Secondhand Smoke Exposure Reduction Intervention among Children in Rural China: A Cluster Randomized Controlled Trial

by

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Graduate Program in Global Health
Duke Kunshan University and Duke University

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Graduate Program
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ABSTRACT

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Abstract

Background: Secondhand smoke (SHS) exposure has direct negative impacts on health, especially for vulnerable infants and young children. With the relatively higher smoking rate and lower levels of cigarette smoking-related knowledge and awareness in rural China, children were facing severe SHS exposure within households. This study aimed to evaluate whether a community health worker (CHW)–delivered tobacco control educational intervention for smoking households will reduce children's SHS exposure in rural settings through 12-month follow-up. Methods: Households with a child younger than or equal to five years old at home were randomized to the intervention group (n = 334) to receive smoking hygiene intervention (SHI) or to the attention-matched comparison group (n = 334) by their clusters. Trained CHWs delivered the intervention. Outcomes were assessed at 6- and 12-month follow-up. Multilevel mixed-effects logistic regression was used to access the intervention performance. Results: We found that children were less likely to be exposed to SHS from smokers at home in the intervention group (OR: 0.56 95% CI: .32, 1.00 P=0.049) than the children in the comparison group at 12-months as measured by the self-reported number of days the smoker smoked in front of children. Our SHI was not effective on smoking cessation, smoke-free home restriction, and improvement of children's respiratory health. Conclusions: The findings of this first study in rural China showed that SHI was promising in reducing children's exposure to

SHS. These findings have implications for SHS exposure reduction and smoking cessation provided by CHWs in rural China.

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Acknowledgements

I would like to first acknowledge the support and selfless devotion of my supervisor and thesis committee chair Dr. Abu Abdullah, for his continuous guidance and support on my study and thesis. I also want to thank my committee members Dr. Truls Østbye and Dr. Qian Long for their insightful comments.

Additionally, I would like to acknowledge the invaluable help of Dr. Henry Lynn from Fudan University for my thesis statistical analysis from the beginning to the end.

I would extend my thanks to all faculties and staff of the DKU Global Health program. I sincerely thank Dr. Lijing Yan for her kind help and understanding. I would also thank Ms. Danyue Tian and Ms. Kaikai Yang for their warm reminder and support for all the process. Without their efforts and consistent support during the past two years, this thesis would not have been possible.

Finally, I would express my appreciation to Ms. Qianmei Du for providing writing support and encouragement.

1. Introduction

Secondhand Smoke (SHS) is a major indoor pollutant caused by smokers who are exhaling cigarettes and the burning smoke of cigarettes or tobacco products (Oberg, 2010). Extensive studies strongly proved that SHS exposure has no safe level; any slight exposure would cause negative impacts on health (CDC), especially for vulnerable infants and young children (Park & Bae, 2020). Children who are exposed to SHS more tend to develop ear infections (Jones et al., 2011), asthma (Halterman et al., 2006), respiratory illness (Avgeri et al., 2017), and impaired lung function (Brunst et al., 2012). Besides, SHS increases children's medical costs and the chance of smoking initiation (Wang et al., 2011).

China has the largest size of tobacco product producers and consumers worldwide (WHO). Although the smoking environment has been improved with the driving of the "Healthy China 2030" Planning Outline, the smoking rate of people aged 15 and above is still relatively high (Dong et al., 2020). According to the 2018 Global Adult Tobacco Survey (GATS)-China, the smoking rate of adults was 26.6% (308 million current smokers), and the SHS exposure rate of nonsmokers was 68.1% (WHO, 2018). Particularly, SHS exposure among children is severer in rural areas regarding higher smoking prevalence among rural residents (28.9%) compared to urban residents (25.1%) (CDC, 2018). Studies estimated that the prevalence of SHS exposure among adolescents (age 12-15) at home was 44.4% (Liang, 2014) and the SHS exposure rate of no-smoking children (age 0-18) at home was 68% in rural China (Yao et al., 2012). With such a large number of exposed children in China, SHS exposure has become a public health challenging and needs more effective and urgent intervention in rural China.

Parental smoking inside home is the primary but preventable source of children's SHS exposure (Wang et al., 2011). WHO has stated that reducing parental smoking is a crucial action element to encourage children's health and development, especially those living with social and economic difficulties (Behbod et al., 2018). Given this, affordable, effective, scalable Smoking Hygiene Intervention (SHI) targets smoking parents to create smoke-free homes are urgent (Orton et al., 2014) (Khetan et al., 2019).

The Community Health Workers (CHWs) program, as a community-based resurging program around the world since 1920, its cost-effectiveness has been demonstrated by multiple successful experiences in various countries (Perry, 2013). In recent years, CHWs appeared to frequently be involved in implementing public health intervention programs (Huang et al., 2018). Previous research findings have shown encouraging results of the implementation of CHW-led programs in maternal and infectious diseases (Lewin et al., 2010) as well as the management of non-communicable diseases in recent years (Scott et al., 2018). Emerging research indicates that community-based interventions are promising in smoking cessation (Hahn et al., 2009) (Free et al., 2011) (Abdullah et al., 2015). CHWs also played an essential role in providing primary healthcare services to rural areas with health resource shortages (Hu et al., 2017). However, few studies conducted in rural China evaluated the effectiveness of CHW-based intervention on reducing Chinese children's exposure to SHS at home (Zhou et al., 2019). In addition, one systematic review suggested that nonpharmacological approaches (i.e., counseling, self-materials) may be effective in lowing children's urine cotinine levels, increasing parents' quitting smoking rating, and reducing their smoking consumption. Still, these positive effects did not last for 3 to 6 months after the interventions (Zhou et al., 2019). Therefore, this study aimed to assess the effectiveness of this evidence-based intervention provided by CHWs in rural settings at 6- and 12-month.

Theoretical foundation of the proposed intervention:

More and more recent health behavior research has been guided by theory (Yan et al., 2014). A number of theories have been applied to develop tobacco control intervention, including Protection Motivation Theory (PMT) (Yan et al., 2014); transtheoretical model (stage of change model) (Fidancı et al., 2017), and social cognitive theory (Bricker et al., 2010). In this study, we designed SHI based on the PMT (Rogers, 1975). According to this theory, when SHS has become a threat to their children's health, parental coping response to the threat is to weigh the costs and benefits of the threat and protective behavior. Ultimately, these measures can motivate smoking parents or family members to quit smoking and/or take measures to reduce second-hand smoke exposure to children (Figure 1). In earlier research in China, researchers have applied this theory to develop an SHS exposure reduction intervention in urban China (i.e., Shanghai) (Abdullah et al., 2015). Before this SHI package can be widely applied to tobacco control in China, we need to explore the feasibility of the application of PMT on children's smoking prevention and parents' smoking cessation in rural areas of China.

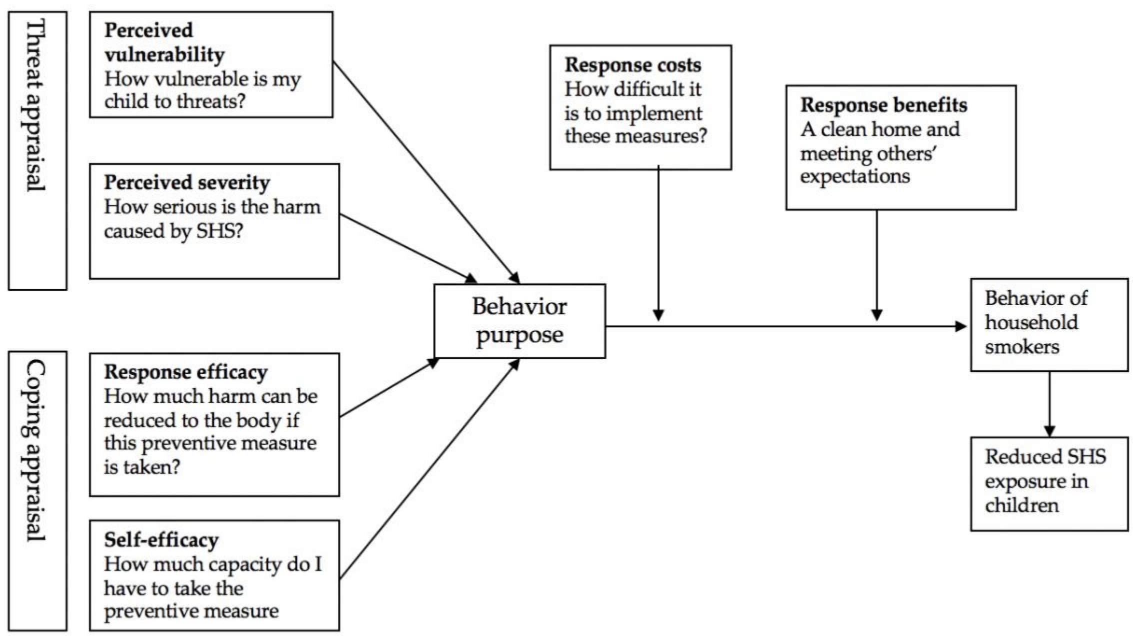

Figure 1: Application of PMT in developing intervention to reduce SHS exposure among children

Aims and objectives:

The overall aim of the study is to examine whether the educational intervention (i.e., SHI) delivered by CHWs would reduce children's exposure to SHS at 6- and 12-month in rural China. There are two research objectives:

1) To explore parents' or caregivers' smoking behaviors and smoking hygiene practices around children under 5 in rural communities of China;
2) To compare the intervention effect over time (at 6-, and 12-month) in smoking behaviors and smoking hygiene practices

2. Methods

2.1 Setting

Our study was conducted in rural communities in Taizhou and Dali. Taizhou is located at the central coast of Zhejiang province, and the GDP per capita was ¥84,718 in 2019 (Taizhou Statistics Bureau, 2020). The rural area population was 2.23 million accounting for 36.3% of the permanent population at the end of 2019 (Zhejiang Statistical Bureau, 2019). Dali Bai Autonomous Prefecture is located in northwestern Yunnan Province, and the GDP per capita in 2019 of Dali was ¥38,097 (Dali Statistics Bureau, 2020). Jianchuan was one of the counties in Dali with a population of over 185 thousand; among them, Bai people accounted for the majority (96.2%) (People's Government of Jianchuan County, 2019). Clusters were conveniently selected by the local Principal Investigator (PI) as intervention or control sites based on the geographical proximity and population characteristics. We selected eight communities as our study clusters from Taizhou and Dali. In the Taizhou site, we selected four communities: Luoyang and Tongyu in Luqiao District; and Hetou and Yongfeng in Linhai city. In Dali, all four villages in Jianchuan town (Shihe, Xingshui, Fada, Zhuliu) were purposively selected as study sites. In each of the two study sites, out of the four clusters, two clusters were randomly assigned to intervention and two to comparison groups. The intervention and comparison sites were neither adjacent to each other, nor receiving care from the same community health center. CHWs worked at community health services stations and village clinics; and they were responsible for the basic medical service and public health services in rural areas (Chen, 2009). CHWs in our study consisted of employees of primary health centers (PHCs) and village doctors who were general practitioners and owned clinics in the village.

2.2 Participants

We included households if they met these criteria: i) households that had at least one child under the age of 5 and at least one active adult smoker (smoked one or more cigarettes daily for the past 30 days); ii) Household members reported that they smoked > 10 cigarettes in front of children per week; iii) smoking household member and the child were living together in the same household and would live together during the entire research period; iv) residents of the study community; v) able to communicate in Mandarin Chinese and vi) has signed an informed consent form or given verbal consent for those could not write or read (Note: If there were more than one smoker in one household, the primary caregiver was selected for study participation. When >1 child under 5 years old in a family, we chose the younger one).

Exclusion criteria were i) self-reported household use of coal-fired and verified by interviewees; ii) families with breastfeeding young children, as coal-fired household cooking or heating may result in higher levels of pollutant emissions in the household, which may interfere with the results of the study (Baker et al., 2006). Breast-feeding also might be a confounder for urine cotinine analysis (Mascola et al., 1998).

2.3 Procedures

2.3.1 Recruitment and baseline assessment

The local CHWs recruited households included children aged 5 years or younger through screening records in the target communities' health centers. Interviews then visited each household, clarified the details of the study, assessed eligibility, invited them to participate and sought informed consent from participants. Families who agreed and signed the informed consents were required to complete a baseline survey including one smoker and one main caregiver.

2.3.2 Intervention implementation

Counseling intervention was provided by CHWs who received a one-day formal practicum training delivered by the PI, which consisted of lectures and mock sessions. Training for these two groups of CHWs was conducted separately. After the baseline session, CHWs conducted 6 different individualized counseling for the intervention group's families within four months, including 2 in-person and 4 by telephone. The initial contact was a home visit lasting for 30-45minutes. Another face-to-face contact was planned for the first month after the first home visit (~30 minutes). In the first week, the second week, the second month, and the fourth month since the first intervention, subjects were followed up through phone counseling, each lasting 15 minutes. The implementation time and duration of the comparison group were the same as the intervention group. Self-help educational materials related to the knowledge about smoking and SHS or children's developmental problems were sent out by hand-delivered or mailed to each participant at 3 months. Surveys and collection of children's urine samples were collected repeatedly at baseline, 2, 6, and 12 months in both groups.

Participants in the intervention group received smoking hygiene intervention (SHI), including information about the health effects of smoking and SHS to adults as well as smokers, how to ensure a smoke-free home, and learned strategies and suggestions about quitting smoking and SHS exposure reduction among children. The counseling was patient-centered, which means household members were engaged in the discussion and making decisions about the counselor's recommendations (Abdullah et al., 2004). At the first counseling, after assessing subjects' nature of SHS exposure of children and the source of SHS, CHWs emphasized the hazards of SHS exposure for young children and potential adverse health outcomes. Then CHWs introduced the nonsmoking household policy and discussed potential obstacles with smokers. Participants were encouraged to make changes and set goals for reducing children's exposure to SHS, emphasizing the relevant benefits and barriers identified by subjects. In subsequent follow-up counseling, for those who did not meet their goals, subjects were encouraged to set new goals and feedbacks on barriers subjects countered were given by CHWs after reviewing the process. For those who achieved their goals, participants were encouraged to make new goals.

Participants in the comparison group received attention intervention not related to SHI including suggestions for children's education and emotional management, discussions on children's nutrition issues. If they were interested in SHI, comparison group participants could receive a customized SHI intervention delivered by counselors after the intervention.

2.3.3 Data collection:

Our data were collected from both groups using a structured questionnaire developed concerning the questionnaires previously used and validated among households with young children in urban China (Abdullah et al., 2015).

The baseline questionnaire for smokers measured as followed: 1) Demographic characteristics 2) Tobacco smoking (e.g., the status, history, and smoking habits). 3) Household smoking (e.g., Ventilation, other smokers in the family); 4) Smoking rules at home and self-efficiency of adherence of the rules 5) Knowledge, attitude and beliefs on smoking 6) Quitting smoking history, reasons and methods. Another questionnaire for caregivers measured as followed: 1) Demographic characteristics; 2) Household smoking rules and self-efficiency; 3) Knowledge, attitude and cognition about smoking; 4) Children's SHS exposure and their health status. The follow-up questionnaire measured the effectiveness of SHI includes 6 parts for both smoker and caregiver: 1) Subject (smoker/ caregiver) information; 2) Smoking status (smoker) / Child health status (caregiver); 3) Children's SHS exposure self-reported by smokers and caregivers; 4) Adherence to household smoking rules; 5) Evaluation of project activities.

Children's urine sample was also collected at baseline and 2-, 6-, and 12 months to measure urine cotinine concentration as a biomarker to validate their total SHS exposure. Surveys were conducted through home visiting by an interviewer and a local CHW. Each smoker and caregiver could answer the questionnaire via either filling in by themselves or responding to questions orally and interviewers collected answers on their behalf.

2.3.3 Ethical approval

This study was approved by the Institutional Review Board (IRB) of Duke Kunshan University (No: 2016ABDU003). All research subjects signed an informed consent form or gave verbal consent for those who were not able to read or write.

2.4 Measures

2.4.1 Children SHS exposure reported by smokers

The question "how many days have you smoked and stayed in the same room with your children?" was used to measure Children's exposure to SHS from household members self-reported by smokers. The answers ranged from 0 to 7, and then we dichotomized them into a binary variable for further analysis. "0" was defined as no SHS exposure from household members while "1-7" was defined as children were exposed to SHS from the smoker at home.

2.4.2 Urinary cotinine level

Cotinine, as the primary nicotine metabolite, can be detected in body fluids (saliva, blood and urine) or hair (WHO, 2008). Urinary cotinine is considered a suitable and widely used biomarker for tobacco smoke exposure (Fernandes et al., 2020). Our study collected urine samples from children to measure urine cotinine level, as a biomarker of total SHS exposure. Due to budget limitations, we only collected urine samples from half of the participating children. Urinary cotinine concentration was detected by ultra-high performance liquid chromatography-tandem mass spectrometer and quantified by the standard internal method (Ling et al., 2006). We excluded cotinine values greater than 100ng/ml because the integrity of the children's urine sample was questionable (Zakarian et al., 2004). We used limits of detection of 0.08 ng /mL as the cut-off point for positive passive smoking. Any measurable urine sample was considered as being exposed to SHS in the following analysis as a binary variable.

2.4.3 Smoking levels

Participants' smoking levels were assessed by the number of cigarettes smoked every day. There is not a consensus on the definition of "light smoking" and "heavy smoking" (Okuyemi et al., 2002). According to the population-based smoking survey conducted in China in 1996 designed based on World Health Organization classifications (WHO, 1983), heavy smokers were defined as smoking at least 20 cigarettes daily (Yang et al., 1999). The dose of 20 cigarettes per day is also commonly used as a cutoff for clinical purposes to define heavy smoking in previous studies (Neumann et al., 2013). Therefore, we defined "heavy smoking" as the daily consumption of over 20 cigarettes. Those who smoked 20 or fewer cigarettes daily were considered as light smokers.

2.4.4 Outcome Measures:

Our ***primary outcome*** was children's SHS exposure from the smoker at home as assessed via the number of days of smoking household members smoked in front of the child last week.

Our ***secondary outcomes*** included: i) improvement of smoking hygiene practices (i.e., establishing smoking restriction at home); ii) reduction of respiratory illness incidence among children as reported by caregivers; iii) doctors' visits of children as reported by caregivers; iv) improvement of smoking behavior (i.e., quitting smoking, attempts of quitting smoking and reduction in the number of cigarettes smokers smoked every day); v) the extent of total SHS exposure among children measured by children's urine cotinine concentrations.

2.5 Analysis

The database was established by EpiData 3.1 double entry error detection. All analyses were conducted on the total sample using STATA 15.1 according to the intention-to-treat principle where all participants were included in the outcome analyses. Data distributions were examined for normality before conducting the inferential analysis. Baseline demographic and other characteristics of participants were first described using means and Standard Deviations (SDs) for continuous variables and counts and proportions for categorical variables. Crude differences between the intervention and comparison groups at baseline, 6- and 12-month follow-up were examined using Pearson's chi-square tests for discrete variables, and independent t tests or Wilcoxon rank-sum test (not normally distributed) for continuous variables without adjusting cluster and covariates' effect. Test statistics values and their corresponding P values were reported in all analyses. All tests were two-sided with a significant level of $P < .05$.

Multilevel mixed-effects logistic regression was fit to all the outcomes in order to estimate the intervention effects (three continuous outcomes were dichotomized into binary outcomes to facilitate analysis). Group status (intervention or comparison), follow-up time (6-, and 12-month), the interaction between group and time, and a random cluster effect were entered as categorical independent variables in each model. All models adjusted for variables that were significantly different at baseline (i.e., occupation and daily average number of cigarettes smoked during the previous week of the survey in front of children) and for the baseline outcome. (Note that the latter adjustment for baseline outcome did not occur for the primary outcome-the child's exposure to SHS from the smoker at home since this outcome was not recorded at baseline, and no baseline adjustment for the abstinence outcome was needed as all subjects were smokers at baseline.) Odds ratio (OR), 95% confidence intervals (CIs) and P values were estimated and presented from models.

3. Results

3.1 Recruitment and follow-up

Figure 2 shows the information of recruitment, randomization and loss to follow-up. In Taizhou, Hetou and Luoyang communities were randomly assigned as the intervention groups. Yongfeng and Tongyu communities were the comparison groups; while in Dali, intervention groups were Shihe and Xingshui communities and comparison groups were Fada and Zhuliu communities. There were a total of 2510 eligible households with children in all the study sites combined. Among 925 invited households, 456 were assigned to the intervention group, and 459 were randomly assigned to the comparison group according to their clusters. Overall, 668 households signed the informed consent, completed the baseline session and received the intervention. Among these households, 334 received SHI counseling as the intervention group, and 334 received children's development counseling as the comparison group. The participation rate was 72.2% (668/925). We compared the basic demographic information of those who refused to participate in the study with those who had participated in the study. However, we did not find any significant difference between these groups (data not shown).

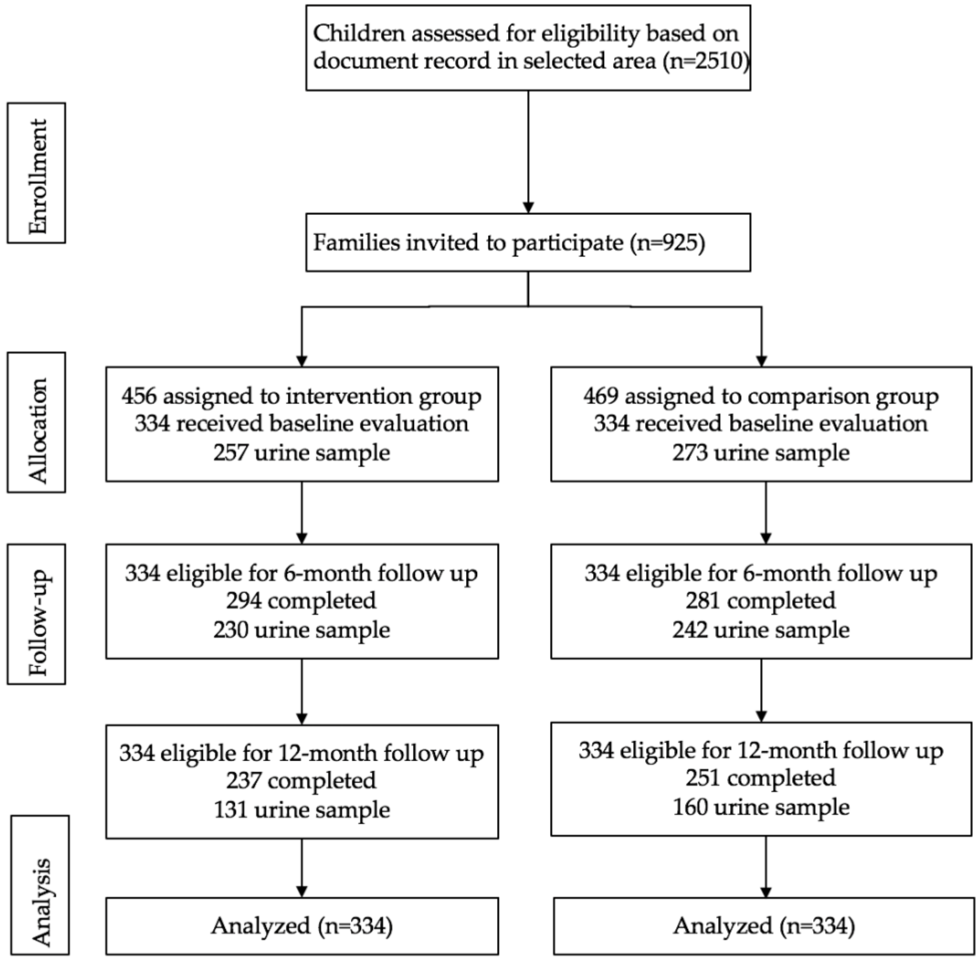

Figure 2: Participant flow chart

3.2 Sociodemographic characteristics of smokers

Table 1 showed the demographic characteristic of smokers at baseline. The mean age of participants was 43 years old. Smokers were mainly fathers (61%) and grandfathers (36%). 70% of the participants attained middle school or below education level; 74% had an annual household income of below 90 thousand RMB. Smoking behavior and household smoking hygiene practices at baseline are shown in Table 2. Generally, smokers consumed an average of 16 cigarettes per week. Over half of them did not attempt to quit smoking (59%) and never made a home smoking regulation (58%) in the past year. Most (88%) of their children did not have any respiratory disease and a few of their children (7%) were in bad or very bad health in the past 3 months. At baseline, except for the participants' occupation (P=0.0044, Table 1) and the number of cigarette smokers smoked last week in front of children (P=0.0362, Table 2), there were no significant differences between intervention and comparison groups. Children had similar SHS exposure in both groups, as indicated by a nonsignificant difference in urine cotinine concentration between intervention and comparison groups. Table 3 and Table 4 show the count and proportion of each variable by clusters. All minority were from clusters in Dali. Compared with Taizhou clusters, participants from Dali clusters had a higher proportion of being farmers and lower annual household incomes.

Table 1: Baseline Demographic Characteristic of Smokers [a]

	Comparison N=334	Intervention N=334	Total N=668	P-value [b]
	Count (%) or Mean ± SD			
Region				0.8669
Dali	104 (31%)	102 (31%)	206 (31%)	
Taizhou	230 (69%)	232 (69%)	462 (69%)	
Age	43.33 (14.08)	43.59 (13.44)	43.45 (13.76)	0.6102
Relationship to child				0.3587
Father	201 (60%)	206 (62%)	407 (61%)	
Mother	2 (1%)	6 (2%)	8 (1%)	
Grandfather	122 (37%)	117 (35%)	239 (36%)	
Others	9 (3%)	5 (1%)	14 (2%)	
Gender				0.2439
Male	327 (99%)	323 (98%)	650 (98%)	
Female	4 (1%)	8 (2%)	12 (2%)	
Ethnicity				0.7368
Han	186 (66%)	287 (76%)	473 (72%)	
Minority	95 (34%)	90 (24%)	185 (28%)	
Marital				0.5048
Married	323 (98%)	325 (99%)	648 (99%)	
Unmarried	6 (2%)	3 (1%)	9 (1%)	
Education				0.6857
Primary school or below	78 (24%)	74 (23%)	152 (23%)	
Middle school	147 (45%)	157 (48%)	304 (47%)	
High school or above	102 (31%)	94 (29%)	196 (30%)	
Occupation				**0.0044***
Farmer	105 (32%)	125 (38%)	230 (35%)	
Worker	80 (24%)	97 (30%)	177 (27%)	
Self-employment	72 (22%)	65 (20%)	137 (21%)	
Unemployment	30 (9%)	11 (3%)	41 (6%)	
Others	44 (13%)	30 (9%)	74 (11%)	

Annual household income				0.6032
Less than 20k	55 (17%)	66 (21%)	121 (19%)	
20k-60k	121 (38%)	118 (37%)	239 (38%)	
60k-90k	58 (18%)	51 (16%)	109 (17%)	
90k-120k	38 (12%)	43 (14%)	81 (13%)	
Above 120k	47 (15%)	38 (12%)	85 (13%)	

a Totals may not equal 334 or 334 as a result of missing data

b P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

* p < .05, ** p < .01, *** p < .001

Table 2: Measures of smoking behavior and household smoking hygiene practices at baseline [a]

	Comparison N=334	Intervention N=334	Total N=668	P-value [b]
	Count (%) or Mean ± SD			
Smoking behavior				
Daily number of cigarettes the smoker smoked last week	16.07 (10.38)	16.38 (10.51)	16.23 (10.44)	0.8129
Daily average number of cigarettes the smoker smoked last week in front of children	2.39 (3.83)	2.82 (3.91)	2.60 (3.87)	**0.0362***
Smoking years	23.07 (13.38)	22.22 (13.08)	22.65 (13.23)	0.4122
Smoking days in the last week	6.66 (1.18)	6.52 (1.34)	6.59 (1.26)	0.0814
Quitting attempts lasting for >24h in the past year				0.1708
Once	52 (16%)	38 (12%)	90 (14%)	
More than once	94 (28%)	85 (26%)	179 (27%)	
None	185 (56%)	204 (62%)	389 (59%)	
Household smoking hygiene practices				
Adopted smoking restriction at home				0.4726
Yes	135 (41%)	142 (43%)	277 (42%)	
No	197 (59%)	185 (57%)	382 (58%)	
Child's health in the past 3 months				0.1311
Very good	92 (28%)	97 (31%)	189 (29%)	

Good	204 (62%)	203 (64%)	407 (63%)	
Bad or very bad	31 (9%)	17 (5%)	48 (7%)	
Any respiratory illness in the past 12 months				0.4670
Yes	29 (11%)	27 (13%)	56 (12%)	
No	230 (89%)	174 (87%)	404 (88%)	
Children's urine cotinine concentration	2.68 (4.58)	2.40 (3.17)	2.54 (3.96)	0.6382
Children's overall SHS exposure time				0.0928
≥30 min/day	51 (15%)	64 (20%)	115 (18%)	
Very short time per day	123 (37%)	86 (27%)	209 (32%)	
> 30 min/week	30 (9%)	30 (9%)	60 (9%)	
Occasional	95 (29%)	98 (31%)	193 (30%)	
No	24 (7%)	30 (9%)	54 (8%)	

a Totals may not equal 334 or 334 as a result of missing data

b P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

* p < .05, ** p < .01, *** p < .001

Table 3: Baseline Demographic Characteristic of Smokers by clusters [a]

	Comparison (N=334)				Intervention (N=334)			
	Yongfeng	Tongyu	Fada	Zhuliu	Hetou	Luoyang	Heshi	Xingshui
	Count (%) or Mean ± SD							
Region								
Dali	0 (0%)	0 (0%)	52 (100%)	52 (100%)	0 (0%)	0 (0%)	50 (100%)	52 (100%)
Taizhou	122 (100%)	108 (100%)	0 (0%)	0 (0%)	120 (100%)	112 (100%)	0 (0%)	0 (0%)
Age	45.88 (14.99)	43.33 (13.83)	38.96 (12.69)	41.41 (12.56)	46.23 (12.83)	44.25 (13.43)	36.08 (12.81)	43.36 (13.12)
Relationship to child								
Father	65 (53%)	68 (63%)	34 (65%)	34 (65%)	71 (59%)	68 (61%)	37 (74%)	30 (58%)
Mother	0 (0%)	2 (2%)	0 (0%)	0 (0%)	3 (2%)	3 (3%)	0 (0%)	0 (0%)
Grandfather	55 (45%)	37 (34%)	13 (25%)	17 (33%)	44 (37%)	40 (36%)	12 (24%)	21 (40%)
Others	2 (2%)	1 (1%)	5 (10%)	1 (2%)	2 (2%)	1 (1%)	1 (2%)	1 (2%)
Gender								
Male	121 (100%)	104 (96%)	50 (100%)	52 (100%)	117 (98%)	108 (97%)	49 (100%)	49 (96%)
Female	0 (0%)	4 (4%)	0 (0%)	0 (0%)	3 (2%)	3 (3%)	0 (0%)	2 (4%)
Ethnicity								
Han	122 (100%)	108 (100%)	6 (12%)	0 (0%)	118 (100%)	110 (100%)	3 (6%)	6 (12%)
Minority	0 (0%)	0 (0%)	43 (88%)	52 (100%)	0 (0%)	0 (0%)	46 (94%)	44 (88%)
Marital								
Married	117 (98%)	108 (100%)	48 (96%)	50 (98%)	117 (98%)	109 (100%)	49 (100%)	50 (98%)
Unmarried	3 (2%)	0 (0%)	2 (4%)	1 (2%)	2 (2%)	0 (0%)	0 (0%)	1 (2%)
Education								
Primary school or below	40 (33%)	27 (26%)	9 (18%)	2 (4%)	30 (26%)	29 (27%)	8 (16%)	7 (14%)
Middle school	44 (36%)	36 (34%)	29 (58%)	38 (75%)	55 (47%)	37 (34%)	31 (63%)	34 (67%)
High school or above	37 (31%)	42 (40%)	12 (24%)	11 (22%)	31 (27%)	43 (39%)	10 (20%)	10 (20%)

Occupation								
Farmer	36 (30%)	17 (16%)	33 (66%)	19 (37%)	46 (39%)	17 (16%)	28 (57%)	34 (67%)
Worker	41 (34%)	28 (26%)	2 (4%)	9 (17%)	43 (36%)	40 (37%)	3 (6%)	11 (22%)
Self-employment	19 (16%)	32 (30%)	7 (14%)	14 (27%)	14 (12%)	34 (31%)	15 (31%)	2 (4%)
Unemployment	11 (9%)	11 (10%)	3 (6%)	5 (10%)	6 (5%)	3 (3%)	1 (2%)	1 (2%)
Others	14 (12%)	20 (19%)	5 (10%)	5 (10%)	10 (8%)	15 (14%)	2 (4%)	3 (6%)
Annual household income								
Less than 20k	12 (10%)	11 (11%)	18 (36%)	14 (27%)	21 (18%)	9 (9%)	12 (25%)	24 (48%)
20k-60k	50 (43%)	17 (17%)	25 (50%)	29 (56%)	44 (38%)	33 (32%)	19 (40%)	22 (44%)
60k-90k	29 (25%)	18 (18%)	5 (10%)	6 (12%)	20 (17%)	22 (21%)	8 (17%)	1 (2%)
90k-120k	10 (9%)	24 (24%)	2 (4%)	2 (4%)	20 (17%)	20 (19%)	2 (4%)	1 (2%)
Above 120k	14 (12%)	32 (31%)	0 (0%)	1 (2%)	10 (9%)	19 (18%)	7 (15%)	2 (4%)

[a] Totals may not equal 334 or 334 as a result of missing data

b P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

* p < .05, ** p < .01, *** p < .001

Table 4: Measures of smoking behavior and household smoking hygiene practices at baseline by clusters [a]

	Comparison (N=334)				Intervention (N=334)			
	Yongfeng	Tongyu	Fada	Zhuliu	Hetou	Luoyang	Heshi	Xingshui
	Count (%) or Mean ± SD							
Smoking behavior								
Daily number of cigarettes the smoker smoked last week	16.37 (10.88)	16.55 (12.17)	16.26 (7.52)	14.25 (7.26)	17.08 (10.98)	14.86 (10.62)	17.78 (10.27)	16.68 (9.20)
Daily average number of cigarettes the	2.74 (4.81)	1.54 (2.89)	3.49 (3.51)	2.27 (2.65)	3.12 (4.83)	1.85 (2.47)	4.09 (4.07)	3.02 (3.39)

smoker smoked last week in front of children								
Smoking years	26.05 (14.13)	22.66 (13.44)	19.33 (11.52)	20.52 (11.84)	25.51 (12.69)	21.35 (13.01)	15.77 (12.50)	23.00 (12.44)
Smoking days in the last week	6.55 (1.42)	6.64 (1.22)	6.78 (0.77)	6.85 (0.70)	6.38 (1.43)	6.58 (1.31)	6.59 (1.22)	6.64 (1.29)
Quitting attempt in the past year								
Once	25 (21%)	7 (6%)	9 (18%)	11 (21%)	15 (13%)	10 (9%)	9 (18%)	4 (8%)
More than once	33 (27%)	41 (38%)	8 (16%)	12 (23%)	32 (27%)	33 (30%)	9 (18%)	11 (22%)
None	63 (52%)	60 (56%)	33 (66%)	29 (56%)	71 (60%)	66 (61%)	31 (63%)	36 (71%)
Household smoking hygiene practices								
Adopted smoking restriction at home								
Yes	61 (50%)	45 (42%)	14 (28%)	15 (29%)	50 (42%)	64 (59%)	8 (16%)	20 (39%)
No	61 (50%)	63 (58%)	36 (72%)	37 (71%)	68 (58%)	45 (41%)	41 (84%)	31 (61%)
Child's health in past 3 months								
Very good	36 (30%)	31 (30%)	11 (22%)	14 (27%)	28 (25%)	34 (32%)	24 (49%)	11 (22%)
Good	72 (60%)	68 (65%)	32 (64%)	32 (62%)	78 (70%)	65 (62%)	22 (45%)	38 (75%)
Bad or very bad	12 (10%)	6 (6%)	7 (14%)	6 (12%)	6 (5%)	6 (6%)	3 (6%)	2 (4%)
Any respiratory illness in past 12 months								
Yes	12 (13%)	9 (9%)	5 (16%)	3 (8%)	14 (16%)	7 (16%)	1 (3%)	5 (15%)
No	81 (87%)	88 (91%)	27 (84%)	34 (92%)	74 (84%)	37 (84%)	35 (97%)	28 (85%)
Children's urine cotinine concentration	3.76 (6.12)	1.96 (2.75)	1.64 (2.42)	2.10 (3.70)	2.93 (3.09)	2.44 (3.78)	1.65 (1.81)	0.63 (0.76)
Children's overall SHS exposure time								
≥30 min/day	25 (21%)	8 (7%)	11 (22%)	7 (13%)	21 (19%)	9 (8%)	17 (35%)	17 (33%)
Very short time per day	39 (32%)	20 (19%)	30 (60%)	34 (65%)	17 (15%)	30 (28%)	20 (42%)	19 (37%)

> 30 min/week	7 (6%)	9 (8%)	4 (8%)	10 (19%)	9 (8%)	3 (3%)	8 (17%)	10 (20%)
Occasional	38 (32%)	56 (52%)	1 (2%)	0 (0%)	45 (40%)	49 (46%)	1 (2%)	3 (6%)
No	10 (8%)	9 (8%)	4 (8%)	1 (2%)	13 (12%)	13 (12%)	2 (4%)	2 (4%)

[a] Totals may not equal 334 or 334 as a result of missing data

b P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

* $p < .05$, ** $p < .01$, *** $p < .001$

3.3 Intervention Effects At 6 Months and 12 Months

Table 5 and Table 6 described the original data and crude P-value of the 6- and 12-month follow-up without controlling covariates and cluster effects. At the 6-month follow-up, smokers in the intervention groups had a slightly higher number of days smoked in front of children last week (1.78 vs. 2.00, P=0.225). There were no significant differences for all outcome indicators except the urine cotinine level. The mean urinary cotinine concentration was significantly lower in the intervention group (2.09 ng/ml) than the comparison group (2.61 ng/ml) (Table 5). At the 12-month follow-up, participants in the intervention group smoked a lower number of days (mean) in front of the children (1.55) than the smokers in the comparison group (2.04); the difference was statistically significant (P=0.011, Table 6).

Table 5: Measures of outcomes at 6-month follow-up [a]

Outcome measures	**Comparison N=334**	**Intervention N=334**	**Total N=668**	**P-value**
	Count (%) or Mean ± SD			
Primary outcome measure				
Children's SHS exposure from the smoker at home (the number of days smoker smoked in front of the child last week)	1.78 (2.68)	2.00 (2.72)	1.89 (2.70)	0.2225
Other outcome measures				
Adopted smoking restriction at home				0.0651
Yes	167 (61%)	195 (68%)	362 (65%)	
No	108 (39%)	91 (32%)	199 (35%)	
Child urine cotinine concentration, (ng/mL)	2.61 (3.53)	2.09 (2.73)	2.35 (3.18)	**0.0242***
Child had respiratory diseases				0.1531
Yes	39 (14%)	53 (18%)	92 (16%)	
No	242 (86%)	237 (82%)	479 (84%)	
Child visited doctor				0.0617
Yes	118 (43%)	101 (35%)	219 (39%)	
No	159 (57%)	188 (65%)	347 (61%)	
Smoker quitted smoking in the past 6 months				0.5127
Yes	17 (6%)	14 (5%)	31 (5%)	
No	263 (94%)	276 (95%)	539 (95%)	
Smoker attempted quitting smoking in the past 6 months				0.5581
Yes	46 (19%)	55 (21%)	101 (20%)	
No	202 (81%)	212 (79%)	414 (80%)	
No. of cigarettes smoker smoked daily in the past 6 months	15.60 (11.82)	13.79 (8.55)	14.67 (10.29)	0.3113

[a] Totals may not equal 334 or 334 as a result of missing data

[b] P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

[*] $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Measures of outcomes at 12-month follow-up [a]

Outcome measures	Comparison N=334	Intervention N=334	Total N=668	P-value
	Count (%) or Mean ± SD			
Primary outcome measure				
Children's SHS exposure from the smoker at home (the number of days smoker smoked in front of the child last week)	2.04 (2.57)	1.55 (2.44)	1.80 (2.52)	**0.0111***
Other outcome measures				
Adopted smoking restriction at home				0.3376
Yes	151 (61%)	142 (65%)	293 (63%)	
No	96 (39%)	75 (35%)	171 (37%)	
Child urine cotinine concentration, ng/mL	1.67 (2.86)	1.51 (1.83)	1.60 (2.45)	0.3035
Child had respiratory diseases				0.2363
Yes	65 (26%)	51 (22%)	116 (24%)	
No	182 (74%)	184 (78%)	366 (76%)	
Child visited doctor				0.2607
Yes	123 (50%)	105 (45%)	228 (47%)	
No	124 (50%)	130 (55%)	254 (53%)	
Smoker quitted smoking in the past 12 months				0.1290
Yes	12 (5%)	19 (8%)	31 (6%)	
No	236 (95%)	211 (92%)	447 (94%)	
Smoker attempted quitting smoking in the past 12 months				0.5035
Yes	64 (27%)	63 (30%)	127 (28%)	
No	173 (73%)	148 (70%)	321 (72%)	
No. of cigarettes smoker smoked daily in the past12 months	15.47 (10.33)	13.69 (7.97)	14.64 (9.33)	0.1208

[a] Totals may not equal 334 or 334 as a result of missing data

[b] P-values were calculated from chi-square tests or Wilcoxon rank-sum test.

[*] p < .05, ** p < .01, *** p < .001

After controlling the covariates and considering the cluster effect, the analysis results of intervention effects on outcomes using multilevel mixed-effects logistic regression are shown in Table 7. Children were less likely to be exposed to SHS from smokers at home in the intervention group (OR: 0.56, 95% CI: .32, 1.00 P=0.049) than children in the comparison group at 12-month. There were no significant differences in the reported smoking restriction, child's health conditions, quitting smoking, and daily cigarettes consumption between the intervention and comparison groups.

Table 7: Analysis of intervention effects using multilevel mixed-effects logistic regression methods [a]

Outcome measurements	**6 months** **N=334**	**12 months** **N=334**
Primary outcome measure	*OR (95% CI)*	
Children's SHS exposure from the smoker at home	1.30 (0.76, 2.23) P=0.344	**0.56 (0.32, 1.00)* P=0.049**
Other outcome measures		
Adopted smoking restriction at home	1.44 (0.73, 2.84) P=0.299	1.13 (0.56, 2.27) P=0.743
Child detected urine cotinine	0.35 (0.06, 1.93) P=0.229	2.29 (0.40, 13.14) P=0.354
Child had respiratory diseases	1.66 (0.78, 3.49) P=0.181	0.57 (0.28,1.15) P=0.118
Child visited doctors	0.66 (0.36, 1.23) P=0.192	0.84 (0.45, 1.48) P=0.586
Smoker quitted smoking in the past 6/12 months	0.86 (0.39,1.85) P=0.694	1.83 (0.83, 4.05) P=0.136
Smoker attempted quitting smoking in the past 6/12 months	1.43 (0.67, 3.06) P=0.355	1.28 (0.61, 2.70) P=0.515
Became a heavy smoker	0.75 (0.31, 1.85) P=0.541	0.57 (0.23, 1.44) P=0.233

[a] Adjusted for occupation, daily average number of cigarettes the smoker smoked last week in front of children and baseline outcome

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.4 Children's Urine Cotinine Concentration

Figure 3 shows the trend of the mean of children's urinary cotinine concentration (ng/mL) during the follow-up points for the intervention and comparison groups. For both groups, the mean cotinine concentration increased from baseline to 2-month and maximum at 2-month. Then in both groups, the values decreased at 6-month and 12-month after continuing to receive the intervention. The mean urine cotinine values of children in the intervention group at baseline, and follow-ups at 2-month, 6-month and 12-month were 2.40 μg/L, 2.53 μg/L, 2.09 μg/L and 1.51 μg/L, respectively; the corresponding values for the comparison group were 2.68μg/L, 3.38μg/L, 2.61μg/L and 1.67μg/L, respectively. The mean of urine cotinine concentration was lower in the intervention group than the comparison group significantly at 6-month (P=0.0242, Table 5) and nonsignificant lower at 12-month (P=0.3035, Table 6). However, after controlling baseline, covariates and cluster effect, results indicated that children in the intervention groups were less likely to be exposed to SHS at 6-months (OR: 0.35 95%CI: .06, 1.93 P=0.229) and more likely to experience SHS exposure at 12-moth (OR: 2.29 95%CI:.40, 13.14 P=0.354) with no significant difference (Table 7).

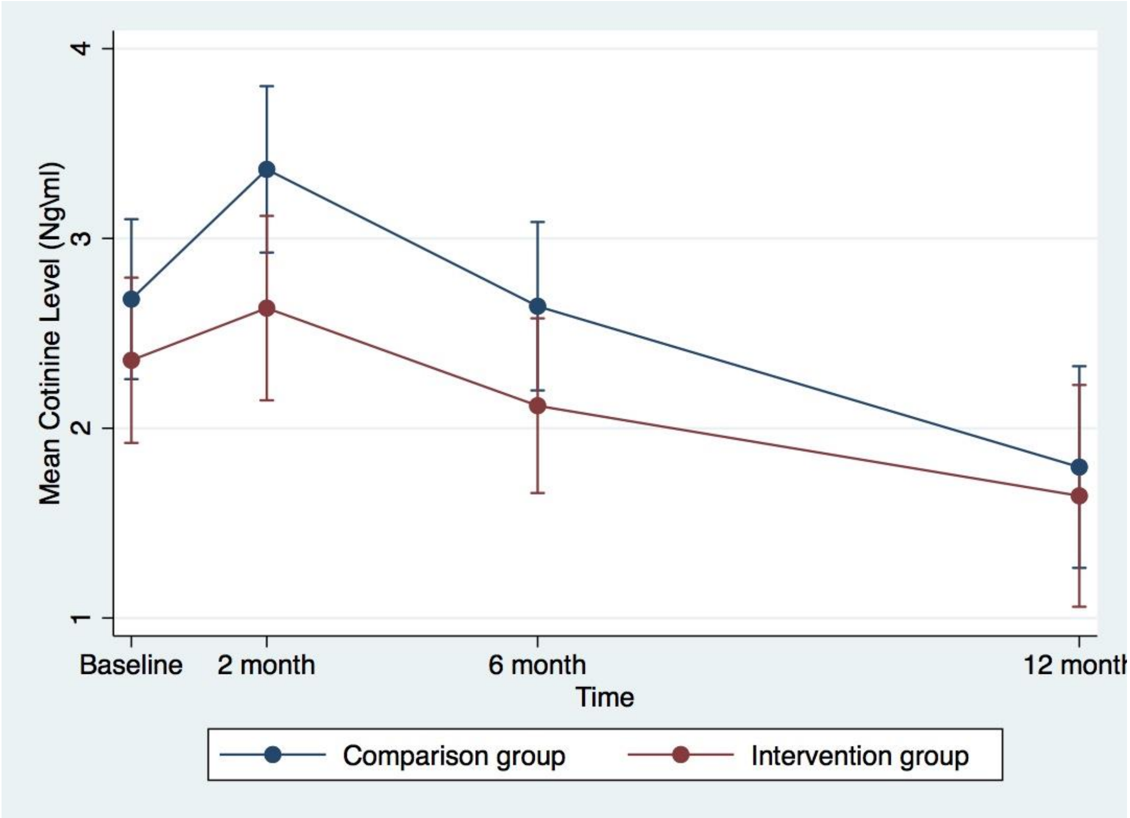

Figure 3: Urine cotinine levels in the intervention and comparison groups over time

4. Discussion

This longitudinal study examined CHW-delivered intervention effects on promoting smoking cessation and reducing children’s SHS exposure in rural China. As the main outcome measurement, children’s SHS exposure as assessed by the number of days the smoker smoked in front of the child in the previous week before the survey; our intervention showed a significant effect on mitigating children’s SHS exposure at home at 12-month, confirming the findings of earlier studies (Hovell et al., 2009) (Collins et al., 2020).

As a continuous variable, children’s urine cotinine concentrations showed an increase from baseline to 2 months with no significant difference. This finding was consistent with our previous study in urban China (Abdullah et al., 2015), possibly due to participants not taking the counseling seriously at the initial period. Urinary cotinine dropped from 2 months to 6 months and further decreased at 12 months in both groups. Many earlier studies showed a similar trend between 2 months to 12 months (Zakarian et al., 2004) (Hovell et al., 2009). When dichotomized into a binary variable, the biochemical results suggested that children in the intervention group were less likely to be exposed to SHS at 6-month while they were more likely to be exposed to SHS at 12 months with no significant difference. It might be because participants reduced the smoking inside the home but did not care about the smoking outside the house leading to children’s total SHS exposure increased (Abdullah et al., 2014). However, this also might be caused by a large amount of missing biomarker data; only 30% of complete participants' data were collected for all the period, which could greatly affect the accuracy of the results.

International studies have shown that smoking-free-rules can help reduce nonsmokers' exposure to SHS, prevent young children smoking initiation, improve smokers' tobacco cessation, and reduce the social acceptability of smoking (Nguyen et al., 2016). Zheng et al. (2014) indicated that households with children less than 5 years of age were more likely to adopt home smoking restriction; however, our SHI package did not successfully exert a similar positive impact on encouraging smoking households to make smoke-free home policy. This result was also opposed to a previous community-based intervention study conducted in the UK which confirmed the smoke-free home could be implemented effectively and had the effect to prevent children from SHS exposure at home (Alwan et al., 2011). Older relatives or visitors were always barriers to establish or maintain such policy in our study, which is related to the Chinese social norms. In Chinese culture, the demands of the elderly or guests should be the priority (Wang et al., 2009). In addition, in rural China, social acceptability of smoking (Wang et al., 2014) and unique smoking culture impeded the implementation of home smoking restrictions (Jin et al., 2014).

Our SHI did not have a great impact in reducing children's respiratory symptoms as well as the total frequency of visiting a child's doctor. It could be explained that our counseling was not intensive enough to make a significant difference in children's health (Abdullah et al., 2015). The comparison group had a significantly larger odd at 12-month compared to 6-month. However, as the total-frequency of doctor's -visits included visits for all the health conditions the result could be over-interpreted.

Only a few participants quitted smoking, which suggested that this intervention might not help smoking cessation. This outcome is not unusual for the tobacco control interventions since quitting smoking was generally recognized as difficult and even needed multiple quit attempts to achieve success (Borland et al., 2012). In Brown et al.'s systematic review of 28 studies, no significant changes were reported in parent self-reported smoking cessation in all included studies (Brown et al., 2015). Evidence indicated that the smoking cessation intervention might be more effective when it only focused on smoking cessation (Patnode et al., 2013) (Rosen et al., 2014) (Thomas et al., 2015). However, our intervention was mainly designed to reduce SHS exposure, which may not greatly affect the smoking cessation performance. Also, without pharmacological support, many smokers, especially heavy smokers, found it difficult to quit smoking (García-Gómez et al., 2019). In our study, we did not provide any pharmacological support to help participants in their quitting effort. Participants' attempts of quitting smoking also did not have a significant difference in our study. While this might be a result of the fact that the intervention was unable to motivate smokers to think about quitting, smokers' recall bias could also have contributed to this result. In an earlier study using longitudinal data across four countries, findings showed that 20% of quitting attempts were underreported in a year because of smokers forgetting or not counting some particularly short quit attempts (Borland et al., 2012).

4.1 Implications for policy and practice

a) Social norms in rural China:

Our study invited 925 eligible households and 668 agreed to participate and complete the baseline assessment. Hence, the participation rate was 72.2% which was lower than previous RCT studies focus on the SHS of young children ranged from 76% to 88% (Brown et al., 2015) and much lower than a similar intervention study conducted in Shanghai (90.2%), the urban area in China (Abdullah et al., 2015). To a great extent, this might be caused by the rural culture in China. According to a qualitative study conducted among 22 families by Mao et al. (2014), rural smokers had limited knowledge about the physical hazards caused by tobacco smoking although all participants were aware of the fact that 'smoking is harmful to health'; and the main barrier was the enhanced social bonds of cigarette smoking. In another earlier study, total scores of knowledge about SHS exposure was lower than active smoking in rural communities (Chen et al., 2019). Confirmed with Rich et al.'s study, smoking and cigarette gifting were highly integrated into family and work including strengthening networks, which led to low motivation to quit smoking (Rich et al., 2014). Given social cohesion and support is an important stimulation for smoking cessation and reduction of SHS (Brunst et al., 2012), this intervention might be more cost-effective and culturally adapted in rural China and other developing countries if it could be extended to all family members and a broader community level (Letona et al., 2014).

b) Engaging CHWs in the delivery of tobacco control intervention

In this study, we demonstrated that CHWs had the advantage of working within the community and have a good rapport with local families and it was feasible to deliver SHI by CHWs (Huang et al., 2018). The current study participants also were highly satisfied with the intervention delivered by CHWs, reflecting their acceptability of the intervention. Relatively flexible working time and trustworthiness with local residence underscore the feasibility and effectiveness of engaging CHWs as counselors or other health advocates in similar SHI or other health intervention programs in the future. Although no research has been published yet about the impact of COVID-19 on CHWs, there is no doubt that the pandemic has added their workload. Because of the ongoing COVID-19 outbreak, CHWs played as the frontline workers during the pandemic. They positioned to track people who contracted COVID-19 and provided residents accurate information. Since 2009, the new healthcare reform dramatically reduced the income of CHWs for canceling their primary income resource-the drug mark-ups (Ding et al., 2013). Although the Ministry of Health increased the compensation for basic public health services per capita for CHWs, the financial incentives were still inadequate for CHWs (Huang et al., 2018). Considering the wide use of CHW in settings that have a shortage of health resources (Hu et al., 2017) (Baqui et al., 2009) (Delacollette et al., 1996), future research should focus on exploring incentive mechanisms that can effectively motivate CHWs and improve the quality of medical services and the cost-effectiveness when designing interventions.

c) SHS exposure reduction in children in rural China

China actively issued several policies to reduce the SHS exposure among non-smokers including prohibiting smoking in indoor workplaces, indoor public places, and public transportation (Article 8, FCTC) to prevent nonsmokers from exposure to tobacco smoke (WHO, 2011). However, in many cases, especially in rural China, the policies seemed inadequate due to the conflict between the tobacco industry and tobacco cessation policies (X. Chen et al., 2019). Indirect marketing also impedes the implementation of these methods, concealing under the guise of sponsorship and corporate social responsibility (Li et al., 2010) (Yang et al., 2015). Robust evidence showed that people in workplaces where smoking was prohibited were more likely to adopt a home-free smoke ban in their homes (Gilpin et al., 1999). Home smoking bans have primarily been promoted to protect non-smokers from SHS (Luo et al., 2015). To better implement smoking cessation and SHS reduction programs, it is necessary to strengthen the enforcement of existing no-smoking rules in all public places and workplaces (Luo et al., 2015) (Mao et al., 2014).

d) Promoting smoking cessation in rural China.

Our SHI contained both smoking cessation and reducing SHS at home. Results showed that there was minimal effect on quitting smoking. Previous evidence pointed out that behavioral interventions combined with medication could increase smoking cessation in multiple settings and populations, which implied that smokers should be encouraged to use both types of tobacco cessation aids (Stead & Lancaster, 2012) (Stitzer, 1999). However, pharmacological therapy in China was adopted with relatively low uptake, although smoking cessation drugs' effectiveness and safety have been proved in the Chinese population (Cahill et al., 2013). The Chinese cultural belief might explain that every medicine had its adverse effects, and the financial burden, since all these drugs were not covered in medical insurance (Xu et al., 2018). The Chinese government has taken measures to support smoking cessation, and further efforts are needed to solve the problems of uneven resource allocation and limited supply of medicines (Lin et al., 2019).

4.2 Implications for further research

Common non-pharmacological approaches strategies used for reducing children's SHS at home were counseling, self-help materials, prompts against smoking at home (e.g., posters or cards), as well as biochemical feedback and health education (Zhou et al., 2019). A meta-analysis of 40 studies conducted by Stead and colleagues (2016) found that behavioral interventions increased the efficacy of pharmacotherapy (RR = 1.27, 95% CI, 1.02–1.58) (Stead et al., 2016). Therefore, a more sustainable intervention needs to be initiated. In some studies, interventions provided through mobile health technologies (i.e., mHealth) have been proved effective in improving smoking cessation outcomes (Spohr et al., 2015) and had advantages over interventions provided by traditional health care providers including higher flexibility, wider accessibility, lower cost, higher customizability, and targeting larger populations (Irvine et al., 2012).

Another mobile application that could serve as intervention media is the widely-used WeChat. WeChat has been used as a health communication tool with more than one billion monthly active users currently (Montag et al., 2018), and been able to exert positive impacts on changing health behaviors including postoperative recovery (Gong Ting et al., 2019), HIV self-testing promotion (Zhu et al., 2019) (Zhao et al., 2018), blood sugar control (Yang et al., 2018) (Dong et al., 2018), health literacy improvement (Sun et al., 2020), positive psychotherapy (Guo et al., 2019) (Li et al., 2019) (Yang et al., 2019), nursing on chronic disease (He & Liu, 2019), weight loss (He et al., 2017), etc. However, the use of WeChat to promote smoking cessation or tobacco control is very limited in China. Studies that used WeChat for tobacco control mainly focused on chronic diseases including chronic obstructive pulmonary disease (COPD) (Huang et al., 2017) (Yang et al., 2016) and cardiovascular disease (CVD) (Li & Zeng, 2014) (Zeng & Mao, 2019). Currently, chronic diseases have increased rapidly in rural China (Yang et al., 2015) and one of the behavioral risk factors is tobacco use (Fu et al., 2017). If WeChat can be applied to communicate with smokers and spread knowledge about smoking cessation, it can largely help smokers change their unhealthy lifestyles. It will make a significant contribution to improving smokers' physical well-being and promoting rural health eventually.

Engaging family members as support persons to promote smoke-free homes and smoking cessation would be helpful because their encouragement and support are significant motivators for smokers to quit smoking and help them to maintain long-term abstinence (Hubbard et al., 2016) (Wang et al., 2014). Huang et al. (2015)

suggested family-assisted smoking cessation intervention combined with motivational interviewing had a significant positive effect on smokers who had low motivation to quit smoking (Huang et al., 2015).

Prior studies have shown the potent efficacy of drug therapy for smoking cessation in clinical trials. Among these pharmacotherapies, nicotine replacement therapy (NRT) is most commonly used (Stitzer, 1999). An overview of Cochrane reviews that included relevant RCTs found that all pharmacotherapies (i.e., NRT, bupropion, and varenicline) had superior efficacy to control group for smoking cessation and none of them reported an incidence of adverse events for general adults (Cahill et al., 2013). Another review focused on the effectiveness and safety of counseling combined with pharmacotherapy intervention for smoking cessation in adults achieved consistent results (Patnode et al., 2015). However, in this study, we did not use any pharmacotherapy to support smoking cessation. Since NRTs or other smoking cessation medications are not widely available in rural China, there would be a need for national policy actions to make these medications widely available to the public.

4.3 Study strengths and limitations

To our knowledge, this is the first study focus on children's SHS exposure in rural China. The SHI package we used was developed based on our previous study among the urban Chinese households and we have adapted this package for rural Chinese settings (Abdullah et al., 2015).

In terms of the study design, our study was a clustered randomized controlled trial. We purposively selected communities geographically separated and randomly assigned them into the intervention group and the comparison group to reduce contamination.

This study has some limitations: (1) Our intervention merely focused on the smoker that had the most interaction with the child. Other smokers in the household were not included. In order to address the issue of multiple smokers, the number of smokers in eligible households could be restricted in the future. (2) There was a non-ignorable number of missing data in the dataset. It is expected that a large proportion of rural residence especially young man would migrate to urban areas (Lu & Xia, 2016). We compared participants who dropped out with those who followed up successfully at 12-month. Findings showed that a significant proportion of households with a higher mean of children's urinary cotinine concentration were dropout of the study. Participants with a lower annual income (<50k RMB) were more likely to follow-up with our intervention than participants with higher income. Besides, a higher proportion of follow-ups was witnessed in Dali compared to Taizhou. It was consistent with the results of ethnicity subgroups, which suggested a higher proportion of follow-up in the minority, and all minority came from Dali. These findings indicated that our educational intervention might be promising and effective for low-income households to participate (data not shown). In addition, because of the limited budget, the number of urine samples that could be tested had to cut in half leading to inadequate statistical analysis. However, our study used a logistic model of mixed-effects that could deal with the loss of longitudinal data to minimize the impact of the absence. (3) Validation studies suggest that self-reported measures of smoking behaviors are reliable for adult and non-pregnant populations to distinguish between active smoking and passive smoking (Patrick et al., 1994) (Vartiainen et al., 2002). However, participants' responses might be affected by their characteristics, research methods and environment, and pressure mediated by social expectations (Williams et al., 2020) (Saberi et al., 2020). To minimize response bias caused by self-reporting, our inquiries were designed to be easy for participants to answer and remember. (4) We combined the data from two study sites with different economic development and population characteristic to increase our study's generalizability. However, we did not do the stratified analysis by region to see the similarities or differences of these two sites at baseline. (5) Our study was an unblinded trial which means participants were informed of the assigned group. This might affect their performance during the study. Additionally, the baseline and follow-up survey questions of their smoking behaviors and children's health might let them get the awareness of the association.

4.4 Personal experience

The final follow-up survey for this study was completed in December 2019. Unfortunately, I did not have the chance to do field research in Dali and Taizhou. However, I looked through the study design, all relevant materials and worked with other collaborators in local research sites to understand the dataset. Therefore, my main role in this project was analyzing the data and complete the thesis writing based on the information gathered from all the relevant researchers. Through this experience, I achieved a better understanding of the hazards of smoking and secondhand smoking in rural China as well as learned the process of how an intervention program could be designed, implemented and evaluated. It is quite difficult to implement and evaluate a cost-effective smoking cessation intervention in rural China and there is still a long way to go for tobacco control in China.

5. Conclusion

To our knowledge, this study was the first study conducted in rural China to examine the efficacy of an SHS exposure reduction intervention to children. Our findings have implications for the development of SHI delivered by CHWs. After controlling the covariates and cluster effect, we found it was feasible to deliver SHI by CHWs in rural China, and the intervention was effective in reducing children's exposure to SHS at 12-months. Our intervention had a minor effect on smoking cessation, smoke-free home restriction, and improvement of children's respiratory health. However, results should be interpreted cautiously because of the limitations. Further studies on how to conduct effective CHW-delivered SHI in order to facilitate smoking cessation and reduce SHS exposure to children are needed.

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