3 Sensitivity analyses of the prevalence of passive smoking in China

Outcome	No. Studies	No. Non-smokers	Prevalence %(95%CI)	I^2, %
All included studies	46	381,580	48.7(44.8-52.5)	99.8
National survey	6	219,243	45.6(36.8-54.3)	99.9
Non-national survey				
non-national survey (sample size ≥1000)	25	153,709	46.6(40.3-52.9)	99.9
non-national survey (sample size <1000)	15	8628	53.5(44.5-62.4)	98.8
overall	40	162,337	49.1(44.1-54.1)	99.8

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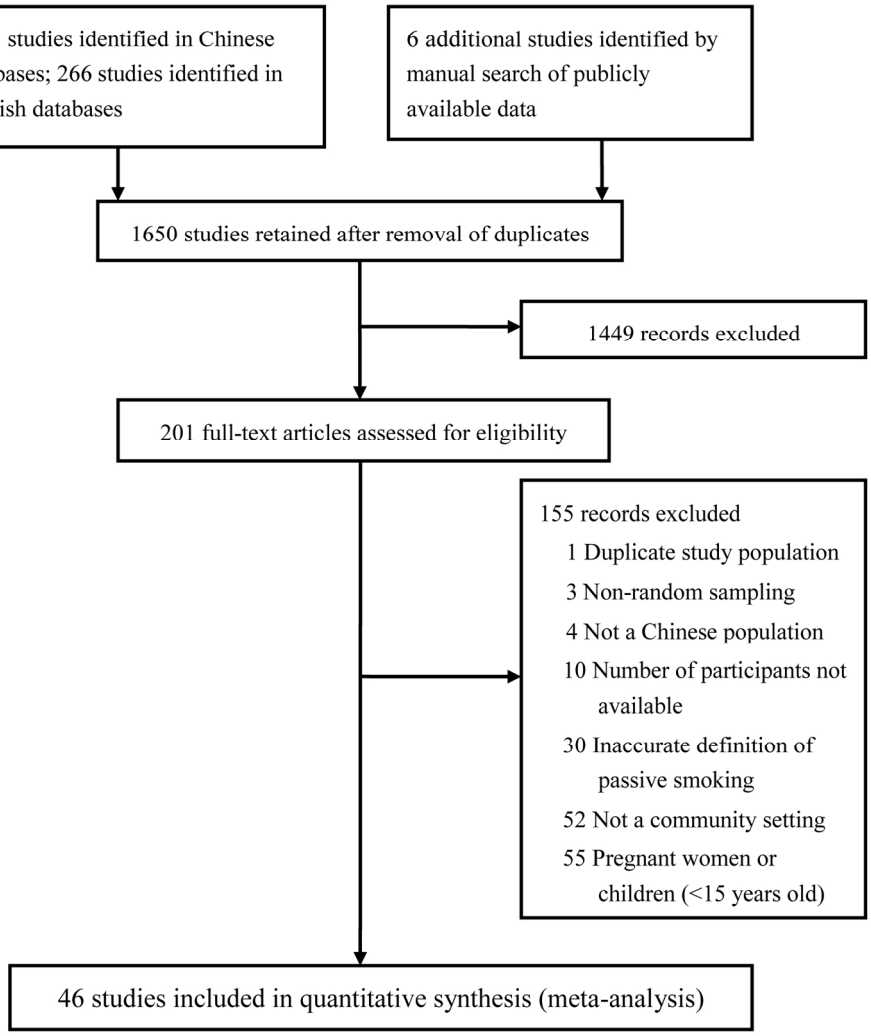
Figure 1 Study selection flow diagram

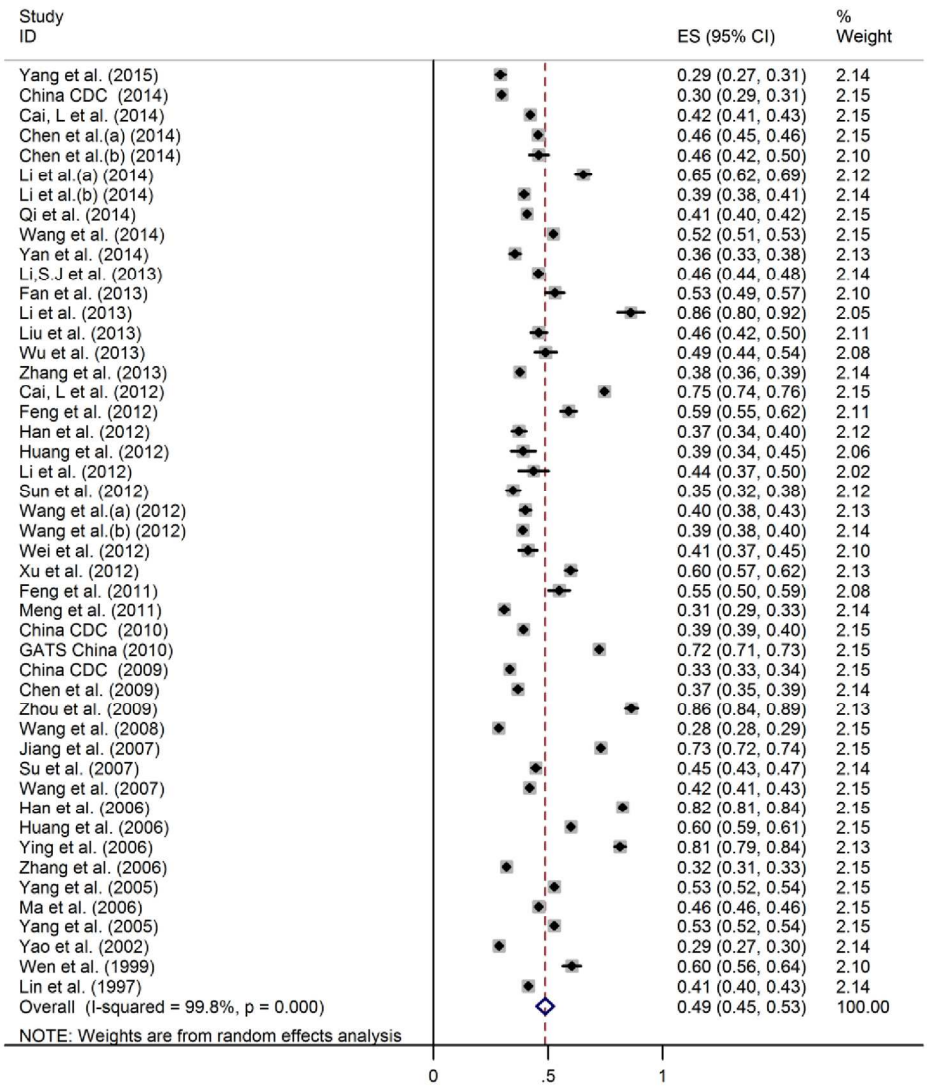
Figure 2 Forest plot of the pooled prevalence and confidence intervals of passive smoking in the community population aged 15 and older in China

Figure 3 Trends in the pooled prevalence of passive smoking by gender, area and age in the community population aged 15 and older in China: 2002-2013

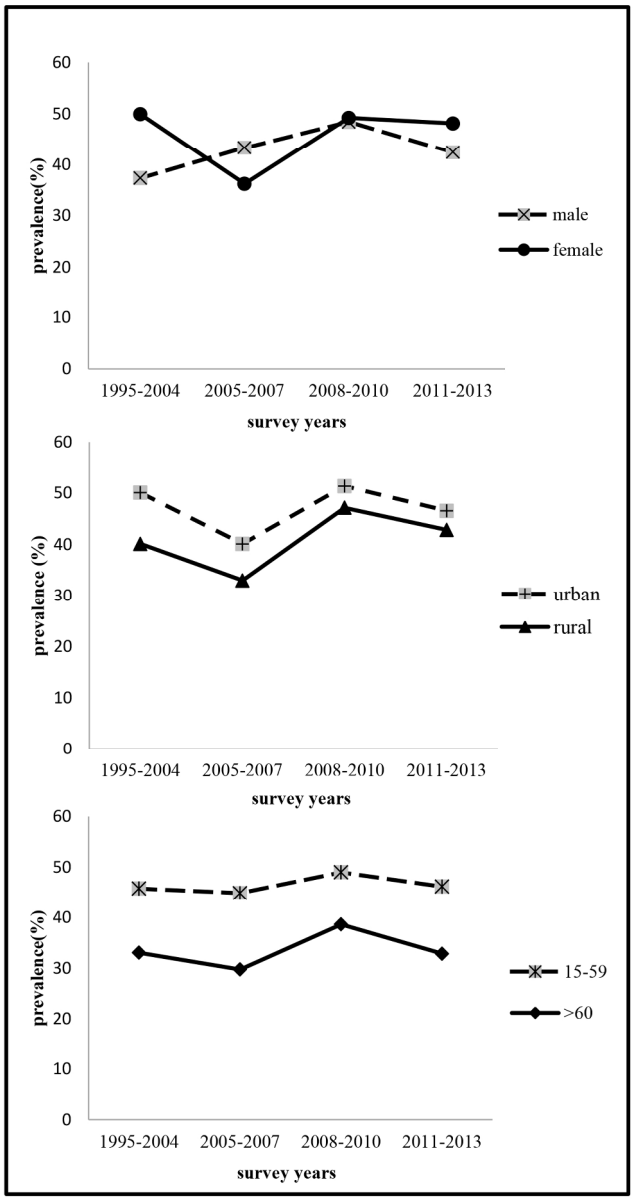
Figure 4 The risk of passive smoking between genders and areas in the community population aged 15 and older in China



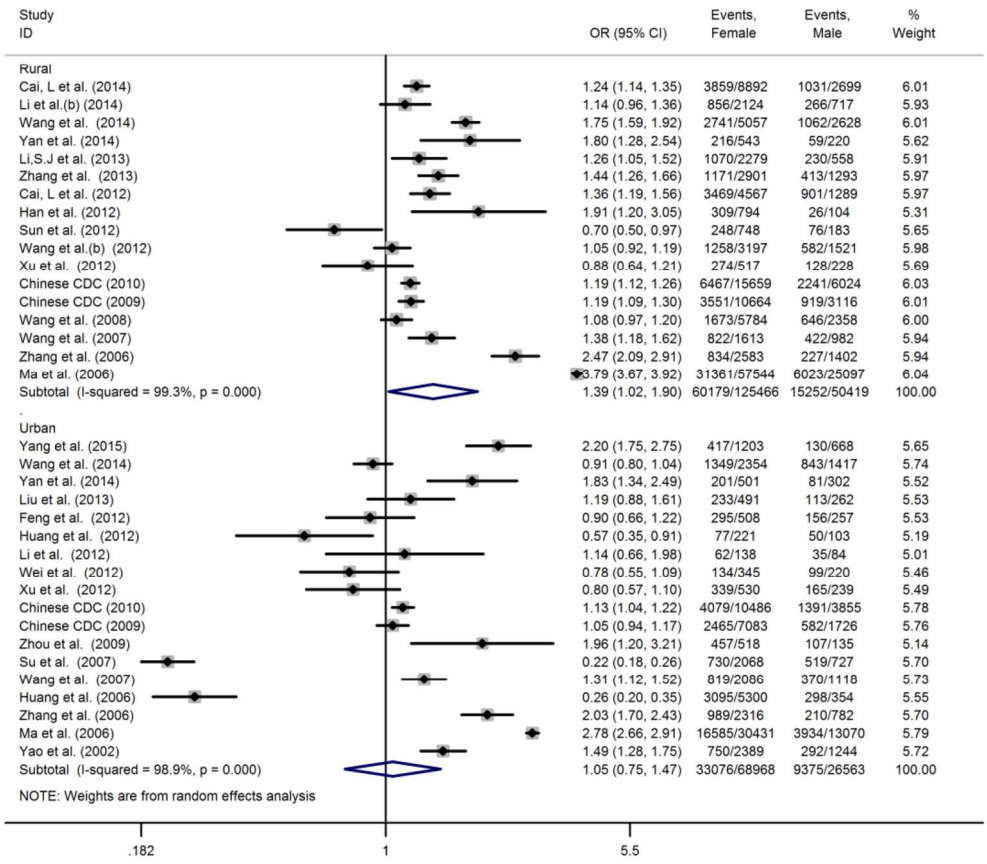
Study selection flow diagram
157x175mm (300 x 300 DPI)



Forest plot of the pooled prevalence and confidence intervals of passive smoking in the community population aged 15 and older in China
146x171mm (300 x 300 DPI)



Trends in the pooled prevalence of passive smoking by gender, area and age in the community population aged 15 and older in China: 2002-2013
120x228mm (300 x 300 DPI)



The risk of passive smoking between genders and areas in the community population aged 15 and older in China
139x127mm (300 x 300 DPI)

1. Search Strategy

Source: PubMed
Searched on: January 29th, 2015
#1 (("Tobacco Smoke Pollution"[Mesh]) OR passive smoking [Title/Abstract]) OR second hand smoke [Title/Abstract]
#2 ((("Cross-Sectional Studies"[Mesh]) OR descriptive study [Title/Abstract]) OR epidemiology [Title/Abstract]) OR survey [Title/Abstract]
#3 ((((China [Affiliation]) OR Macau [Affiliation]) OR Hong Kong [Affiliation])) OR Taiwan [Affiliation]
#4 #1 AND #2 AND #3

Source: CBM (the Chinese Biological Medical Literature database)
Searched on: January 29th, 2015

主题词检索(Mesh search)

("烟草烟污染"[不加权:扩展]) AND "横断面研究"[不加权:扩展]

="Tobacco Smoke Pollution" [Mesh] AND "Cross-Sectional Studies"[Mesh]

关键词检索(Keyword search)

#1 被动吸烟 AND 横断面

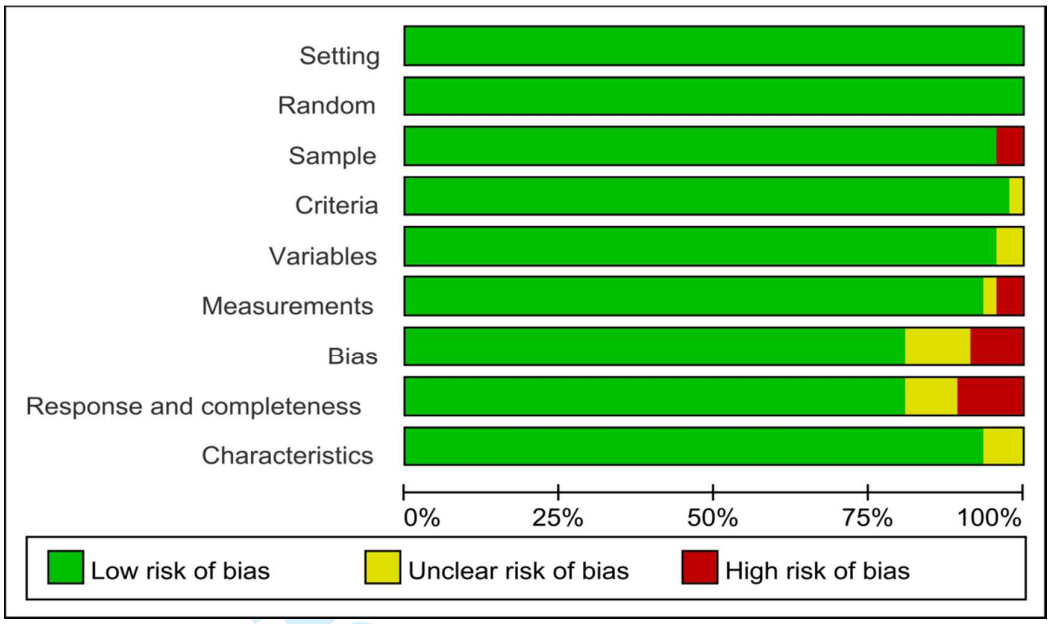
#2 被动吸烟 AND 现况

#3 环境烟草 AND 横断面

#4 环境烟草 AND 现况

#5 #1 OR #2 OR #3 OR #4

The search strategy in other database just did some adjustments on the basis of the above database.



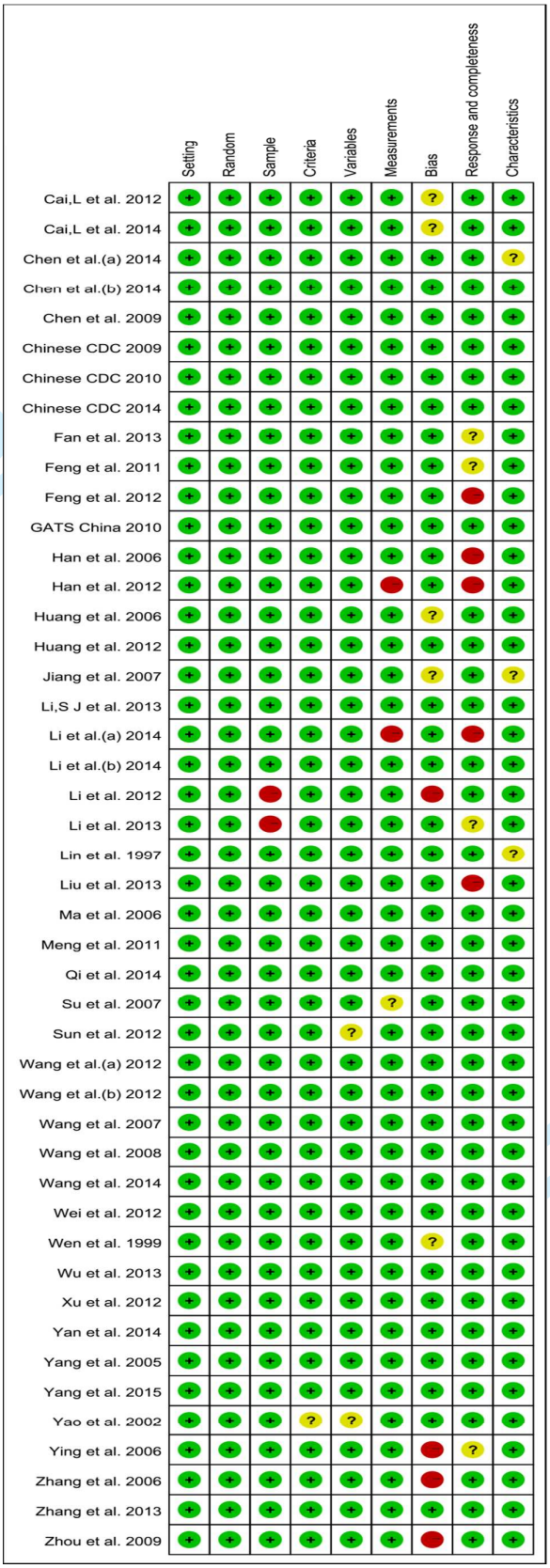


Figure S1 Risk of bias in the meta-analysis.

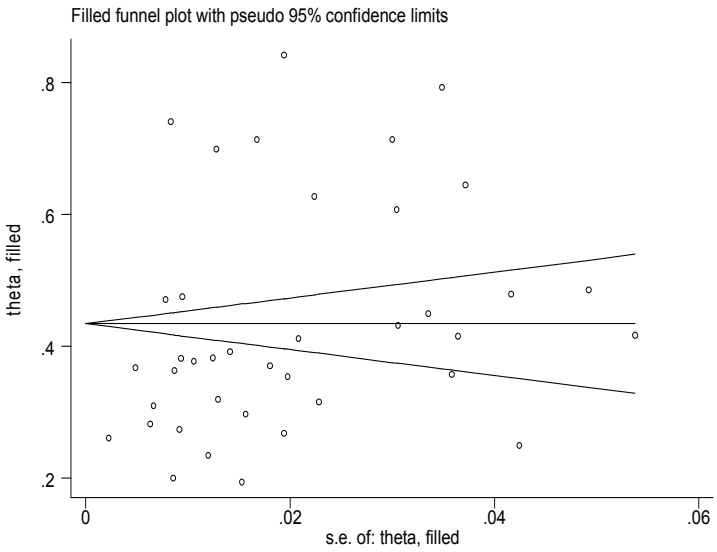


Figure S2 'Trim and fill' method

Table S1 Trends in the pooled prevalence of passive smoking by sex, area and age in the community population aged 15 and above in China: 1995-2013

Survey year	1995-1999	2002-2004	2005-2007	2008-2010	2011-2013
Prevalence% (95%CI)					
overall	43.4(30.2-56.5)	50.9(42.2-59.6)	51.6(35.6-67.6)	47.3(41.7-52.9)	50.4(44.7-56.2)
male	31.3(15.9-46.8)	39.0(30.6-47.4)	43.3(28.0-58.6)	48.4(38.5-58.3)	42.4(35.7-48.8)
female	36.8(26.2-47.4)	52.8(43.1-62.6)	36.2(32.1-40.3)	49.2(41.9-56.5)	48.1(42.8-53.5)
urban	28.7(27.2-30.2)	53.6(39.5-67.6)	40.1(35.5-44.6)	51.3(39.3-63.2)	46.5(31.9-61.0)
rural	..	40.1(31.4-48.8)	33.0(18.9-47.1)	47.1(33.1-61.0)	42.8(37.1-48.5)
15-59	29.4(27.9-31.0)	48.5(40.0-57.0)	44.9(36.6-53.1)	49.0(40.7-57.3)	46.2(38.7-53.6)
≥60	26.5(21.2-31.8)	34.1(28.1-40.1)	29.7(28.4-31.0)	38.6(31.8-45.4)	32.8(24.9-40.7)
No. studies (sample**)**					
overall	3(9065)	9(190324)	5(32005)	19(115141)	9(34147)
male	2(2437)	7(52785)	4(12044)	17(17489)	8(9565)
female	2(6030)	9(137539)	4(31810)	19(70688)	8(24446)
urban	1(3633)	6(63112)	3(18254)	8(33043)	3(5327)
rural	..	6(116797)	2(23063)	6(28035)	4(14126)
15-59	1(3369)	6(135921)	2(32291)	9(47754)	4(23521)
≥60	1(264)	6(27147)	2(4931)	11(25429)	4(2799)

MOOSE Checklist

Prevalence of passive smoking in the community population aged 15 and older in China: a systematic review and meta-analysis

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Criteria		Brief description of how the criteria were handled in the meta-analysis
Reporting of background should include		
√	Problem definition	Passive smoking is casually linked to several chronic diseases, and is deemed to one of primary risk factors for global disease burden. However, effective interventions can control its harm to health. The accurate epidemiology of passive smoking is meaningful for targeted public policies. We aimed to estimate the prevalence and distribution of passive smoking in the community population aged 15 and above of China.
√	Hypothesis statement	The epidemiology of passive smoking in China is severe and requires national concerns regarding specific research and tobacco control.

√	Description of study outcomes	Prevalence and distribution of passive smoking in China.
√	Type of exposure or intervention used	Passive smoking
√	Type of study designs used	We included cross-sectional studies about the prevalence of passive smoking in the community population aged 15 years and above in China.
√	Study population	The community population aged 15 and above in China.
Reporting of search strategy should include		
√	Qualifications of searchers	The credentials of all authors are indicated in the author list.
√	Search strategy, including time period included in the synthesis and keywords	Time: the start of the database to January 2015 Term "(tobacco smoke pollution or passive smoking or second hand smoke or environmental tobacco smoke) and (cross-sectional study or descriptive research or survey or epidemiology)"
√	Databases and registries searched	Medline, PUBMED, EMBASE, and four representative Chinese databases.
√	Search software used, name and version, including special features	We did not employ search software. EndNote(X7) and NoteExpress (version 3) was used to merge retrieved citations and eliminate duplications.
√	Use of hand searching	We hand-searched relevant annual investigation reports and reference lists.
√	List of citations located and those excluded, including justifications	Details of the literature search process are outlined in the flow chart. The citation list is available upon request.
√	Method of addressing articles published in languages other than English	We placed no restrictions on language. However, we included the study reported the prevalence of passive smoking in China, so authors are almost Chinese writhing in English or Chinese.
√	Method of handling abstracts and unpublished studies	If eligible, we would contact with the authors.
√	Description of any contact with authors	We contacted with some authors who had conducted investigation on the prevalence of passive smoking to gain relative data for analysis.
Reporting of methods should include		
√	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Detailed inclusion and exclusion criteria were described in the methods section.
√	Rationale for the selection and coding of data	Data extracted from each of the studies was the following information: first author, year of publication, participant characteristics (geographical location, sex, age and sample size), study methods (time of survey, type of survey, method of random sampling, and definition and measurement of passive smoking).

√	Assessment of confounding	Assessed publication bias using Egger's test. And conducted subgroup and sensitivity analyses to restrict the possible confounders such as sex, age, area, and sample size.
√	Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	The Agency for Healthcare Research and Quality (ARHQ) methodology checklist, STROBE statement and Patricia L. Loney's methodological scoring system were integrated into nine items used to evaluate the methodological quality of the studies.
√	Assessment of heterogeneity	Heterogeneity of the studies was explored with the I^2 index, which assesses not only heterogeneity in a meta-analysis but also the extent of that heterogeneity.
√	Description of statistical methods in sufficient detail to be replicated	Description of methods of meta-analyses, subgroup analyses, and sensitivity analyses and assessment of publication bias are detailed in the methods.
√	Provision of appropriate tables and graphics	The detailing of the searching terms was not complicated and written in the section of search strategy; searching database and outcomes was presented in the flow chart.
Reporting of results should include		
√	Graph summarizing individual study estimates and overall estimate	Figure 1
√	Table giving descriptive information for each study included	Table 1
√	Results of sensitivity testing	Table 3
√	Indication of statistical uncertainty of findings	95% confidence intervals were presented with all summary estimates, I^2 values and results of sensitivity analyses
Reporting of discussion should include		
√	Quantitative assessment of bias	The result of Egger's test indicated that there was no publication bias except for male nonsmokers' tobacco exposure. Subgroup and sensitivity analyses indicated the high heterogeneity was due to most common biases in observational studies.
√	Justification for exclusion	Considering the commonly high heterogeneity in meta-analyses of observational studies, we developed strict exclusion criteria. In particular, we checked whether data used in provincial studies had already been utilized in national studies, and if so, we excluded the provincial study.
√	Assessment of quality of included studies	A risk of bias graph and summary are available in online supplementary Figure S1.

Reporting of conclusions should include		
√	Consideration of alternative explanations for observed results	We noted that the high and stable prevalence of passive smoking in China may be due to the lack of nationwide concern and effective cessation interventions. Hence, we need more concern and actions.
√	Generalization of the conclusions	The estimated prevalence of passive smoking in the community population aged 15 and above in China was 48.7% (95% CI: 44.8-52.5). Young and middle-aged populations, regardless of region, are vulnerable to exposure. Although women have been the primary focus to date, attention should also be given to male non-smoker.
√	Guidelines for future research	We recommend future studies on specific studies regarding passive smoking in Chinese populations, especially on male non-smokers' tobacco exposure.
√	Disclosure of funding source	See Funding.

BMJ Open

Prevalence of passive smoking in the community population aged 15 and older in China: a systematic review and meta-analysis

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Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	passive smoking, Epidemiology < TROPICAL MEDICINE, Chinese, meta-analysis

Prevalence of passive smoking in the community population aged 15 and older in China: A systematic review and meta-analysis

Running head: Prevalence and distribution of passive smoking in China

Jing Zeng, [1, 2, #] Shanshan Yang, [1, 2, 5, #] Lei Wu, [1, 2] Jianhua Wang, [1, 2] Yiyan Wang, [1, 2] Miao Liu, [1, 2] Di Zhang, [1, 2] Bin Jiang, [4] Yao He, [1, 2, 3,*]

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Key words: passive smoking, epidemiology, Chinese, meta-analysis

Text word count: 3272

ABSTRACT

Objectives: To estimate the prevalence and distribution of passive smoking in the community population aged 15 and older in China.

Design: A systematic review and meta-analysis of cross-sectional studies reporting the prevalence of passive smoking in China and a series of subgroup, trend, and sensitivity analyses were conducted in this study.

Data source: The systematic review and meta-analysis, which included 46 studies with 381,580 non-smokers, estimated the prevalence and distribution of passive smoking in China. All studies were published between 1997 and 2015.

Results: The pooled prevalence of passive smoking was 48.7% (95%CI: 44.8-52.5) and was relatively stable from 1995 to 2013. The prevalence in the subgroups of gender, area, age, and time varied from 35.1% (95%CI: 31.8-38.3) in the elderly (≥60 years) to 48.6% (95%CI: 42.9-54.2) in urban areas. The prevalence was lower in the elderly (≥60 years) than in those between 15 and 59 years (OR 1.61, 95%CI: 1.44-1.81). The difference between females and males in both urban and rural areas was not statistically significant (OR: 1.27, 95%CI 0.93-1.74 and OR: 1.14, 95%CI 0.82-1.58, respectively). In addition, a significantly increasing trend was found among males from 2002 to 2010. Heterogeneity was high in all pooled estimates (I^2>98%, p<0.001).

Conclusions: The high and stable prevalence of passive smoking in China is raising increasing national concern regarding specific research and tobacco control programs. Attention should be focused on young, middle-aged and male non-smokers regardless

of region.

Strengths and limitations of this study

1. The study is the first meta-analysis of the prevalence and distribution of passive smoking in the community population aged 15 and older in China.
2. To reduce the limitations of the meta-analysis regarding prevalence, strict inclusion and exclusion criteria were developed, and a series of subgroup, trend, and sensitivity analyses were performed.
3. The high and stable prevalence of passive smoking in China is increasing national interest in specific research and tobacco control programs.
4. The prevalence and distribution of passive smoking in the community population aged 15 and older indicate that targeted public tobacco control policies are needed in China.

INTRODUCTION

The economic burden of tobacco use, including both active and passive smoking, is substantial and is deemed to be one of the primary contributors to the global disease burden. [1-3]Relevant studies have examined the causal relationships between passive smoking and lung cancer, coronary heart disease, respiratory diseases, and multiple adverse health effects in infants and children. [4] Tobacco use is also a leading risk factor for premature mortality and disability from non-communicable diseases in China. [5] In China, 300 billion smokers and 740 billion non-smokers are exposed to second-hand smoke (SHS)[6], and 16.5% of all deaths (1.4 million) in 2010 were attributed to SHS exposure[7]. SHS exposure could result in approximately 3 million deaths per year by 2050 if effective interventions for tobacco control are not implemented. [8]

Previous studies have indicated that public smoking bans are effective ways to reduce exposure to SHS.[9] Approximately 44 countries have implemented smoking bans. China endorsed the WHO Framework Convention on Tobacco Control and stated that it was “determined to give priority to the right to protect public health” in 2003.[10] Many large cities have local regulations regarding tobacco control, but the effect has been less than expected.[11 12] China is the largest tobacco grower and consumer in the world. Chinese national legislators have actively commenced the process of national bans on smoking in public and work places since 2014.[5] However, because of significant interference, particularly from the tobacco industry, few effective legislative, executive, administrative or other measures designed to protect

all persons from exposure to tobacco smoke have been implemented at any governmental level. [10 13] The passive smoking problem in China is widespread and not taken seriously.[14 15] Few studies on smoking have focused specifically on passive smoking, with the passive smoking rate generally included in surveys on active smoking or as a social demographic characteristic in health behaviour studies. The passive smoking rate in China varies greatly among studies, ranging from 28% to 86%, independent of the time period of the study.[16 17] Even national-level studies conducted by different institutions in the same year reported a wide range in the passive smoking rate in China(39%-72%).[6 18] Accurate and scientific reports on passive smoking are needed to provide the government with information on the extent and seriousness of the epidemiology of passive smoking in China, to help evaluate the influence of passive smoking on health, and to provide data and evidence to support tobacco control policies in China.

Herein, we performed a systematic review and meta-analysis to estimate the prevalence of passive smoking in the community population aged 15 years and older in China and examined the prevalence of passive smoking by gender, area, age and survey years. The synthesis of these data would be helpful in determining susceptible populations and areas that could benefit from the establishment and implementation of targeted public policies based on the effects of previous tobacco control efforts.

METHODS

We performed this analysis in accordance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE)[19] guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[20] guidelines (when generating the flow diagram).

Search strategy

We searched Medline, PUBMED, EMBASE, the Chinese Biological Medical Literature database (CBM), the Chinese Wanfang database, the Chinese National Knowledge Infrastructure (CNKI) and the Chongqing VIP database using the terms "(tobacco smoke pollution or passive smoking or second hand smoke or environmental tobacco smoke) and (cross-sectional study or descriptive research or survey or epidemiology)" to identify studies on the prevalence of passive smoking among Chinese adults (aged ≥15 years) published from inception to January 2015. We also manually searched relevant annual investigation reports and reference lists to ensure the integrity of the electronic search results. See the online supplementary information for the search strategy.

Selection criteria

Inclusion criteria

Passive smoke exposure was defined as a non-smoker being exposed to another person's tobacco smoke for at least 15 minutes daily for more than 1 day per week.[21]

Studies had to meet the following criteria for inclusion: (1) a sample of community non-smokers aged 15 years and older; (2) a cross-sectional study or surveillance of the prevalence of passive smoking in China; and (3) census or random sampling survey as the investigation type.

Exclusion criteria

We excluded studies if the definition of passive smoking was unclear, the data were incomplete and could not be obtained from the authors, or the study data had been published previously. In particular, we verified whether data used in provincial studies had already been utilised in national studies; if so, we excluded the provincial study.

Data extraction and quality assessment

Two reviewers independently extracted data and assessed the quality of each eligible study. Disagreements were discussed to reach consensus. The standardised extraction form included the following information: first author, year of publication, participant characteristics (geographical location, gender, age and sample size) and study methods (time of survey, type of survey, method of random sampling, and definition and measurement of passive smoking). Patricia L. Loney's methodological scoring system[22] with 8-item questions was used to perform quality assessments for all included studies. Each item was scored either as a 'yes' (score=1) or 'no/unclear' (score=0). The total possible score ranged from 0-8 and was classified as either 'poor' (total score=0–3), 'moderate' (total score=4–6) or 'good' (total score=7–8)[23]. See the

online supplementary information for the methodological scoring system.

Statistical analysis

As the sample size of non-smokers was sufficient, reaching a prevalence of approximately 0.5 in all studies, we used the raw data to pool the overall prevalence estimates.[24 25] In addition, the random effects model with the D-L method was used to calculate the pooled estimates and 95% confidence intervals (CIs) due to the high heterogeneity among studies (I^2>75%).[26-28] Publication bias was evaluated by Egger's test. If bias existed, the 'trim and fill' method was used to adjust for the publication bias.

In the subgroup analyses, we calculated the prevalence of passive smoking by gender (male and female), area (urban and rural), and age (15-60 and ≥60 years old), and differences were determined by calculating odds ratios (ORs). To observe the relatively continuous and long-term trends of prevalence in passive smoking, trend analyses were performed by gender, area and age using the studies that conducted surveys between 2002 and 2013. In addition, due to the wide range of sample sizes of the included studies, we excluded national health surveys and divided the non-national studies into two groups (sample sizes ≥1000 and <1000) for the sensitivity analyses. We performed all meta-analyses using Stata version 12.0 with the command metan. The trend figures were graphed in Excel 2010.

RESULTS

Our search yielded 1722 studies from the CNKI, 103 from the CBM, 133 from the Wanfang database, and 45 from the VIP. We also identified 194 records in PUBMED, 63 in Medline, and 9 in EMBASE. Six additional records were identified through a manual search of publicly available data. After removing duplicates, 1,650 studies remained. We screened the titles and abstracts of these studies and excluded 1,449 records due to inappropriate study types. The remaining 201 full-text articles were assessed for eligibility, and 46 studies with 381,580 non-smokers published between 1997 and 2015 on data obtained from 1995 to 2013 were finally included **(Figure 1)**. The quality of all eligible studies was moderate and acceptable. Online supplementary table S1 shows the methodological quality assessment results of included studies. Overall, studies with 'good', 'moderate' and 'poor' quality scores were 6(13%), 39(85%) and 1(2%), respectively. Zero score was mainly in the item 2(unbiased sampling frame), item 6(refusers described) and item 7(confidence intervals).

Descriptions of studies

Among the eligible studies, 17[6 15 17 29-42] were special investigations of passive smoking, and the remaining studies were generally part of broader investigations on smoking behaviour. In addition, 6 studies[6 18 38 41 43 44] were conducted at the national level, and the remaining studies were conducted at the provincial level. Therefore, the sample sizes varied greatly, ranging from 136[45] to 126,142[44] participants. The multistage method of random sampling was primarily employed, although 5 studies[15]

[46-49] used the cluster method and 2[16 50] used the stratified method. The area of study also varied, with 12 studies[15 16 32 34 39 40 42 46 47 51-53] examining urban areas, 11[17 30 33 35 37 48 49 53-56] examining rural areas, and the remainder examining both urban and rural areas; nine[18 36 38 44 57-61] of these latter studies could be stratified for further subgroup analyses. Nearly all studies reported data for both genders, but female participants were more common, comprising between 61%[46] to 100%[32 39 40] of the study populations. Most study populations covered the full spectrum of adulthood except for two that focused on persons 35 years of age and older[47] and 45 years of age and older[32] and one[15] that only examined persons 60 years of age and older **(Table 1)**. Passive smoking was measured by self-reporting in all studies, and the estimated publication bias was not significant (Egger's test, p=0.493).

Overall prevalence of passive smoking

A total of 173,622 non-smokers had been exposed to passive smoke. Estimates of the prevalence of passive smoking ranged from 28.7% to 86.4% **(Figure 2)** with high heterogeneity (χ^2=25,612.75, p<0.001; I^2=99.8%). The pooled prevalence was 48.7% (95%CI: 44.8-52.5) and increased at an even rate over the survey years from 43.4% (95%CI: 30.2-56.5) in the 1995-1999 period to 51.6% (95%CI: 35.6-67.6) in the 2005-2007 period **(Table S2)**.

Subgroup and trend analyses

We collected and stratified the eligible studies by gender, area, and age for further

subgroup analyses **(Table 1).** The results are presented in **Table 2**.

Thirty-nine studies reported data for both genders, and 3 studies[32 39 40] reported data only for females, so we included a total of 271,307 females and 94,424 males in the subgroup analyses. We excluded the data from one study[62] that only included 5 male non-smokers. The pooled prevalence of passive smoking among females and males were 47.8% (95%CI: 43.9-51.6) and 43.4% (95%CI: 38.9-48.0), respectively. However, the difference calculated using the data of the 39 studies was not statistically significant (OR 1.19, 95%CI: 0.99-1.43). In addition, the pooled prevalence of passive smoking among females changed significantly over the survey years, whereas among males it increased significantly from 2002 to 2010 and has decreased slightly in recent years **(Figure 3).** The highest prevalence of passive smoking among females and males were between 2002 and 2004 [52.8% (95%CI: 43.1-62.6)] and between 2008 and 2010 [48.4% (95%CI: 38.5-58.3)], respectively **(Table S2)**. However, the estimated publication bias indicated that more studies are necessary to accurately pool the prevalence of passive smoking among males (Egger's test, p=0.002).

Twenty-one studies reported data for urban areas. These studies included a total of 123,369 non-smokers, 55,905 of whom were exposed to second-hand smoke. This resulted in a pooled prevalence of 48.6% (95%CI: 42.9-54.2). Twenty studies reported data for rural areas. A total of 192,375 non-smokers were included in these studies, 86,824 of whom were exposed to second-hand smoke, resulting in a pooled prevalence of 43.5% (95%CI: 37.5-49.5). We did not estimate the difference in the

prevalence of passive smoking between urban and rural areas because of the small number of studies (n=9) that examined both areas. However, the prevalence of passive smoking was higher in urban areas than in rural areas for all those studies, and the prevalence in both areas showed an upward trend, particularly from 2005 to 2013 (**Figure 3**). We also conducted a comparison of gender by area **(Figure 4)**; no significant difference was found between genders in either urban or rural areas (OR 1.27, 95%CI: 0.93-1.74 and OR 1.14, 95%CI: 0.82-1.58, respectively).

The participants in the 46 included studies were divided into two age groups, with 60 years of age designated the cutoff between groups to simplify the data analysis. A higher prevalence was found in the 15 to 59-year-old group than in the ≥60-year-old group (OR 1.61, 95%CI: 1.44-1.81). The pooled prevalence for the two groups were 47.1% (95%CI: 43.2-50.9) and 35.1% (95%CI: 31.8-38.3), respectively, and the difference remained constant throughout the survey years (**Figure 3**).

Sensitivity analysis

The results of four sensitivity analyses did not significantly alter the pooled prevalence (**Table 3**). When all included studies were compared, the absolute change in estimated prevalence ranged from 3.1% to 4.8%. The results of the 'trim and fill' method indicated that the pooled prevalence of males was moderate despite the existent publication bias (Egger's test, p=0.002) (**Figure S1**). The heterogeneity of all analyses was substantial (I^2>98%).

DISCUSSION

Our meta-analysis of the prevalence of passive smoking in the community population aged 15 and older in China identified 46 studies and 381,580 non-smokers. The pooled overall prevalence of passive smoking was 48.7% (95% CI: 44.8-52.5) and remained high throughout the study period. Compared with the estimated prevalence of passive smoking in other developing countries, China is at an intermediate level; [63] however, passive smoking in China is much more common than in the United States, where the prevalence of adult (>20 years) non-smokers exposed to passive smoke was 48.0% (42.6%-53.4%) between 1999 and 2000 and decreased to 21.3% (18.6%-24.0%) between 2011 and 2012.[64] This finding indicates that China has not yet met its commitment to the Framework Convention on Tobacco Control and that we need to further accelerate the process of legislation and the implementation of tobacco control.

The prevalence of passive smoking in China varies by gender, area, and age group. Specifically, previous studies showed that females were more likely to be exposed to passive smoke due to the high proportion and rate of smoking among Chinese men and to women's difficulty in avoiding exposure because of the social environment that existed at the time of those studies, in which women held a weak position in the family and workplace.[6] However, our trend and subgroup analyses revealed a remarkable increase in the prevalence of passive smoking among males, particularly from 2002 to 2010, and found that the differences in the overall prevalence and the prevalence in both urban and rural areas between females and

males were not significant. This result may be valuable from a public health standpoint as it suggests that although tobacco exposure of females in China is a source of major concern, attention should also be given to male non-smokers, who have a greater likelihood of passive smoking in the workplace and in public areas. [63]

The prevalence of passive smoking in urban areas was higher than in rural areas throughout the survey years, and an upward trend was found in both areas from 2002 to 2013. However, a previous meta-analysis on the prevalence of passive smoking in China obtained the opposite results, indicating that the prevalence of passive smoking was greater in rural areas than in urban areas.[65]Several factors may have contributed to this divergence. First, our meta-analysis used stricter criteria and included 30 studies published between 2010 and 2015 that were not included in the previous meta-analysis. Second, people in urban areas may be more likely to be exposed to passive smoke in the workplace and during social interactions. Third, passive smoking was measured by self-reporting in all eligible studies. The much greater health consciousness in urban areas could have led to more self-reports of passive smoking[66], and the prevalence may have been underestimated in rural areas. With the trend of urbanization and the massive annual migration to urban areas in China for jobs, tobacco control policies should focus on both populations.

The age analysis showed that people aged 15-59 were 61% more likely to be exposed to second-hand smoke than those aged ≥60. The possible explanation for this finding is that the retired elderly are more concerned about health, and some have quit smoking or intentionally reduced tobacco exposure because of multiple chronic

diseases and on the advice of their doctors.[67] In addition, the high prevalence of passive smoking among people aged 15-59, which was stable for nearly a decade, suggests that more attention should be paid to tobacco exposure in young and middle-aged non-smokers.

There are some limitations in this meta-analysis. First, the heterogeneity between studies was substantial despite the strict inclusion and exclusion criteria. Subgroup, trend, and sensitivity analyses were performed to explore the high heterogeneity but with no conclusive results. Therefore, the more conservative random effects meta-analysis model was used. The high heterogeneity might have been due to the confounding effects of the variations in geographical distribution of the eligible studies, and these could not be extracted based on characteristics such as age in different genders, education level, ethnicity, and passive source because many of the included studies reported passive smoking as an additional outcome. Second, no studies on special administrative regions were included, which limits the representativeness and significance of these findings. Third, most eligible studies were written in Chinese, which makes it difficult for non-Chinese readers to review the original materials. Finally, pregnant women and children (<15 years old), whose health is more seriously affected by passive smoking, were not included in the review.

4

CONCLUSION

Tobacco control has been difficult to implement since China committed to the

Framework Convention on Tobacco Control. This meta-analysis summarises the prevalence and distribution of passive smoking in the community population aged 15 and older in China to help inform public policy. Young and middle-aged populations, regardless of region, are vulnerable to exposure. Although women have been the primary focus to date, attention should also be given to male non-smoker. The existing studies specially regarding passive smoking in China are insufficient, and the high and stable prevalence of passive smoking over the past decade requires a nationwide focus and effective cessation interventions.

Table 1 Characteristics and stratified data of the included studies

First author and year published	Survey year	Type (special investigation / contains relative data)	Location	Methods of random sampling	Female (%)	Age	Subgroup					
							Male	Female	15-59	≥60	Urban	Rural
Yang et al. (2015)[15]	2010	Special	Province	Cluster	64	60-95	130/668	417/1203	..	547/1871	547/1871	..
Chinese CDC (2014)[43]	2010	Relative	National	Multistage	66	≥60	1434/5085	3306/9923	..	4470/15,008	..	..
Cai, L. et al. (2014)[33]	2010	Special	Province	Multistage	77	≥18	1031/2699	3859/8892	3655/8447	1235/3144	..	4890/11,591
Chen et al.(a) (2014)[32]	2008-2010	Special	Province	Multistage	100	45-65	..	12,730/27,874	11,457/25,033	1273/2843	12,730/27,874	..
Chen et al.(b)	2013	Relative	Province	Multistage	68	15-69	64/179	189/371	..	..	..	..

(2014)[68]												
Li et al.(a) (2014)[31]	2011	Special	Province	Multistage	71	≥18	162/227	345/549	..	..	..	..
Li et al.(b) (2014)[30]	2011	Special	Province	Multistage	75	≥18	266/717	856/2124	758/1897	190/483	..	1122/2841
Li et al. (2014)[29]	2012	Special	Province	Multistage	77	15-74	1110/3055	4297/10,177	4692/11,185	169/623	..	..
Wang et al. (2014)[58]	2011	Relative	Province	Multistage	65	≥18	1905/4045	4090/7411	5238/9786	661/1670	1855/3291	4420/7486
Can et al. (2014)[57]	2012	Relative	Province	Multistage	67	15-69	140/522	417/1044	..	..	321/700	373/866
Li, S.J et al. (2013)[54]	2011	Relative	Province	Multistage	81	≥18	230/558	1070/2279	2813/3629	..	..	1300/2837
Can et al. (2013)[69]	2010	Relative	Province	Multistage	71	15-69	107/166	202/417	..	..	..	..
Li et al. (2013)[45]	2012	Relative	Province	Multistage	..	15-69	..	..	..	..	..	..
Liu et al. (2013)[34]	2012	Special	Province	Multistage	65	≥15	113/262	233/491	322/653	-	346/753	..
Wu et al. (2013)[70]	2010	Relative	Province	Multistage	66	≥18	69/144	141/285	182/366	28/63	..	..
Zhang et al. (2013)[35]	2010	Special	Province	Multistage	67	15-69	413/1293	1171/2901	1525/3967	59/227	..	1584/4194
Cai, L. et al. (2012)[37]	2010	Special	Province	Multistage	78	≥18	901/1289	3469/4567	..	775/1194	..	4370/5856

Feng et al. (2012)[52]	2010	Relative	Province	Multistage	66	≥15	156/257	295/508	403/687	..	551/765	..
Han et al. (2012)[56]	..	Relative	Province	Multistage	88	≥18	26/104	309/794	..	..	..	335/898
Huang et al. (2012)[51]	2010	Relative	Province	Multistage	68	15-65	50/103	77/221	..	..	127/324	..
Li et al. (2012)[47]	2010	Relative	Province	Cluster	62	35-86	35/84	62/138	..	..	97/222	..
Sun et al. (2012)[50]	2010	Relative	Province	Stratified	81	≥18	76/183	248/748	266/589	58/159	..	324/931
Wang et al.(a) (2012)[71]	2010	Relative	Province	Multistage	74	15-69	131/415	501/1159	464/1122	27/93	..	..
Wang et al.(b) (2012)[55]	2010	Relative	Province	Multistage	68	≥15	582/1521	1258/3197	1605/3914	235/804	..	1840/4718
Wei et al. (2012)[46]	2010	Relative	Province	Cluster	61	≥15	99/220	134/345	..	..	233/565	..
Xu et al. (2012)[36]	2010	Special	Province	Multistage	69	≥15	293/467	613/1047	..	..	513/821	420/806
Zeng et al. (2011)[62]	2010	Relative	Province	Multistage	99	≥18	1/5	243/440	..	..	..	..
Meng et al. (2011)[59]	2007	Relative	Province	Multistage	66	15-69	254/853	519/1647	..	..	417/1118	356/1380

Chinese CDC (2010)[18]	2007	Relative	National	Multistage	72	15-69	3632/9879	10,546/26,145	12,116/ 69,768	1384/4659	5470/14,341	8708/21,683
GATS China (2010)[6]	2010	Special	National	Multistage	69	≥15	2045/2760	4514/6305	..	..	..	..
Chinese CDC (2009)[38]	2004	Special	National	Multistage	79	18-69	1501/4842	6016/ 17,747	6243/ 17,929	612/2519	3047/8809	4470/ 13,780
Chen et al. (2009)[72]	2007	Relative	Province	Multistage	77	15-69	207/585	727/1950	..	..	..	..
Zhou et al. (2009)[16]	2008	Relative	Province	Stratified	79	≥15	107/135	457/518	..	..	564/653	..
Wang et al. (2008)[17]	2004	Special	Province	Multistage	71	18-69	646/2358	1673/5784	2022/7079	211/1063	..	2391/8142
Jiang et al. (2007)[48]	2004-2005	Relative	Province	Cluster	..	≥18	..	..	..	..	..	11,037/ 15,110
Su et al. (2007)[53]	2006	Relative	Province	Multistage	74	≥18	519/727	730/2068	1240/2523	81/272	1249/2795	..
Wang et al. (2007)[60]	2004	Relative	Province	Multistage	64	15-69	792/2100	1641/3699	..	..	1268/3054	1222/2244
Han et al. (2006)[40]	2002	Special	Province	Multistage	100	15-94	..	2886/3500	..	..	2886/3500	..

Huang et al. (2006)[49]	2002	Relative	Province	Cluster	93	≥40	298/354	3895/5300	1559/2201	500/1192	..	3393/5654
Ning et al. (2006)[39]	2002	Special	Province	Multistage	100	15-86	..	814/1000	619/753	81/110	814/1000	..
Zhang et al. (2006)[61]	2002	Relative	Province	Multistage	69	≥15	437/2184	1823/4899	1908/5789	310/1242	1768/3850	1441/3764
Xia et al. (county team)(2006)[44]	2002	Relative	National	Multistage	70	≥15	9957/38,167	47,946/87,975	43,136/ 102,170	6108/21,021	29,236/47,792	56,699/ 89,991
Wang et al. (2005)[41]	2002	Special	National	Multistage	74	15-69	1323/2780	4169/7635	..	..	..	..
Yao et al. (2002)[42]	1999	Special	Province	Unclear	66	≥18	292/1244	750/2389	992/3369	70/264	1042/3633	..
Wen et al. (1999)[73]	1996	Relative	Province	Multistage	..	≥15	..	..	..	..	..	..
Lin et al. (1997)[74]	1995	Relative	Province	Multistage	75	15-69	468/1193	1537/3641	..	..	..	..

Table 2 Pooled prevalence of passive smoking by gender, area, and age in the community population aged 15 and older in China

Subgroup	No. studies	Prevalence %(95%CI)	Heterogeneity χ^2	*P*	I^2,%	Egger's test t	*P*
Gender							
male	39	43.4(38.9-48.0)	7386.26	<0.001	99.5	3.29	0.002
female	43	47.8(43.9-51.6)	16,726.46	<0.001	99.7	-0.39	0.701
Area							
rural	20	43.5(37.5-49.5)	12,889.39	<0.001	99.9	-0.41	0.688
urban	21	48.6(42.9-54.2)	7321.31	<0.001	99.7	0.54	0.596
Age							
≥60	24	35.1(31.8-38.3)	1378.78	<0.001	98.3	1.44	0.164
15-59	22	47.1(43.2-50.9)	6681.43	<0.001	99.7	1.17	0.257

Table 3 Sensitivity analyses of the prevalence of passive smoking in China

Outcome	No. Studies	No. Non-smokers	Prevalence %(95%CI)	I^2, %
All included studies	46	381,580	48.7(44.8-52.5)	99.8
National survey	6	219,243	45.6(36.8-54.3)	99.9
Non-national survey				
non-national survey (sample size ≥1000)	25	153,709	46.6(40.3-52.9)	99.9
non-national survey (sample size <1000)	15	8628	53.5(44.5-62.4)	98.8
overall	40	162,337	49.1(44.1-54.1)	99.8

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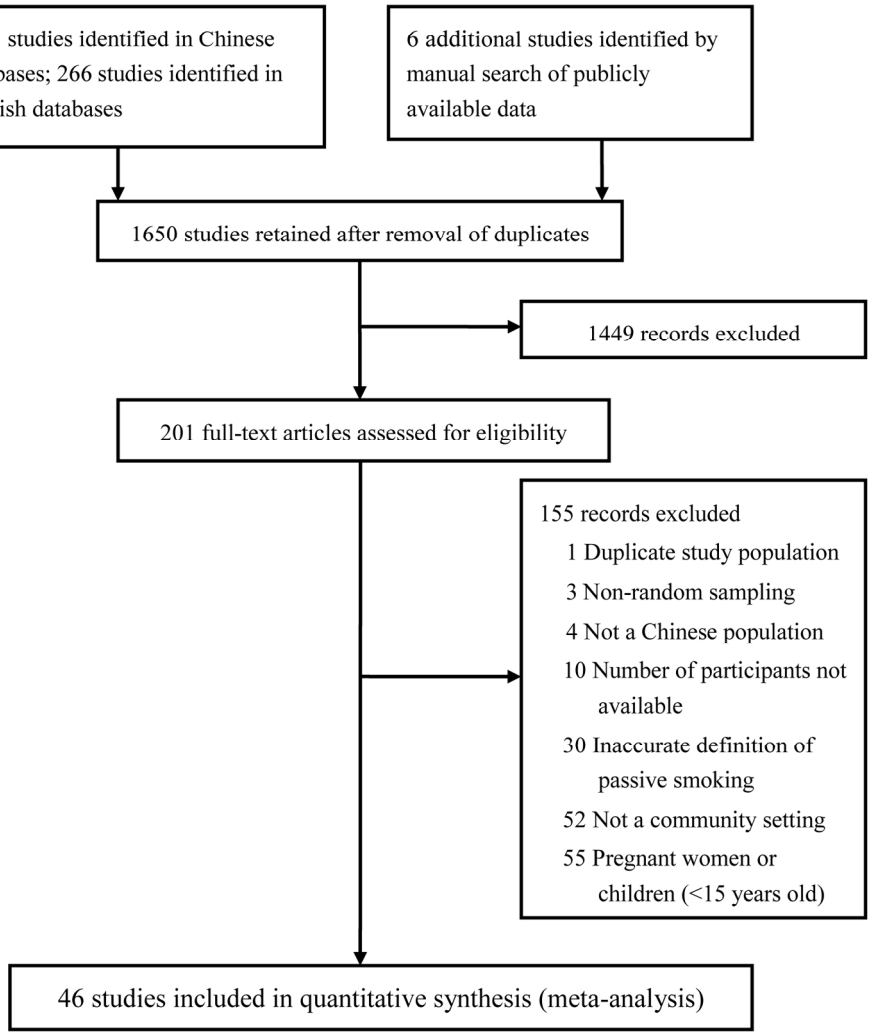
Figure 1 Study selection flow diagram

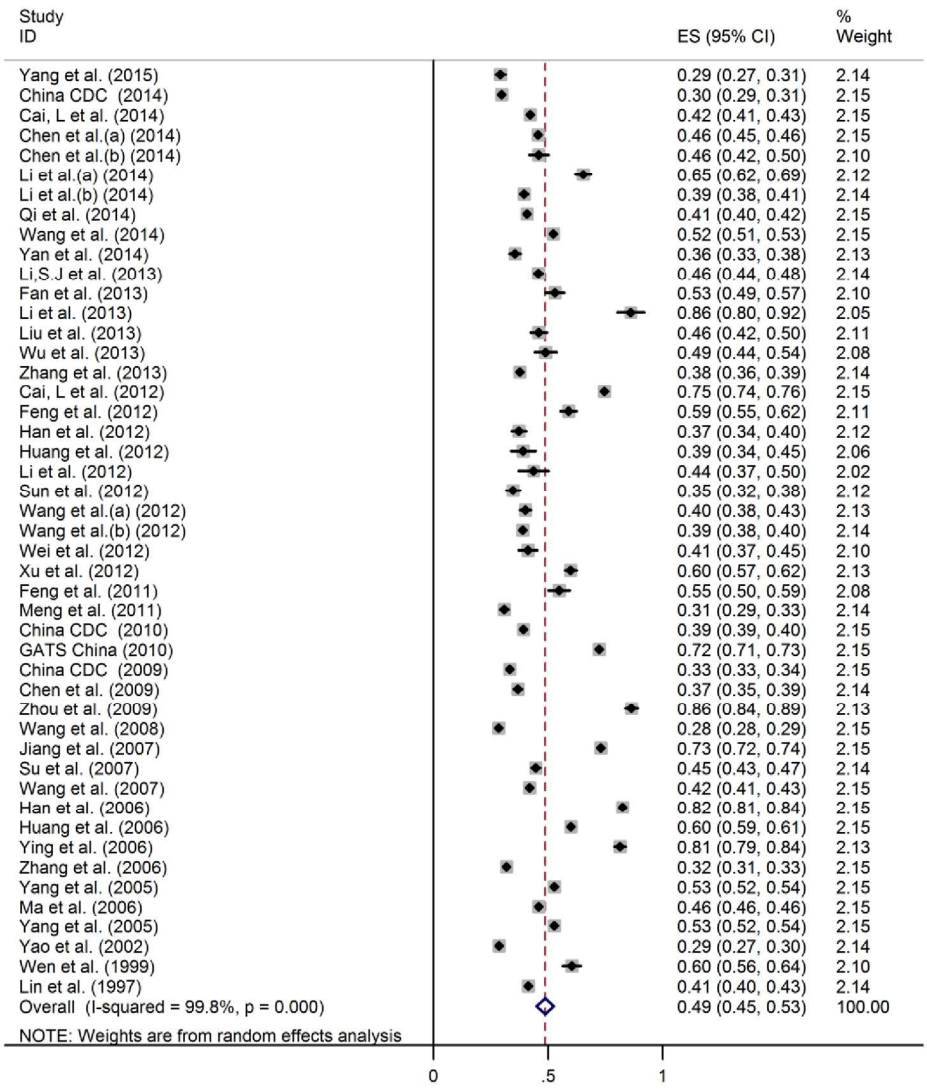
Figure 2 Forest plot of the pooled prevalence and confidence intervals of passive smoking in the community population aged 15 and older in China

Figure 3 Trends in the pooled prevalence of passive smoking by gender, area and age in the community population aged 15 and older in China: 2002-2013

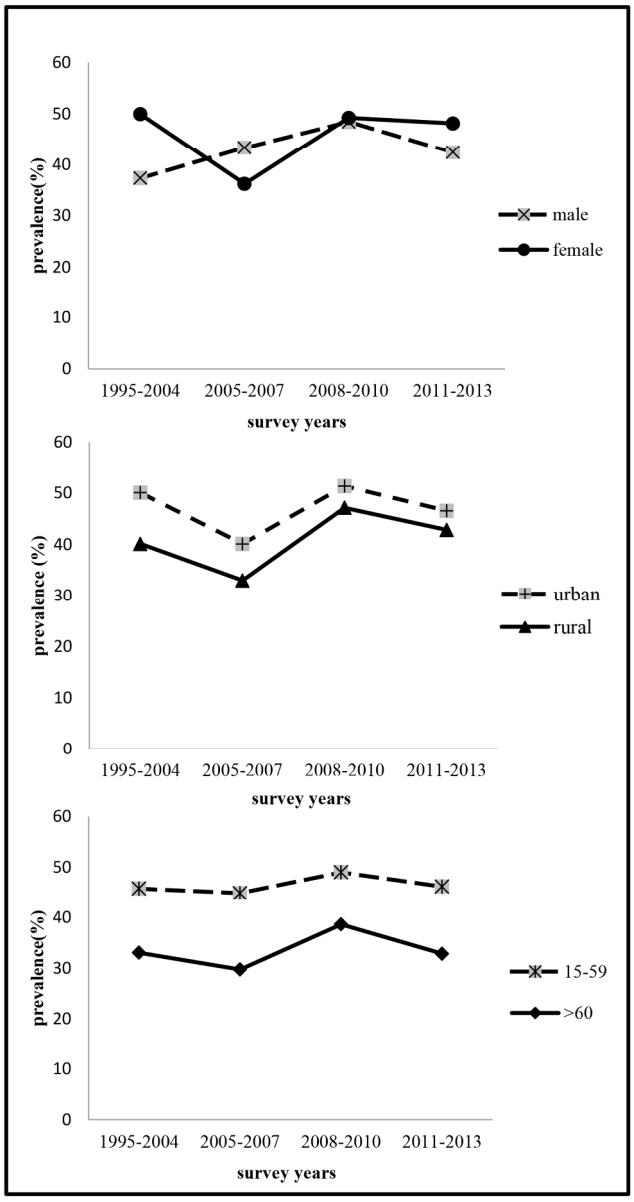
Figure 4 The risk of passive smoking between genders and areas in the community population aged 15 and older in China



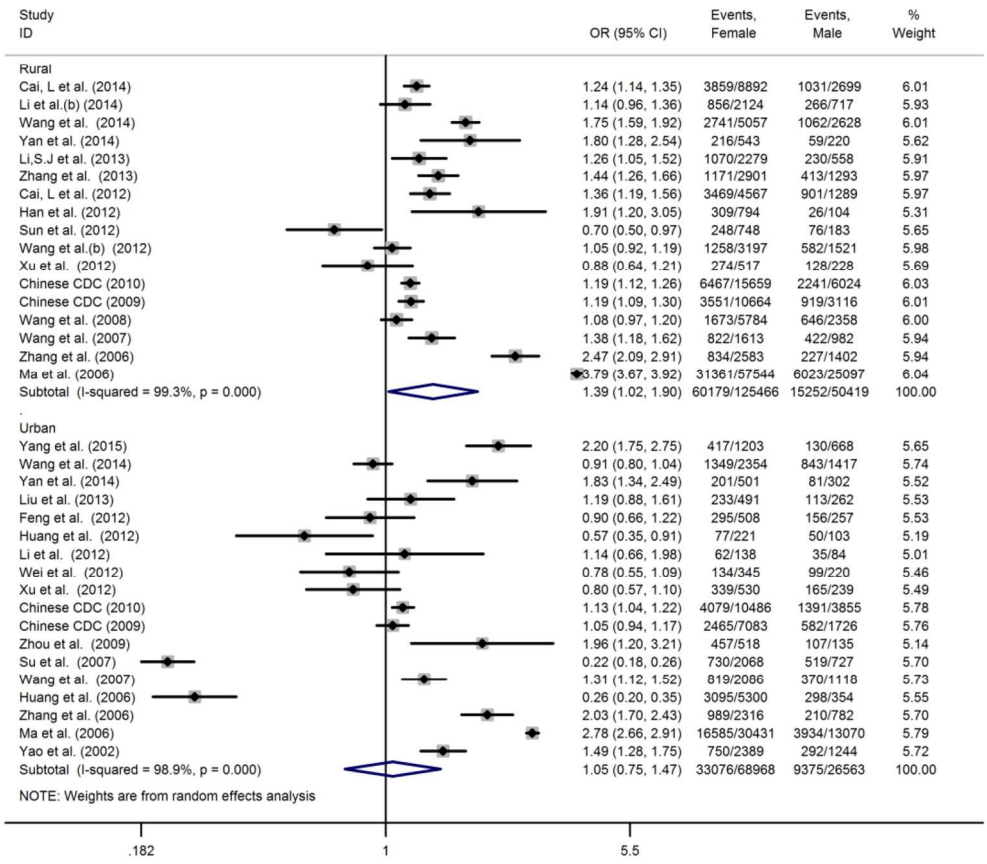
Study selection flow diagram
157x175mm (300 x 300 DPI)



Forest plot of the pooled prevalence and confidence intervals of passive smoking in the community population aged 15 and older in China
146x171mm (300 x 300 DPI)



Trends in the pooled prevalence of passive smoking by gender, area and age in the community population aged 15 and older in China: 2002-2013
120x228mm (300 x 300 DPI)



The risk of passive smoking between genders and areas in the community population aged 15 and older in China
139x127mm (300 x 300 DPI)

1. Search Strategy

Source: PubMed
Searched on: January 29th, 2015
#1 (("Tobacco Smoke Pollution"[Mesh]) OR passive smoking [Title/Abstract]) OR second hand smoke [Title/Abstract]
#2 ((("Cross-Sectional Studies"[Mesh]) OR descriptive study [Title/Abstract]) OR epidemiology [Title/Abstract]) OR survey [Title/Abstract]
#3 ((((China [Affiliation]) OR Macau [Affiliation]) OR Hong Kong [Affiliation])) OR Taiwan [Affiliation]
#4 #1 AND #2 AND #3

Source: CBM (the Chinese Biological Medical Literature database)
Searched on: January 29th, 2015
主题词检索(Mesh search)
("烟草烟污染"[不加权:扩展]) AND "横断面研究"[不加权:扩展]
="Tobacco Smoke Pollution" [Mesh] AND "Cross-Sectional Studies"[Mesh]
关键词检索(Keyword search)
#1 被动吸烟 AND 横断面
#2 被动吸烟 AND 现况
#3 环境烟草 AND 横断面
#4 环境烟草 AND 现况
#5 #1 OR #2 OR #3 OR #4

The search strategy in other database just did some adjustments on the basis of the above database.

2. Methodological scoring system used to rate studies included

Item	Score
1. Random sample or whole population	1 point
2. Unbiased sampling frame (i.e. census data)	1 point
3. Adequate sample size (>300 subjects)	1 point
4. Measures were the standard	1 point
5. Outcomes measured by unbiased assessors	1 point
6. Adequate response rate (70%), refusers described	1 point
7. Confidence intervals, subgroup analysis	1 point
8. Study subjects described	1 point
Maximum score	8 points

Table S1 Methodological quality assessment results for included studies

Study	item 1	item 2	item 3	item 4	item 5	item 6	item 7	item 8	Total*	Quality Category#
Yang et al. (2015)[15]	1	0	1	1	1	0	1	1	6	Moderate
Chinese CDC (2014)[44]	1	1	1	1	1	1	0	1	7	Good
Cai, L. et al. (2014)[34]	1	0	1	1	1	0	1	1	6	Moderate
Chen et al.(a) (2014)[33]	1	0	1	1	1	1	0	1	6	Moderate
Chen et al.(b) (2014)[69]	1	0	1	1	1	1	0	1	6	Moderate
Li et al.(a) (2014)[32]	1	0	1	1	1	0	0	1	5	Moderate
Li et al.(b) (2014)[31]	1	0	1	1	1	0	0	1	5	Moderate
Qi et al. (2014)[30]	1	0	1	1	1	0	0	1	5	Moderate
Wang et al. (2014)[59]	1	0	1	1	1	0	1	1	6	Moderate
Yan et al. (2014)[58]	1	0	1	1	1	0	0	1	5	Moderate
Li, S.J et al. (2013)[55]	1	0	1	1	1	0	1	1	6	Moderate
Fan et al. (2013)[70]	1	0	1	1	1	0	0	1	5	Moderate
Li et al. (2013)[46]	1	0	0	1	1	0	0	1	4	Moderate
Liu et al. (2013)[35]	1	0	1	1	1	0	0	1	5	Moderate
Wu et al. (2013)[71]	1	0	1	1	1	1	0	1	6	Moderate
Zhang et al. (2013)[36]	1	0	1	1	1	1	0	1	6	Moderate
Cai, L. et al. (2012)[38]	1	0	1	1	1	0	1	1	6	Moderate
Feng et al. (2012)[53]	1	0	1	1	1	0	0	1	5	Moderate
Han et al. (2012)[57]	1	0	1	1	1	0	0	1	5	Moderate
Huang et al. (2012)[52]	1	0	1	1	1	0	0	1	5	Moderate
Li et al. (2012)[48]	1	0	0	1	0	0	0	1	3	Poor
Sun et al. (2012)[51]	1	0	1	1	1	0	0	1	5	Moderate
Wang et al.(a) (2012)[72]	1	0	1	1	1	0	0	1	5	Moderate

Wang et al.(b) (2012)[56]	1	0	1	1	1	1	0	6	Moderate
Wei et al. (2012)[47]	1	0	1	1	1	0	0	5	Moderate
Xu et al. (2012)[37]	1	0	1	1	1	0	0	5	Moderate
Feng et al. (2011)[63]	1	0	1	1	1	0	0	5	Moderate
Meng et al. (2011)[60]	1	0	1	1	1	0	0	5	Moderate
Chinese CDC (2010)[18]	1	1	1	1	1	1	0	7	Good
GATS China (2010)[6]	1	1	1	1	1	1	1	8	Good
Chinese CDC (2009)[39]	1	1	1	1	1	1	0	7	Good
Chen et al. (2009)[73]	1	0	1	1	1	0	0	5	Moderate
Zhou et al. (2009)[16]	1	0	1	1	1	0	0	5	Moderate
Wang et al. (2008)[17]	1	0	1	1	1	1	0	6	Moderate
Jiang et al. (2007)[49]	1	0	1	1	0	0	0	4	Moderate
Su et al. (2007)[54]	1	0	1	1	1	1	0	6	Moderate
Wang et al. (2007)[61]	1	0	1	1	1	0	0	5	Moderate
Han et al. (2006)[41]	1	0	1	1	1	0	0	5	Moderate
Huang et al. (2006)[50]	1	0	1	1	1	0	0	5	Moderate
Ying et al. (2006)[40]	1	0	1	1	0	0	0	4	Moderate
Zhang et al. (2006)[62]	1	0	1	1	0	0	0	4	Moderate
Ma et al. (2006)[45]	1	1	1	1	1	1	0	7	Good
Yang et al. (2005)[42]	1	1	1	1	1	1	0	7	Good
Yao et al. (2002)[43]	1	0	1	1	1	0	0	5	Moderate
Wen et al. (1999)[74]	1	0	1	1	1	0	0	5	Moderate
Lin et al. (1997)[75]	1	0	1	1	0	0	1	5	Moderate

*Each item is scored 0 (no/unclear) or 1 (yes) to yield a total score ranging from 0-8.

#Quality category, total quality score was classified as either ‘poor’ (total score=0–3), ‘moderate’ (total score=4–6),or ‘good’ (total score=7–8).

Table S2 Trends in the pooled prevalence of passive smoking by sex, area and age in the community population aged 15 and above in China: 1995-2013

Survey year	1995-1999	2002-2004	2005-2007	2008-2010	2011-2013
Prevalence% (95%CI)					
overall	43.4(30.2-56.5)	50.9(42.2-59.6)	51.6(35.6-67.6)	47.3(41.7-52.9)	50.4(44.7-56.2)
male	31.3(15.9-46.8)	39.0(30.6-47.4)	43.3(28.0-58.6)	48.4(38.5-58.3)	42.4(35.7-48.8)
female	36.8(26.2-47.4)	52.8(43.1-62.6)	36.2(32.1-40.3)	49.2(41.9-56.5)	48.1(42.8-53.5)
urban	28.7(27.2-30.2)	53.6(39.5-67.6)	40.1(35.5-44.6)	51.3(39.3-63.2)	46.5(31.9-61.0)
rural	..	40.1(31.4-48.8)	33.0(18.9-47.1)	47.1(33.1-61.0)	42.8(37.1-48.5)
15-59	29.4(27.9-31.0)	48.5(40.0-57.0)	44.9(36.6-53.1)	49.0(40.7-57.3)	46.2(38.7-53.6)
≥60	26.5(21.2-31.8)	34.1(28.1-40.1)	29.7(28.4-31.0)	38.6(31.8-45.4)	32.8(24.9-40.7)
No. studies (sample**)**					
overall	3(9065)	9(190324)	5(32005)	19(115141)	9(34147)
male	2(2437)	7(52785)	4(12044)	17(17489)	8(9565)
female	2(6030)	9(137539)	4(31810)	19(70688)	8(24446)
urban	1(3633)	6(63112)	3(18254)	8(33043)	3(5327)
rural	..	6(116797)	2(23063)	6(28035)	4(14126)
15-59	1(3369)	6(135921)	2(32291)	9(47754)	4(23521)
≥60	1(264)	6(27147)	2(4931)	11(25429)	4(2799)

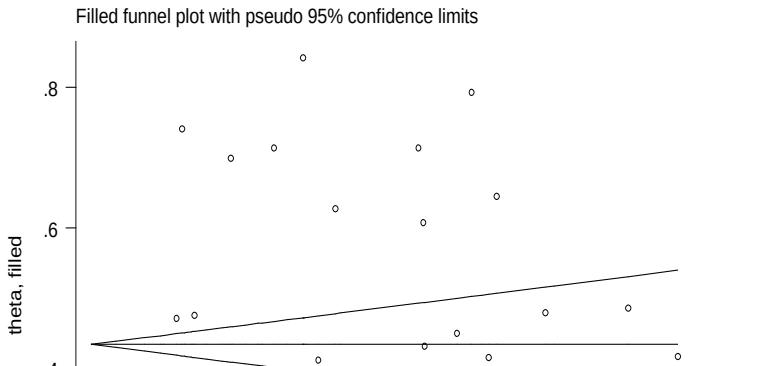


Figure S1 'Trim and fill' method

MOOSE Checklist

Prevalence of passive smoking in the community population aged 15 and above in China: a systematic review and meta-analysis

Jing Zeng, [1, 2, #] Shanshan Yang, [1, 2, 5, #] Lei Wu, [1, 2] Jianhua Wang, [1, 2] Yiyan Wang, [1, 2] Miao Liu, [1, 2] Di Zhang, [1, 2] Bin Jiang, [4] Yao He, [1, 2, 3, *]

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Criteria		Brief description of how the criteria were handled in the meta-analysis	Page
Reporting of background should include			
√	Problem definition	Passive smoking is casually linked to several chronic diseases, and is deemed to one of primary risk factors for global disease burden. However, effective interventions can control its harm to health. The accurate epidemiology of passive smoking is meaningful for targeted public policies. We aimed to estimate the prevalence and distribution of passive smoking in the community population aged 15 and above of China.	5-6
√	Hypothesis statement	The epidemiology of passive smoking in China is severe and requires national concerns regarding specific research and tobacco control.	4,6

√	Description of study outcomes	Prevalence and distribution of passive smoking in China.	6
√	Type of exposure or intervention used	Passive smoking	6
√	Type of study designs used	We included cross-sectional studies about the prevalence of passive smoking in the community population aged 15 years and above in China.	6
√	Study population	The community population aged 15 and above in China.	6
Reporting of search strategy should include			
√	Qualifications of searchers	The credentials of all authors are indicated in the author list.	1
√	Search strategy, including time period included in the synthesis and keywords	Time: the start of the database to January 2015 Term: See the online supplementary information for the search strategy.	7,38
√	Databases and registries searched	Medline, PUBMED, EMBASE, and four representative Chinese databases.	7
√	Search software used, name and version, including special features	We did not employ search software. EndNote(X7) and NoteExpress (version 3) was used to merge retrieved citations and eliminate duplications.	7
√	Use of hand searching	We hand-searched relevant annual investigation reports and reference lists.	7
√	List of citations located and those excluded, including justifications	Details of the literature search process are outlined in the flow chart. The citation list is available upon request.	10,34
√	Method of addressing articles published in languages other than English	We placed no restrictions on language. However, we included the study reported the prevalence of passive smoking in China, so authors are almost Chinese writhing in English or Chinese.	7
√	Method of handling abstracts and unpublished studies	If eligible, we would contact with the authors.	8
√	Description of any contact with authors	We contacted with some authors who had conducted investigation on the prevalence of passive smoking to gain relative data for analysis.	8
Reporting of methods should include			
√	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Detailed inclusion and exclusion criteria were described in the methods section.	7-8
√	Rationale for the selection and coding of data	Data extracted from each of the studies was the following information: first author, year of publication, participant characteristics and study methods.	8
√	Assessment of confounding	Assessed publication bias using Egger's test. And conducted subgroup and sensitivity analyses to restrict the possible confounders such as sex, age, area, and sample size.	9
√	Assessment of study quality, including blinding of quality assessors; stratification or regression on possible	Patricia L. Loney's methodological scoring system with 8-item questions was used to perform quality assessments for all included studies.	8

	predictors of study results		
√	Assessment of heterogeneity	Heterogeneity of the studies was explored with the I^2 index, which assesses not only heterogeneity in a meta-analysis but also the extent of that heterogeneity.	9
√	Description of statistical methods in sufficient detail to be replicated	Description of methods of meta-analyses, subgroup analyses, and sensitivity analyses and assessment of publication bias are detailed in the methods.	9
√	Provision of appropriate tables and graphics	The detailing of the searching terms was not complicated and written in the section of search strategy; searching database and outcomes was presented in the flow chart.	10,34
Reporting of results should include			
√	Graph summarizing individual study estimates and overall estimate	Figure 1	10,34
√	Table giving descriptive information for each study included	Table 1	11,18
√	Results of sensitivity testing	Table 4	13,24
√	Indication of statistical uncertainty of findings	95% confidence intervals were presented with all summary estimates, I^2 values and results of sensitivity analyses	11-13
Reporting of discussion should include			
√	Quantitative assessment of bias	The result of Egger's test indicated that there was no publication bias except for male nonsmokers' tobacco exposure. Subgroup and sensitivity analyses indicated the high heterogeneity was due to most common biases in observational studies.	12-13
√	Justification for exclusion	Considering the commonly high heterogeneity in meta-analyses of observational studies, we developed strict exclusion criteria. In particular, we checked whether data used in provincial studies had already been utilized in national studies, and if so, we excluded the provincial study.	8
√	Assessment of quality of included studies	The quality of all eligible studies was moderate and acceptable. See online supplementary table S1 shows the methodological quality assessment results of included studies.	10,40
Reporting of conclusions should include			
√	Consideration of alternative explanations for observed results	We noted that the high and stable prevalence of passive smoking in China may be due to the lack of nationwide concern and effective cessation interventions. Hence, we need more concern and actions.	17
√	Generalization of the conclusions	The estimated prevalence of passive smoking in the community population aged 15 and above in China was 48.7% (95% CI: 44.8-52.5). Young and middle-aged populations, regardless of region, are vulnerable to exposure. Although women have been the primary focus to date, attention should also be given to male non-smoker.	14

√	Guidelines for future research	We recommend future studies on specific studies regarding passive smoking in Chinese populations, especially on male non-smokers' tobacco exposure.	17
√	Disclosure of funding source	See Funding.	25