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Probability and predictors of long-term smoking relapse among Chinese adult smokers: A longitudinal study

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ABSTRACT

Numerous smokers attempt to quit smoking, but most cessation efforts prove unsuccessful. Scarce evidence exists regarding predictors of long-term relapse in China. This study aims to evaluate the probability of relapse and examine factors may contribute to relapse among Chinese adults. A dynamic cohort of 6,036 observations on 2,378 adult quitters was constructed from the China Family Panel Studies in 2010, 2012, 2014, 2016 and 2018. The life table method was employed to calculate the probability of relapse for long-term smoking abstinence. Multivariate complementary log-log survival models were developed to examine the predictors of smoking relapse. We found that the probability of relapse decreased as the duration of abstinence increased, with rates of 49.07 %, 20.05 %, 10.29 %, and 6.63 % at 2, 4, 6, and 8 years of abstinence, respectively. The cumulative probability of relapse within 8 years was 65.89 %. Age ≥65 years, higher educational attainment, respiratory disease, and a satisfying lifestyle were associated with a reduced likelihood of relapse. Conversely, higher occupational prestige, alcohol drinking, cohabitant smoking, and greater future confidence were associated with an increased risk of relapse. These findings demonstrated that the probability of relapse decreased progressively over time, with most relapses occurring in the initial two years following quit attempts. Predictors of Chinese quitters' relapse behavior in our study were similar to those in previous studies. Drinking and cohabitant smoking were identified as strong predictors of relapse in this population.

1. Introduction

Cigarette smoking significantly contributes to preventable morbidity and mortality worldwide, resulting in 7.69 million deaths and a loss of 200 million disability-adjusted life years in 2019(GBD 2019 Tobacco Collaborators, 2021). China, recognized as the world's largest tobacco manufacturer and consumer, boasts an estimated 341 million current smokers(Zhang et al., 2022). The economic burden of tobacco-related diseases amounted to 53 billion RMB (equivalent to approximately US $9 billion) in 2014, constituting 1.5 % of national health-care expenditures(Xue, 2020). Failure to address smoking behaviors is expected to culminate in the deaths of one-third of Chinese men smokers by 2030 (Chen et al., 2015). Quitting smoking represents an immensely effective strategy for mitigating the adverse consequences of tobacco use and exposure, as its preventive benefits on premature mortality span the entire lifetime(Jha et al., 2013).

Despite the evident benefits of quitting, the success rate of self-quitters is disappointingly low, with only 3–5 % achieving smoking cessation(Hughes et al., 2004). Stable abstinence can be conceptualized as a two-stage process: making quit attempts and maintaining abstinence. Previous studies have predominantly focused on the former stage, investigating quitting attempts and their potential influencing factors(Li et al., 2011; Vangeli et al., 2011; Borland et al., 2012). In a given year, 40.1 % of smokers reported attempts to quit, with an average of 2.1 attempts(Borland et al., 2012). However, unsuccessful quit attempts, particularly multiple attempts in the past year, have been associated with a reduced likelihood of maintaining abstinence for at least six consecutive months(Partos et al., 2013). It is well-established that factors motivating smokers to attempt quitting are distinct from those sustain abstinence(Vangeli et al., 2011). Based on these premises, recent efforts have shifted toward identifying what might prevent smoking relapse.

Existing theories regarding the maintenance of abstinence indicate that duration of abstinence is a crucial factor influencing relapse(Piasecki et al., 2002). The probability of relapse for those with less than 12 months of abstinence was 54%-67%, dropping to below 50% after one

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year and further to less than 30% after five years, with this downward trend becoming insignificant after ten years. (García-Rodríguez et al., 2013). Other characteristics, such as older age, marriage, higher educational attainment, higher social class, and lower initial nicotine dependence, have been reported to be associated with a lower probability of long-term smoking relapse(Gökbayrak et al., 2015; Fernández et al., 2006; Qiu et al., 2020). Acute instigators include alcohol consumption, the presence of other smokers in social networks, and being in situations where cigarettes are readily available(Lynch et al., 2019; Saxby et al., 2022). The dynamics of three smoking motivational processes – withdrawal symptoms, negative affect, and craving – have also proven to be reliable predictors of early relapse(Piasecki, 2006). Nevertheless, these studies were either derived from follow-ups of individuals participating in smoking cessation intervention trials, relatively short-term longitudinal follow-ups (i.e., 12–24 months), or limited to specific populations and mostly in high-income countries (HICs) like the United States. Relevant research in China is relatively scarce despite the significant population of smokers in the country.

Models of effective tobacco control have been established in HICs, those patterns may only achieve similar success in China if they are tailored to accommodate the unique characteristics of Chinese tobacco use and cultural differences. Therefore, the primary aim of this study was to determine predictors of smoking relapse using a nationally representative longitudinal Chinese cohort. The findings can provide a foundation for determining the optimal timing of cessation interventions and developing targeted cessation programs, particularly for populations at high risk of relapse.

2. Methods

2.1. Data sources and sample selection

Data were extracted from the China Family Panel Studies (CFPS), a nationwide, large-scale, multidisciplinary biennial social-tracking survey conducted by the Institute of Social Science Survey (ISSS) of Peking University. The survey sample covers 25 provinces, representing 94.5 % of the total population in China(Xie and Lu, 2015). Face-to-face interviews collected extensive information on demographic characteristics, socioeconomic status, health-related behaviors, and many other aspects. Further details about the design of the CFPS, including the sampling technique, can be found at https://charls.pku.edu.cn/en/(Xie and Hu, 2014).

A dynamic analysis cohort was constructed to model risk factors for relapse (Fig. 1). Initially, we reduced the analytic sample to participants with smoking cessation in any one of the 2012–2020 waves (n = 3,673), and then further restricted the analysis to participants who responded to their smoking status in at least one subsequent wave (n = 2,730). Participants who reported quitting at the last wave in 2020 (n = 328) were not included because we could not observe whether they relapsed at follow-up. Furthermore, participants with missing smoking intensity variables (n = 24) were excluded from the analysis. Participants who reported smoking cessation were followed until relapse and not included in follow-up waves after relapse. Individuals who were lost to follow-up were censored at their last follow-up date. This resulted in a cohort of 6,036 observations on 2,378 individuals, with follow-up divided into four periods (2012–2020, 2014–2020, 2016–2020, and 2018–2020) and an average of 2.5 waves of follow-up per individual (maximum of 5 waves).

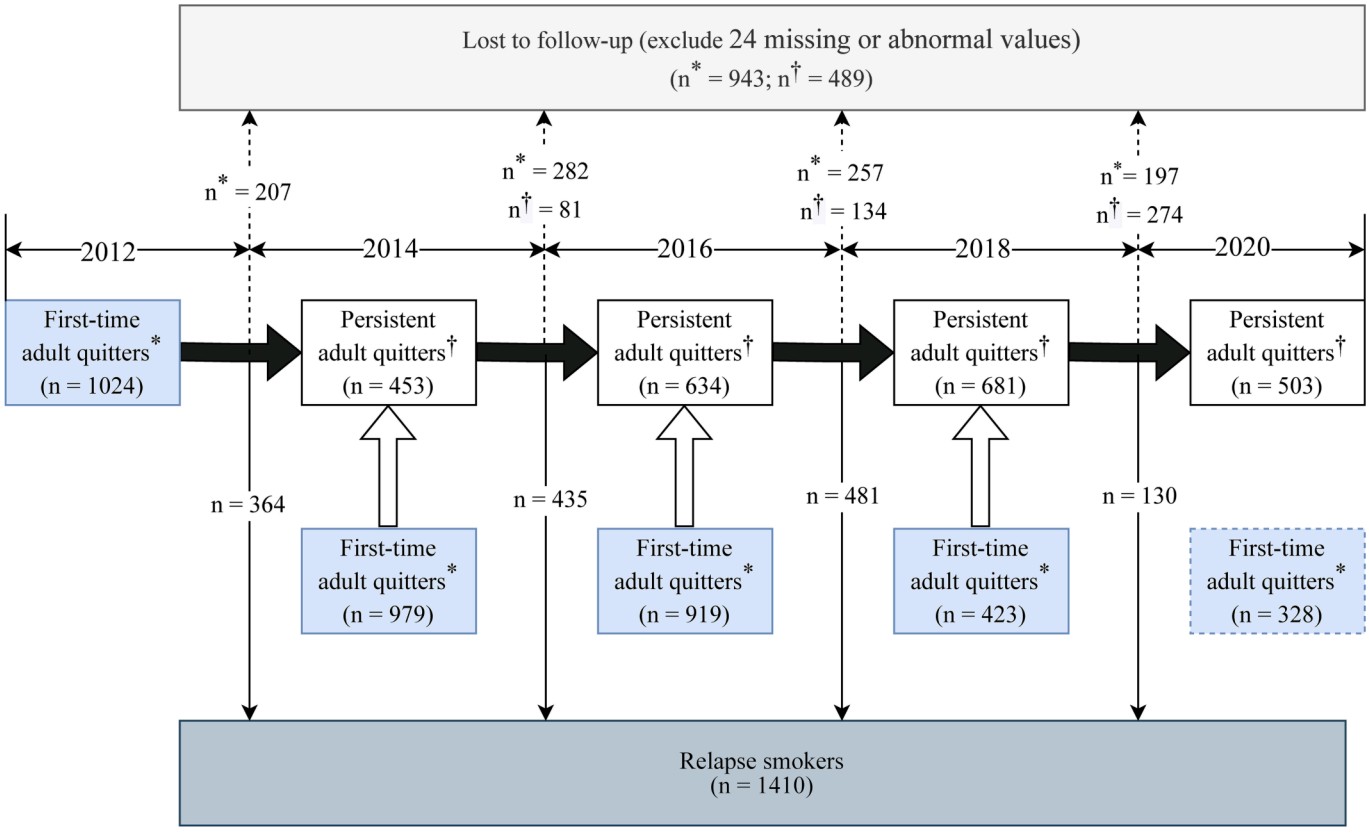

Fig. 1. Flow diagram of the study selection and exclusion process. Note: *Those who initially reported quitting smoking; †those who continuously reported quitting smoking.

2.2. Measurements

2.2.1. Smoking, quitting and relapse

By the definitions utilized by the Global Adult Tobacco Survey and the American Centers for Disease Control and Prevention(Global Adult Tobacco Survey Collaborative Group, 2020; Centers for Disease Control and Prevention, 2017), participants' smoking status at each wave was ascertained by asking, "Did you smoke cigarettes in the past month?". Current smokers were categorized as individuals who had smoked at least 100 cigarettes in their lifetime and had smoked in the past month. Individuals who reported not smoking in one wave or reported duration of abstinence after formerly reporting being current smokers in at least one wave were considered quitters, the time they first reported quitting was designated as the baseline period. Those who answered "yes" to the same question again after reporting quitting smoking were classified as relapsed.

2.2.2. Smoking intensity

Smoking intensity included the number of cigarettes smoked daily and smoking length as reported by individuals before quitting. The average number of cigarettes smoked daily was classified into four categories: ≤1, 2–10, 11–20, and ≥21 (Inoue-Choi et al., 2019). Since the cessation termination time varies for each individual and is constrained by the CFPS survey interval, this study defined the unit of abstinence length as the number of waves surveyed.

2.2.3. Covariates

Demographic variables included age (18–44, 45–64 and ≥65), gender (women, men), residence (rural, urban), region (East, Central, West and Northeast), and marital status (have cohabiting partner versus not). Assessment of socioeconomic status involved educational attainment, occupational prestige and per capita household income, where occupational prestige was measured by the Standard International Occupational Prestige Scale, and per capita household income was adjusted for the consumer price index(Ganzeboom and Treiman, 1996). Tobacco-related diseases were identified by the CFPS Disease Classification Codes, comprsing respiratory diseases, cardiovascular and cerebrovascular diseases, digestive diseases, diabetes, and cancer(Xie and Hu, 2014). Mental health was evaluated using the Kessler Psychological Distress Scale-6 items and the Indonesian version of the Center for Epidemiologic Studies Depression Scale (revised), with a dichotomous variable defined using thresholds of 12 and 20(Tran et al., 2019). Individual behavioral variables included alcohol drinking and frequency of exercise. Life satisfaction was measured on a 5-point scale from 1 (very dissatisfied) to 5 (very satisfied), and future confidence was rated between 1 (feeling very unconfident) and 5 (feeling very confident). Utilizing the panel data available in the CFPS at the family level, we also evaluate the impact of family behavior potentially prompts relapse (e.g., cohabiting household members' smoking status and living with children under 3 years of age). Specific assessment methods for variables can be found in Supplementary Table A1.

2.3. Statistical analysis

Characteristics between those who relapsed and maintained abstinence were compared using the chi-square test for categorical variables, *t*-test for continuous variables, and Mann-Whitney *U* test for ordered multicategory variables. The life table method was applied to calculate the relapse probability for 2 waves, 4 waves, 6 waves, and 8 waves of smoking cessation.

A discrete time-to-event complementary log-log (cloglog) model (an alternative to continuous-time Cox proportional hazards models) was constructed to explore the association between predictors and relapse (Jenkins, 1995). This model is beneficial for analyzing data where the hazard rate changes nonmonotonically over time, such as when the risk of an event is highest in the early phases and then decreases over time (Boyko et al., 2015; Shibayama et al., 2018). The cloglog model takes the following form:

$$\log\left(-\log\left(1-\lambda_{ij}\right)\right)=\alpha_j+\beta' x_i$$

where λ_{ij} represents the discrete-time hazard of the i th subject ($i=1,\ldots,n$) in the j th time interval ($j=1,\ldots,n$) with the matrix of covariates x_i, and β is the vector of coefficients. The model leads to the baseline survival function S_0 at the j th time interval of

$$S_{0j}=\prod_{k=1}^{j} exp(-exp(\alpha_k))$$

and the survivor function adjusted by covariates at the j th time interval of

$$S_j=\left[S_{0j}\right]^{exp(\beta' x)}$$

All analyses in our research were weighted using individual and national panel weights adjusted for nonresponse and lost follow-up to obtain robust results. Analyses were conducted using Stata/MP 16 (StataCorp, TX), and $P<0.05$ was considered statistically significant.

3. Ethics approval

The CFPS has submitted applications for ethical review to the Biomedical Ethics Committee of Peking University (approval number: IRB00001052-14010). All study procedures were approved by the Ethics Committee of Wuhan University of Science and Technology (202 063). All participants were provided informed consent before the interviews.

4. Results

4.1. Characteristics of the analytic sample

Table 1 presents the characteristics of the study participants at baseline. The 2,378 participants included 2,181 men with an average age of 50.98 years (SD = 14.25) and 197 women with an average age of 56.10 years (SD = 13.26). The participants smoked an average of 13.78 cigarettes per day (SD = 9.88) and had a mean smoking duration of 25.35 years (SD = 14.08) before quitting. 1,408 (59.21 %) individuals eventually reported relapse and 970 (40.79 %) remained abstinent at the follow-up waves. Notably, statistically significant differences between the two groups were observed in age, residence, per capita household income, living with children under 3 years of age, cardiovascular disease, digestive disease, alcohol drinking, frequency of exercise, cigarette consumption, smoking duration, and life satisfaction.

4.2. Probability of relapse

Table 2 illustrates the relapse probability as a function of the length of abstinence. The relapse probability was 49.07 % at one wave of abstinence, 20.05 % at two waves of abstinence, 10.29 % at three waves of abstinence, and 6.63 % at four waves of abstinence. The cumulative probability of relapse within four waves of quitting smoking was 65.89 %.

4.3. Predictors of relapse

Table 3 shows the results of the multivariate complementary log-log survival analysis model. A longer duration of abstinence, age ≥65 years, higher educational attainment, respiratory disease, and a satisfying lifestyle were associated with a reduced likelihood of relapse. Higher occupational prestige, alcohol drinking, cohabitant smoking, and greater future confidence were associated with an increased risk of relapse.

Table 1
Characteristics and univariate analysis of individuals ≥18 years who relapse and maintain abstinence from China Family Panel Studies 2012–2020.

Variable	Total baseline individuals n = 2,378	Individuals reporting relapse n = 1,408	Individuals maintaining abstinence n = 970	$X^2/t/Z$	P
The number of waves followed up in the analysis cohort	3.08±1.73	2.43±1.05	4.01±2.07	24.377	<0.001
Age				35.393	<0.001
18–44	762 (32.04)	510 (36.22)	252 (25.98)		
45–64	1,152 (48.44)	665 (47.23)	487 (50.21)		
≥65	464 (19.51)	233 (16.55)	231 (23.81)		
Gender				0.304	0.581
Women	197 (8.28)	113 (8.03)	84 (8.66)		
Men	2,181 (91.72)	1,295 (91.97)	886 (91.34)		
Residence				6.650	0.010
Rural	1,379 (57.99)	847 (60.16)	532 (54.85)		
Urban	999 (42.01)	561 (39.84)	438 (45.15)		
Region				4.804	0.187
East	689 (28.97)	396 (28.13)	293 (30.21)		
Central	653 (27.46)	388 (27.56)	265 (27.32)		
West	647 (27.21)	404 (28.69)	243 (25.05)		
Northeast	389 (16.36)	220 (15.63)	169 (17.42)		
Having cohabiting partner				0.006	0.938
No	256 (10.77)	151 (10.72)	105 (10.82)		
Yes	2,122 (89.23)	1,257 (89.28)	865 (89.18)		
Educational level				1.857	0.063
Illiteracy	639 (26.87)	392 (27.84)	247 (25.46)		
Primary & Junior high school	1,268 (53.32)	754 (53.55)	514 (52.99)		
High school and above	471 (19.81)	262 (18.61)	209 (21.55)		
Occupational prestige	26.71±18.27	27.14±18.01	26.10±18.63	−1.363	0.173
Household income per capita				2.206	0.027
1st quintile	555 (23.34)	338 (24.01)	217 (22.37)		
2nd quintile	498 (20.94)	306 (21.73)	192 (19.79)		
3rd quintile	473 (19.89)	281 (19.96)	192 (19.79)		
4th quintile	455 (19.13)	273 (19.39)	182 (18.76)		
5th quintile	397 (16.69)	210 (14.91)	187 (19.28)		
Respiratory disease				2.832	0.092
No	2,300 (96.72)	1,369 (97.23)	931 (95.98)		
Yes	78 (3.28)	39 (2.77)	39 (4.02)		
Cardiovascular and cerebrovascular diseases				14.914	<0.001
No	2,185 (91.88)	1,319 (93.68)	866 (89.28)		
Yes	193 (8.12)	89 (6.32)	104 (10.72)		
Digestive disease				11.316	0.001
No	2,280 (95.88)	1,366 (97.02)	914 (94.23)		
yes	98 (4.12)	42 (2.98)	56 (5.77)		
Diabetes				0.055	0.815
No	2,342 (98.49)	1,386 (98.44)	956 (98.56)		
Yes	36 (1.51)	22 (1.56)	14 (1.44)		
Cancer				0.766	0.382
No	2,373 (99.79)	1,406 (99.86)	967 (99.69)		
Yes	5 (0.21)	2 (0.14)	3 (0.31)		
Mental disease				0.003	0.959
No	2,146 (90.24)	1,271 (90.27)	875 (90.21)		
Yes	232 (9.76)	137 (9.73)	95 (9.79)		

(*continued on next page*)

Table 1 (*continued*)

Variable	Total baseline individuals n = 2,378	Individuals reporting relapse n = 1,408	Individuals maintaining abstinence n = 970	$X^2/t/Z$	*P*
Drink				6.195	0.013
No	1,888 (79.39)	1,142 (81.11)	746 (76.91)		
Yes	490 (20.61)	266 (18.89)	224 (23.09)		
Exercise frequency per week				11.060	<0.001
≤1	1,451 (61.02)	898 (63.78)	553 (57.01)		
2–3	251 (10.56)	147 (10.44)	104 (10.72)		
≥4	676 (28.43)	363 (25.78)	313 (32.27)		
Cigarettes per day				56.242	<0.001
≤1	101 (4.25)	30 (2.13)	71 (7.32)		
2–10	910 (38.27)	522 (37.07)	388 (40.00)		
11–20	1,082 (45.50)	652 (46.31)	430 (44.33)		
≥21	285 (11.98)	204 (14.49)	81 (8.35)		
Smoking length	25.35±14.08	24.09±13.82	27.17±14.26	5.283	<0.001
Life satisfaction	3.61±1.05	3.57±1.05	3.67±1.04	2.230	0.026
Future confidence	3.81±1.11	3.80±1.09	3.83±1.13	0.587	0.558
Cohabitant smoking				1.150	0.284
No	1,685 (70.86)	986 (70.03)	699 (72.06)		
Yes	693 (29.14)	422 (29.97)	271 (27.94)		
Living with child under 3 years of age				5.937	0.015
no	2,239 (94.15)	1,312 (93.18)	927 (95.57)		
yes	139 (5.85)	96 (6.82)	43 (4.43)		

Note: Data are expressed as the mean ± standard deviation or number (%).

Table 2
Probability of smoking relapse among individuals ≥18 years with different smoking cessation durations from the China Family Panel Studies 2012–2020.

Length of quit (waves)	Number abstinence at beginning of period	Number relapsing during year	Number not present in survey next year	Probability of relapse during year (%)	Cumulative probability of continued cessation (%)	*SE*
1	2,378	1,167	0	49.07	50.93	0.0102
2	1,066	188	257	20.05	40.72	0.0106
3	471	42	126	10.29	36.53	0.0111
4	206	11	80	6.63	34.11	0.0121

Note: SE means standard error.

The results of the subgroup analysis stratified by gender are displayed in Supplementary Table A2. There was a significant association between relapse and age, educational attainment, occupational prestige, respiratory disease, alcohol drinking, cohabitant smoking, and life satisfaction among men. For women quitters, the risk of relapse was lower in the middle-income group than the low-income group, and those who suffered from mental diseases and drank were more likely to relapse.

The analysis results stratified by age are presented in Supplementary Table A3. Individuals aged 18–44 who smoked ≥21 cigarettes per day had a higher risk of relapse than those who smoked ≤1. For those aged 45–54, people with the second quintile per capita household income were more likely to relapse compared with the lowest quintile, and those who smoked 2–10 cigarettes per day had 1.423 times the risk of relapse versus those who smoked ≤1 cigarette. In the ≥65 years group, relapse was significantly associated with reducing the number of daily cigarettes.

5. Discussion

This study demonstrates that prolonged periods of abstinence are associated with a lower probability of relapse based on a nationally representative cohort. A substantial proportion of quitters relapsed after 2 years of abstinence, and the probability of relapse decreased following a hyperbolic curve, consistent with previous research using a national survey of U.S. adults(García-Rodríguez et al., 2013). This effect of prolonged abstinence can be attributed to multitude of complementary processes, including reductions in smoking urges, enhancements in abstinence self-efficacy, lower frequency and intensity of cravings and withdrawal symptoms, as well as improvements in perceived costs of smoking (e.g., negative health consequences, money spent on cigarettes) and benefits of quitting (e.g., improved quality of life, benefits)(Gwaltney et al., 2005; Herd and Borland, 2009; Schnoll et al., 2016).

The cumulative probability of relapse within the initial two years of quitting in this study (49.07 %) surpasses the previously reported figure of 22.9 % from an analysis of the British Household Panel Data(Qian et al., 2010). This disparity may be attributed to the deep-rooted historical and political ties between tobacco and Chinese culture, encompassing gift-giving within official circles, chain-smoking habits of senior leaders, and the endorsement of widespread misperceptions by political leaders(Mackay, 2016). Another possible explanation is that the availability of smoking cessation services and medications is extremely limited in China, with only 48 % of physicians questioning patients' smoking status and less than 7 % of physicians setting quit dates or prescribing pharmaceutical therapies to help smokers quit(Jiang et al., 2007). Our findings revealed that 65.89 % of quitters will relapse within

Table 3
Results of the complementary log-log survival analysis for factors associated with relapse among individuals ≥18 years quitters from the China Family Panel Studies 2012–2020.

Variable	Hazard ratio	95 % CI	*P*
Abstinence length			
1 wave	Reference		
2 waves	0.416	(0.354,0.488)	<0.001
3 waves	0.232	(0.169,0.319)	<0.001
4 waves	0.192	(0.104,0.356)	<0.001
Age			
18–44	Reference		
45–64	0.860	(0.729,1.015)	0.075
≥65	0.734	(0.573,0.940)	0.014
Men	1.191	(0.960,1.478)	0.113
Urban	0.936	(0.831,1.053)	0.369
Region			
Central	Reference		
East	1.063	(0.918,1.232)	0.415
West	1.104	(0.952,1.280)	0.190
Northeast	1.000	(0.839,1.192)	0.999
Have cohabiting partner	0.989	(0.826,1.184)	0.904
Educational level			
Illiteracy	Reference		
Primary & Junior high school	0.825	(0.717,0.948)	0.007
High school and above	0.711	(0.590,0.856)	<0.001
Occupational prestige	1.006	(1.002,1.010)	0.002
Household income per capita			
1st quintile	Reference		
2nd quintile	0.876	(0.740,1.036)	0.122
3rd quintile	0.919	(0.775,1.090)	0.331
4th quintile	0.916	(0.770,1.090)	0.324
5th quintile	0.937	(0.778,1.127)	0.488
Respiratory disease	0.483	(0.328,0.713)	<0.001
Cardiovascular and cerebrovascular diseases	0.995	(0.819,1.209)	0.961
Digestive disease	0.855	(0.642,1.140)	0.286
Diabetes	1.156	(0.798,1.673)	0.443
Cancer	0.326	(0.081,1.313)	0.115
Mental disease	1.031	(0.863,1.232)	0.738
Drink	1.233	(1.091,1.393)	0.001
Exercise frequency per week			
≤1	Reference		
2–3	0.975	(0.807,1.178)	0.400
≥4	0.945	(0.829,1.078)	0.792
Cigarettes per day			
≤1	Reference		
2–10	1.109	(0.891,1.381)	0.356
11–20	0.807	(0.643,1.012)	0.064
≥21	0.793	(0.592,1.061)	0.119
Smoking length	0.998	(0.992,1.004)	0.481
Life satisfaction	0.916	(0.860,0.975)	0.006
Future confidence	1.070	(1.007,1.138)	0.030
Cohabitant smoking	1.266	(1.122,1.429)	<0.001
Living with child under 3 years of age	0.868	(0.667,1.128)	0.289
Baseline time			
2012	Reference		
2014	1.249	(1.089,1.432)	0.001
2016	1.368	(1.178,1.588)	<0.001
2018	0.897	(0.677,1.190)	0.451

Note: CI means confidence intervals.

8 years, corresponding to an annualized relapse probability of 8.24 %. A *meta*-analysis of clinical trials estimated the incidence of relapse to be slightly higher at 10 %/yr(Hughes et al., 2008), another longitudinal study involving 3,708 middle-aged and older Chinese adults indicated an annual relapse probability of 6.65 %(Qiu et al., 2020). The higher estimate in our research reflects differences between the middle-aged and elderly populations and the whole population, further supported by our age group results.

Historical and cultural norms in China perceived smoking as an inappropriate behavior for women(Chen et al., 2015), as demonstrated in the current smoking rate being close to 60 % among men and less than 5 % among women(Huang et al., 2023). Nonetheless, empirical evidence has shown that women experience more significant difficulties than men in sustaining long-term abstinence from smoking(Smith et al., 2016). Our results did not find such significant differences. Perhaps since women quitters accounted for only 8.28 % of the sample population in this study, this underrepresentation may contribute to biased findings. Additionally, aligned with prior research(Gökbayrak et al., 2015), our study suggested that older adults were less prone to relapse than middle-aged adults. One plausible explanation is that younger people have more opportunities to smoke in groups at events such as parties and are more susceptible to peer pressure(Watson et al., 2018), consequently increasing their chances of relapse. In contrast, older smokers face poorer health due to smoking, making them inclined to heed their physician's advice and quit(Malarcher et al., 1995), ultimately reducing their risk of relapse.

Socioeconomic status inequalities in smoking relapse among populations in HICs have been extensively documented, focusing on social class and education level(Pisinger et al., 2011; Albasheer et al., 2023). Few studies in low-income (LICs) and low- and middle-income countries (LMICs) have investigated the role of Socioeconomic status on smoking behavior. Our study supports previous searches in HICs(Pisinger et al., 2011; Fernández et al., 2006), indicating that individuals with elevated levels of education exhibit a lower likelihood of relapse. This may partly be the result of better-educated individuals displaying a more robust health perception and outstanding commitment to smoking cessation (Verguet et al., 2015). However, our study also highlights that occupational prestige, a distinct indicator of social status associated with one's occupation(Ganzeboom and Treiman, 1996), posed a risk factor for relapse. This is aligned with a cross-sectional study in the Jazan Region of Saudi Arabia, finding that governmental employees demonstrated a lower percentage of smoking abstinence success than private-sector employees(Albasheer et al., 2023). In contrast, a study conducted in a Spanish hospital showed that participants who were managerial and senior technical staff and freelance professionals had significant hazard ratios of relapse after long-term follow-up compared to manual workers (Fernández et al., 2006). Future researches in LICs and LIMCs are required to corroborate the direction of these inequalities.

As expected and consistent with past research(Chandola et al., 2004; Nakajima and al'Absi, 2012; Lynch et al., 2019; Finocchio et al., 2021; Saxby et al., 2022), alcohol drinking, and cohabitant smoking were substantial obstacles to successful cessation, and mental diseases predicted smoking relapse in women but not in men, while suffering from respiratory diseases reduced the risk of relapse. Intriguingly, we found that the negative correlation between the number of cigarettes smoked

per day and relapse was most pronounced in individuals aged ≥65 years. The opposite trend was observed among those aged 18–44 and 45–64. This indicates that heavy smokers in the elderly population are less inclined to quit, whereas once they do, they tend to remain abstinent (Hughes and Carpenter, 2005).

Although our estimation of long-term smoking relapse probabilities and identification of pertinent factors provide valuable evidence for developing smoking cessation interventions in China. There still exist certain limitations. Firstly, smoking-related variables were restricted by gaps of approximately two years between surveys, providing only a point estimate of current smoking behavior. Therefore, reporting not smoking in two consecutive waves does not necessarily equate to four years of continuous abstinence but may include one or more episodes of relapses and quitting in that period. Secondly, using self-reported data instead of biometric validation to ascertain smoking behavior may introduce recall bias. Thirdly, the definition of smoking utilized in CFPS solely encompasses cigarette smoking and ignores the use of other tobacco products. This may lead to an underestimation of the relapse probability, notwithstanding that this particular population represents only a minor portion of China's smoking population. Finally, our conceptualization of maintenance of cessation as a static phenomenon ignores its dynamic nature, including the time course of relapse and events that follow relapse (such as the return to abstinence).

6. Conclusion

Long-term relapse probabilities declined following a hyperbolic curve, implying that the probability of relapse remains even after prolonged abstinence. Our study's predictors of Chinese quitters' relapse behavior were similar to previous studies, including age, socioeconomic status, respiratory diseases, alcohol drinking, cohabitant smoking, and life attitude factors. Alcohol consumption and cohabitant smoking were the most prominent factors contributing to relapse in this population. When tailoring specific actions for smoking cessation interventions in the clinical setting, it is crucial to spotlight the early stages of smoking cessation, with extended follow-up and a focus on quitters who drink alcohol and have cohabitant smoking.

CRediT authorship contribution statement

Zhongmin Zhang: Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Mingzhao Huang:** Methodology, Writing – review & editing. **Ting Chen:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

I have shared the link to my data at the end of the manuscript

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102482.

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