Trends in Socio-economic Inequality in Smoking Among Middle-Aged and Older Adults in China: Evidence from the 2011 and 2018 China Health and Retirement Longitudinal Study

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Abstract

Introduction: Socio-economic inequalities in smoking and related health problems are a public health concern worldwide. To support the development of effective tobacco control policies, this study examines trends in smoking rates according to socio-economic status (SES) in China.

Methods: We analysed data from repeated cross-sectional China Health and Retirement Longitudinal Study (CHARLS) on adults aged ≥ 45 years for the years 2011 and 2018, which involved 16,471 participants in 2011 and 19,367 in 2018. We then estimated the SES of individuals based on four types of wealth-related variables, namely, education, occupation, household characteristics and durable consumer goods. Principal-component analysis was conducted to measure SES, and the Erreygers normalised concentration index (ECI) was used to calculate socio-economic inequality in current smoking by gender, age and region.

Results: The overall ECI (95% confidence interval) for women was −0.042 (−0.054 to −0.031) and −0.038 (−0.047 to −0.029) for 2011 and 2018, respectively. The ECI (95% confidence interval) for men was −0.077 (−0.101 to −0.050) and −0.019 (−0.042 to 0.005) for 2011 and 2018, respectively. The inequality in smoking by SES for adults aged < 60 years in the Northeast region increased during 2011–2018, from −0.069 (−0.144 to 0.006) to −0.119 (−0.199 to −0.038) for women and from 0.009 (−0.115 to 0.132) to −0.164 (−0.296 to −0.032) for men.

Conclusions: smoking inequality by socio-economic among adults aged ≥ 45 years declined in recent years in China. However, smoking inequality by SES increased in other population groups.

Implications: Our research indicated that socio-economic inequality of current smoking among residents aged 45 years and older declined in 2018 when compared with 2011 numbers, particularly for men aged ≥ 60 years. Women in the Northeast region displayed more significant smoking inequality by SES than women in other regions did. During the study period, there was an increase in inequality in smoking by SES for adults aged < 60 years in the Northeast region. Thus, tobacco control policies and interventions should be targeted at high-risk subpopulations with lower SES, particularly in Northeast China.

Keywords: China, Erreygers normalised concentration index, inequality, middle-aged and older adults, smoking

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Data Availability Statement

The data that support the findings of this study are available in the China Health and Retirement Longitudinal Study (CHARLS) at http://charls.pku.edu.cn.

Declaration of Interests: None declared.

Ethics Approval: All study procedures were approved by the Ethics Committee of Wuhan University of Science and Technology (202 063). Additionally, CHARLS was approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015).

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Introduction

Smoking is a significant risk factor for many preventable diseases, such as cardiovascular and respiratory diseases and more than 20 different types of cancer.[1] In 2015, smoking resulted in 6.4 million deaths worldwide and was one of the five major risk factors for disability-adjusted life years in 109 countries and territories in reports of the World Health Organization.[2] China is both the world's largest tobacco manufacturer and consumer, accounting for 33% of the global tobacco production and 40% of global tobacco consumption.[3] The number of Chinese smokers was 316 million in 2015, almost 33% of the world's smoking population.[4] Recently, China has embarked on a massive campaign to control tobacco use, including 19 cities with comprehensive smoke-free laws and expanded smoking cessation services.[5] However, significant challenges remain to meet the 2030 Healthy China goal of reducing smoking prevalence to 20% and to identify disadvantaged groups more vulnerable to tobacco use and multiple inequalities, necessary for the development of precise and effective smoking prevention policies. Addressing health inequalities is a particularly significant aspect because they can reinforce gaps in income and wealth, which leads to a vicious cycle of health poverty traps. Poor health due to smoking can result in reduced economic productivity, bankruptcy of households and impoverished families.[6]

The prevalence of smoking is often more concentrated among the population with lower socio-economic status (SES).[7-9] smoking inequality by SES may lead to economic and health burdens among those with low SES. Reducing smoking inequality by socio-economic is a public health concern worldwide; it may play a significant role in reducing health inequity and is conducive to health globally.[10] smoking inequality by SES occurs due to multiple mechanisms, such as lack of social cohesion and psychological and financial strain.[11,12] Tobacco control interventions have predominately focused on modifying individual-level tobacco-related perceptions, attitudes, and exposures, including motivation to quit and knowledge about the harms of smoking or modification of exposure to smoking cues through smoking bans and advertising.[12] However, the equity impacts of these tobacco control interventions are less clear: only price/taxation policies demonstrate consistent evidence of equity-positive impacts.[1] While tobacco control efforts have reduced smoking prevalence globally, tobacco control policies may not reduce inequality in smoking prevalence by SES. For example, mass media health education is associated with greater decreases in smoking among higher SES populations.[14–16] Likewise, smoke-free rules are more likely to be implemented in professional rather than manual workplaces; similarly, smoke-free rules in

public places are less likely to be enforced in disadvantaged compared to higher income areas; similarly, smoke-free rules in public places are less likely to be enforced in disadvantaged compared to higher income areas.[17–20] To identify the measures most likely to reduce smoking inequality, it is necessary to continuously monitor the status of tobacco control and inequality in smoking to support the development of evidence-based tobacco control policies that reduce inequality.[10]

The relationship between SES and smoking prevalence varies across regions and times in China. Two perspectives can be attributed as reasons. On the one hand, economic growth and rising incomes have increased access to tobacco products.[21,22] In other words, tobacco is becoming increasingly affordable across social strata over time, which could exert a greater impact on people with low levels of income or education.[23] By contrast, the types and availability of control measures for tobacco may vary by region and time, which leads to differential impacts on vulnerable populations.[13,17] For example, tobacco restrictions in the workplace are higher in the north and east of China, whereas smoking in public places is more common in the west, central and far northeast places.[24] Although previous studies reflected the socio-economic inequality of smoking behaviour in China, only a few studies have examined smoking inequality trends over time.[22,25,26] Furthermore, the country is geographically divided into a more developed East China and a less developed Middle and West China. The analysis of the prevalence of smoking stratified by region (East, Middle, West and Northeast) will improve the understanding of the socio-economic gradient of smoking in different areas of China. Changes in smoking prevalence over time among different SES subgroups will provide valuable information on the impacts of national measures for national tobacco control on health inequality and for the future development of tobacco control policies in the direction of health equity.

Methods

Data sources and sample selection

We used data from the 2011 and 2018 cross-sectional surveys from China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal study of adults aged ≥ 45 years conducted by the China Centre for Economic Research at Peking University.[2] Samples were selected using a multistage probability proportional-to-size sampling technique, stratified by regions urban districts or rural counties, and per capita gross domestic product in that order. The sample covered 150 county-level units, 450 village-level units and 17,708 individuals from 10,257 households across 28 provinces. The

response rate for the survey was 80.5%.[27,28] The CHARLS baseline survey was launched in 2011, where sampling was conducted every 2 or 3 years. Face-to-face interviews were conducted to collect information on socio-demographic characteristics and self-reported smoking status. The questionnaire provided information about socio-demographic status, health care and status, cognition and depression, work retirement and property status.[29] After excluding invalid and missing data, the number of adults aged ≥ 45 years enrolled in the CHARLS study was 16,471 in 2011 and 19,367 in 2018, including 12,652 individuals who participated in the 2011 and 2018 surveys. The invalid and missing values rate of this study was 4.5%. All analyses were weighted using individual weights adjusted for non-response to obtain robust results.

Ethics approval and consent to participate

The Biomedical Ethics Review Committee approved CHARLS for Peking University in January 2011 (approval number: IRB00001052-11015). All participants provided informed consent before interviews. We requested approval from the CHARLS Team for this study and received anonymous participant data.[30] All study procedures were approved by the Ethics Committee of Wuhan University of Science and Technology (approval number: 202063).

Measurements

The SES of individuals may be defined according to several variables, such as education, income, occupation, durable consumer goods and household characteristics.[31-34] In this study, we used wealth (durable consumer goods and household characteristics) as a proxy for income for two reasons: (1) the number of missing values for income was substantial, and (2) in developing countries, it is frequently difficult to measure income accurately because of its volatility.[35] It is well documented that wealth represents longer-term economic status than income or consumption.[35,36] However, the wealth index may be an inadequate measure of SES if education and occupation are omitted.[37]

Thus, this study used four types of wealth-related index variables to represent the SES of the participants: (1) *education*, (2) *occupation*, (3) *household characteristics* and (4) *durable consumer goods*. Out of the four variables, education was classified as no formal education, primary school, middle school and high school and above. Occupation was categorised as either agricultural or non-agricultural. Household

characteristics included improved or unimproved material, number of bedrooms, having a toilet, electricity, tap water, heating, bath facility, coal gas or natural gas, telephone and Internet connection. Durable consumer goods included owning an automobile, electric bicycle, motorcycle, fridge, washing appliance, television, computer, sound system, video camera, camera, air conditioner, mobile phone, furniture, musical instrument, valuable decorations, jewellery or precious metals and collectibles or artistic works.

To measure the SES with the wealth-related index variables, we used principal-component analysis, a standard factor analysis method to reduce a series of variables into a single index.[38] Based on wealth-related index variables, principal-component analysis computes several components. Only the first component can represent the SES because the top part of variance was explained by it (61.86% in 2011 and 61.79% in 2018).[33,39] Based on the first component, the participants were classified into five SES quintiles, with Quintile 1 including the lowest 20% and Quintile 5 the highest 20%. Analysis of SES in our study was conducted for each year.

Participants were stratified by *gender* (women, men), *age* (< 60 y and ≥ 60 y) and *region* (East, Middle, West and Northeast). The *East* region includes Shanghai, Beijing, Tianjin, Shandong, Guangdong, Jiangsu, Hebei, Zhejiang and Fujian; the *Middle* region includes Anhui, Shanxi, Jiangxi, Henan, Hubei and Hunan; the *West* region includes Yunnan, Sichuan, Guangxi, Mongolia, Xinjiang, Gansu, Guizhou, Chongqing, Shaanxi and Qinghai; and the *Northeast* region includes Jilin, Liaoning and Heilongjiang.

In the CHARLS, *smokers* were defined as those who smoked more than 100 cigarettes over a lifetime and were classified as current and former smokers according to the following question: Do you still have the smoking habit or have you quit?

Statistical analysis

We used concentration curve and concentration index to estimate the smoking inequality by SES. The concentration curve plots the cumulative percentage of the current smoking (*y* axis) against the cumulative percentage of the population, ranked by their SES from lowest to highest (*x* axis).[40] The *diagonal 45° line* in the concentration curve plot is defined as the *line of equality*, which indicates the lack of association between SES and smoking. If the curve is above the line of equality, it indicates that the current smoking rate is higher among the population with lower SES. The curve that lies *below* the line of equality indicates

that the relatively more affluent population has a higher rate of current smoking.[9]

The concentration index (C) is defined as double the area between the concentration curve and the line of equality, which quantifies the degree of smoking inequality by SES, as shown in the following equation:

$$C_{(y)} = \frac{2}{u} Cov(y_i . R_i)$$

where y_i represent the health variable of individuals, u is the mean of y, and R_i is the fractional ranking of individual SES.[41] The value of concentration index ranges from −1 to 1 under the assumption that a negative (vs. positive) value suggests the health outcome as concentrated among people with lower (vs. higher) SES. However, for the binary health variable, the concentration index ranges from u-1-1 $-u$. We used the Erreyger's method to estimate the normalised concentration index (ECI) ranging from −1 to 1, because current smoking is a binary outcome.[42] The ECI is defined in the following equation:

$$ECI = 4 * u * C_{(y)}$$

where the $C_{(y)}$ is the generalised concentration index, and the u is the mean of the health outcome.[36]

Results

Table 1 shows the participant characteristics by SES. The gender distribution among samples was 51.68% women versus 48.32% men for 2011 and 51.36% women versus 48.64% men for 2018. The proportion of participants aged < 60 years decreased from 55.5% in 2011 to 43.5% in 2018, and the proportion of those aged ≥ 60 years increased from 44.5% in 2011 to 56.5% in 2018. This change in age distribution over time was due to the ageing of individuals who participated in the 2011 and 2018 surveys. Generally, the SES was lower among older adults and residents in the *West* region. During the study period, the proportion of participants with lower SES increased, whereas that with high levels of SES decreased in the *Northeast* region.

Supplementary Table 1 shows the age-adjusted prevalence of current smokers by gender and region for 2011 and 2018. The current smoking rate was much higher for men than it was for women; 50.3% versus 5.5% in 2011 and 50.0% versus 4.4% in 2018. Significantly, the current smoking rates among women in Northeast China (14.5% in 2011 and 13.2% in 2018) were much higher than they were in other regions (4.3%–5.4% in 2011 and 3.3%–4.1% in 2018). The rate of current smoking in 2018 tended to be

lower than that in 2011 although 95% confidence intervals indicate that the differences in smoking prevalence between 2011 and 2018 were statistically non-significant in general.

Figure 1 presents the change in age-adjusted prevalence of current smokers by SES quintile and gender in 2011 and 2018. The current smoking rates for women in 2018 were lower than they were in 2011 in all SES quintile groups. For the prevalence of current smokers among men, a curve with a steep slope indicated much higher smoking prevalence in lower-SES subgroups in 2011, and a relatively more flat curve implies reduced differences in smoking prevalence across SES subgroups in 2018 (Fig. 1). The smoking rates in men decreased in low-SES subgroups and increased in high-SES subgroups in 2018 when compared with the corresponding rates in 2011.

Figure 2 presents the concentration curves for current smoking by gender in 2011 and 2018. For women, the concentration curves were clearly above the line of equality, which indicates the existence of smoking inequality by SES. The concentration curves for 2011 and 2018 were close to each other and suggested no significant change in SES inequality in current smoking over time. Although the concentration curves for men were also above the line of equality in both 2011 and 2018, the concentration curve shifted considerably closer to the line of equality in 2018, which indicated the decline of SES inequality in current smoking in men.

Table 2 presents the ECI estimates by gender, region and age for 2011 and 2018. The overall ECI (and 95% confidence interval) for women were −0.042 (−0.053 to −0.031) in 2011 and −0.037 (−0.046 to −0.028) in 2018. The ECI and 95% confidence intervals for men were −0.076 (−0.101 to −0.050) in 2011 and −0.018 (−0.042 to 0.005) in 2018. Because the 95% confidence interval overlaps with the line of equality, the ECI for men in 2018 was statistically non-significant ($P > 0.05$).

For women and men, adults aged ≥ 60 years had a higher SES inequality of current smoking in 2011. However, the inequality in smoking by SES for adults aged ≥ 60 years declined in 2018 when compared with the corresponding inequality in 2011, whereas no significant changes were noted for adults aged < 60 years over time. Particularly, the overall ECI for men aged ≥ 60 years declined from −0.131 (−0.168 to −0.094) in 2011 to −0.041 (−0.072 to −0.010) in 2018.

Women in the *Northeast* region displayed higher levels of smoking inequality by SES than women in other regions did (Table 2). The smoking inequality by SES for women aged < 60 years in the *Northeast* region increased from −0.069 (−0.144 to 0.006) in 2011 to −0.119 (−0.199 to −0.038) in 2018. The

increase in smoking inequality by SES for men aged < 60 years in the *Northeast* region was particularly considerable, that is, from 0.009 (−0.115 to 0.132) in 2011 to −0.164 (−0.296 to −0.032) in 2018.

Discussion

Our research explored the trend in socio-economic inequality of smoking among residents aged 45 years and older in China. This study shows that the SES inequality of current smoking declined in 2018 when compared with 2011, especially for men. Previous research found higher levels of smoking prevalence among smokers who were less educated and with lower SES, engaged in a lower-ranking occupation or lived in a disadvantaged area.[9,43] Our estimated ECIs in 2018 showed negative values for both women and men, suggesting that smoking behaviour is still concentrated among adults with lower SES.

The prevalence of current smoking among men was much higher than that among women in China, and similar patterns in smoking prevalence have been documented in other Asian countries.[9] Our study showed that the current smoking rate had a decreasing trend among those with lower SES. The decline of SES inequality in current smoking could be attributed to the tobacco control policy in China. Some research indicated that increasing the price of tobacco products reduces smoking inequality by SES because the impact of price increase on smoking behaviour is larger for individuals with lower SES.[17,44] The tobacco tax in China is at a low level when compared with other countries, with the growth of gross domestic product making cigarettes more affordable over time.[45,46] To strengthen the tobacco control policy in China, the tobacco excise tax was raised in 2009, leading to an increase in the retail price of cigarettes by 3.4% (US$0.98 to US$1.01).[47,48] In 2015, the tobacco excise tax was raised again—the fourth significant national tobacco tax reform since 1994. The retail price of cigarettes has increased by 11% (US$11.6 to US$12.8) on average, with that of the least expensive type of cigarettes brands increasing by 20% (US$0.38 to US$0.45) from 2014 to 2016.[49] Substantial evidence has shown that raising the tobacco tax was the most effective tobacco control policy instrument in China.[46]

Our study found that all subpopulations had a decrease in SES inequality of current smoking, except the *Northeast* regional population, especially among the middle-aged population, as well as middle-aged men in the *Middle* and *West* regions. For middle-aged men in Middle and West China, the increase in SES inequality indicated that the distribution of current smoking shifted to people with lower SES. A previous

study showed a consistent pattern in which a less developed region had an increasing trend in current smoking among younger men.[9] For the smoking inequality by SES among *Northeast* adults, a possible reason is that the development speed of the *Northeast* region was relatively slow when compared with other regions in 2018 and when compared with those in 2011, which resulted in the decline of SES for adults in the *Northeast* region. Previous research showed that the extent of SES inequality of tobacco expenditure was more significant in less developed regions, in which the concentration of tobacco expenditure was among those with lower SES.[34]

In 2018, the *Northeast* region participants with lower SES had a higher prevalence of current smoking than that for corresponding participants in other regions, for both men and women. The highest SES inequality in all subpopulations was among the *Northeast* region's middle-aged men, which indicates a higher current smoking rate among men with lower SES. This may be due to the increased prevalence of current smoking among the *Northeast* region's men, with a significant rise among the more impoverished. Previous findings showed that the *Northeast* region's residents had a higher prevalence of current smoking among women. These findings were consistent with our study results.[24,50] Although smoking in public places might harm public health through passive smoking,[24,51] many people in the *Northeast* region did not support the total ban on smoking in public places.[50] Therefore, tobacco control policies need to pay increased attention to health problems among the *Northeast* region's population with low levels of SES.

The strength of this study is that it is the first to show the trends of socio-economic inequality in current smoking among residents aged 45 years and older in China. We estimated the smoking inequality according to four SES components of the wealth-related index: education, occupation, household characteristics and durable consumer goods. This study also had some limitations. First, self-reported prevalence of smoking may result in recall bias, and the participants excluded due to missing data may result in error. Second, our study only presented the trends of socio-economic inequality in current smoking rather than other smoking behaviours, such as initiation, cessation and dependence. Third, our study did not further analyse the determinants of disparities in smoking behaviours.

Conclusions

SES inequality of current smoking among residents aged 45 years and older declined in 2018 when compared with that in 2011, which is particularly notable for men aged ≥ 60 years. Women in the *Northeast* region exhibited high levels of smoking inequality by SES when compared with women in other

regions. During the study period, there was an increase in the smoking inequality by SES for adults aged < 60 years in the *Northeast* region. Tobacco control policies and interventions should be targeted at high-risk subpopulations with low levels of SES, particularly in Northeast China.

References

1. Jha P Avoidable global cancer deaths and total deaths from smoking. Nat Rev Cancer 2009;9:655-664. DOI: 10.1038/nrc2703. published online first: 2009/8/21.
2. GBD 2015 Tobacco Collaborators Smoking prevalence and attributable disease burden in 195 countries and territories, 1990-2015: a systematic analysis from the Global Burden of Disease Study 2015. Lancet 2017;389:1885-1906. DOI: 10.1016/S0140-6736(17)30819-X. published online first: 2017/4/10.
3. Wipfli H, Samet JM Global economic and health benefits of tobacco control: part 1. Clin Pharmacol Ther 2009;86:263-271. DOI: 10.1038/clpt.2009.93. published online first: 2009/6/19.
4. Zhong Z, Wei H, Yang L, Yao T, Mao Z, Sun Q Catastrophic health expenditure: A comparative analysis of smoking and non-smoking households in China. PLOS ONE 2020;15:e0233749. DOI: 10.1371/journal.pone.0233749. published online first: 2020/5/30.
5. Parascandola M, Xiao L Xiao L. Tobacco and the lung cancer epidemic in China. Transl Lung Cancer Res 2019;8(suppl 1):S21-S30. DOI: 10.21037/tlcr.2019.03.12. published online first: 2019/6/19.
6. Bor J, Cohen GH, Galea S Population health in an era of rising income inequality: USA, 1980-2015. Lancet 2017;389:1475-1490. DOI: 10.1016/S0140-6736(17)30571-8. published online first: 2017/4/14.
7. Ciapponi A, World Health Organization. Systematic Review of the Link between Tobacco and Poverty; 2014.
8. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M Socioeconomic status and smoking: a review. Ann N Y Acad Sci 2012;1248:107-123. DOI: 10.1111/j.1749-6632.2011.06202.x. published online first: 2011/11/19.
9. Mariapun J, Hairi NN, Ng CW Socioeconomic differences in smoking and cessation across a period of rapid economic growth in an upper-middle-income country. Nicotine Tob Res 2019;21:1539-1546. DOI: 10.1093/ntr/nty203. published online first: 2018/9/27.
10. Tabuchi T, Iso H, Brunner E Tobacco control measures to reduce socioeconomic inequality in smoking: the necessity, time-course perspective, and future implications. J Epidemiol 2018;28:170-175. DOI: 10.2188/jea.JE20160206. published online first: 2017/11/21.

11. Martinez SA, Beebe LA, Thompson DM, Wagener TL, Terrell DR, Campbell JE A structural equation modeling approach to understanding pathways that connect socioeconomic status and smoking. PLOS ONE 2018;13:e0192451.

12. Parnia A, Siddiqi A Socioeconomic disparities in smoking are partially explained by chronic financial stress: marginal structural model of older US adults. J Epidemiol Community Health 2020;74:248-254. DOI: 10.1136/jech-2019-213357. published online first: 2019/12/25.

13. Smith CE, Hill SE, Amos A Impact of population tobacco control interventions on socioeconomic inequalities in smoking: A systematic review and appraisal of future research directions. Tob Control 2020;30(e2):e87-e95. DOI: 10.1136/tobaccocontrol-2020-055874. published online first: 2020/10/1.

14. Giskes K, Kunst AE, Benach J, Borrell C, Costa G, Dahl E, Dalstra JA, Federico B, Helmert U, Judge K, Lahelma E, Moussa K, Ostergren PO, Platt S, Prattala R, Rasmussen NK, Mackenbach JP Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. J Epidemiol Community Health 2005;59:395-401. DOI: 10.1136/jech.2004.025684. published online first: 2005/4/16.

15. Tanaka H, Mackenbach JP, Kobayashi Y Widening Socioeconomic inequalities in smoking in Japan, 2001-2016. J Epidemiol 2021;31:369-377. DOI: 10.2188/jea.JE20200025. published online first: 2020/7/1.

16. Song F, Elwell-Sutton T, Naughton F, Gentry S Future smoking prevalence by socioeconomic status in England: A computational modelling study. Tob Control 2020;30:380-385. DOI: 10.1136/tobaccocontrol-2019-055490. published online first: 2020/5/25.

17. Hill S, Amos A, Clifford D, et al Impact of tobacco control interventions on socioeconomic inequalities in smoking: review of the evidence. Tob Control 2014;23(e2):e89-e97. DOI: 10.1136/tobaccocontrol-2013-051110. published online first: 2013/9/21.

18. Niederdeppe J, Farrelly MC, Nonnemaker J, Davis KC, Wagner L Socioeconomic variation in recall and perceived effectiveness of campaign advertisements to promote smoking cessation. Soc Sci Med 2011;72:773-780. DOI: 10.1016/j.socscimed.2010.12.025. published online first: 2011/2/15.

19. Brenner H, Born J, Novak P, Wanek V Smoking behavior and attitude toward smoking

regulations and passive smoking in the workplace. A study among 974 employees in the German metal industry. Prev Med 1997;26:138-143. DOI: 10.1006/pmed.1996.9981. published online first: 1997/1/1.

20. Lock K, Adams E, Pilkington P, Duckett K, Gilmore A, Marston C Evaluating social and behavioural impacts of English smoke-free legislation in different ethnic and age groups: implications for reducing smoking-related health inequalities. Tob Control 2010;19:391-397.

21. Bhan N, Karan A, Srivastava S, Selvaraj S, Subramanian SV, Millett C Have socioeconomic inequalities in tobacco use in India increased over time? Trends from the national Sample Surveys (2000-2012). Nicotine Tob Res 2016;18:1711-1718. DOI: 10.1093/ntr/ntw092. published online first: 2016/4/7.

22. Si Y, Zhou Z, Su M, Wang X, Li D, Wang D, He S, Hong Z, Chen X Socio-Economic inequalities in tobacco consumption of the older adults in China: A decomposition method. Int J Environ Res Public Health 2018;15. DOI: 10.3390/ijerph15071466. published online first: 2018/7/13.

23. Licht AS, Hyland AJ, O'Connor RJ, Chaloupka FJ, Borland R, Fong GT, Nargis N, Cummings KM Socio-economic variation in price minimizing behaviors: findings from the International Tobacco Control (ITC) Four country Survey. Int J Environ Res Public Health 2011;8:234-252. DOI: 10.3390/ijerph8010234. published online first: 2011/2/15.

24. Astell-Burt T, Zhang M, Feng X, Wang L, Li Y, Page A, Zhou M, Wang L Geographical inequality in tobacco control in China: multilevel evidence from 98 058 Participants. Nicotine Tob Res 2018;20:755-765. DOI: 10.1093/ntr/ntx100. published online first: 2017/5/19.

25. Liu Y, Wang M, Tynjälä J, Villberg J, Lv Y, Kannas L Socioeconomic differences in adolescents' smoking: a comparison between Finland and Beijing, China. BMC Public Health 2016;16:805. DOI: 10.1186/s12889-016-3476-0. published online first: 2016/8/19.

26. Wang Q, Shen JJ, Sotero M, Li CA, Hou Z Income, occupation and education: are they related to smoking behaviors in China? PLOS ONE 2018;13:e0192571. DOI: 10.1371/journal.pone.0192571. published online first: 2018/2/9.

27. Su D, Chen YC, Gao HX, Li HM, Chang JJ, Jiang D, Hu XM, Lei SH, Tan M, Chen ZF Effect of integrated urban and rural residents medical insurance on the utilisation of medical services by residents in China: a propensity score matching with difference-in-differences regression

approach. BMJ Open 2019;9:e026408. DOI: 10.1136/bmjopen-2018-026408. published online first: 2019/2/21.

28. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). Int J Epidemiol 2014;43:61-68. DOI: 10.1093/ije/dys203. published online first: 2012/12/18.

29. Liu J, Yang Y, Zhou J, Liu T, Zhang W, Wei L, Wu S Prevalence and associated factors of compliance behaviors among middle-aged and older hypertensive patients in China: results from the China Health and Retirement Longitudinal Study. Int J Environ Res Public Health 2020;17. DOI: 10.3390/ijerph17197341. published online first: 2020/10/15.

30. Qiu D, Chen T, Liu T, Song F Smoking cessation and related factors in middle-aged and older Chinese adults: evidence from a longitudinal study. PLOS ONE 2020;15:e0240806. DOI: 10.1371/journal.pone.0240806. published online first: 2020/10/16.

31. JieAnNaMu XX, Xu X, You H, Gu H, Gu J, Li X, Cui N, Kou Y Inequalities in health-related quality of life and the contribution from socioeconomic status: evidence from Tibet, China. BMC Public Health 2020;20:630. DOI: 10.1186/s12889-020-08790-7. published online first: 2020/5/8.

32. Wondimu A, van der Schans J, van Hulst M, Postma MJ Inequalities in rotavirus vaccine uptake in Ethiopia: A decomposition analysis. Int J Environ Res Public Health 2020;17. DOI: 10.3390/ijerph17082696. published online first: 2020/4/17.

33. Yazdi-Feyzabadi V, Rashidian A, Amini Rarani M Socio-economic inequality in unhealthy snacks consumption among adolescent students in Iran: a concentration index decomposition analysis. Public Health Nutr 2019;22:2179-2188. DOI: 10.1017/S1368980019000740. published online first: 2019/6/15.

34. Rezaei S, Pulok MH, Ebrahimi M Socioeconomic inequality in tobacco expenditure in Iran: a cross-sectional analysis at national and subnational levels. BMC Public Health 2020;20:1031. DOI: 10.1186/s12889-020-09144-z. published online first: 2020/7/1.

35. Rutstein SO, Johnson K. The DHS Wealth Index. DHS Comparative Reports No. 6. *Calverton: ORC Macro*; 2004.

36. Shifti DM, Chojenta C, Holliday EG, Loxton D Socioeconomic inequality in short birth interval in Ethiopia: a decomposition analysis. BMC Public Health 2020;20:1504. DOI: 10.1186/s12889-

020-09537-0. published online first: 2020/10/8.

37. Dudeja P, Bahuguna P, Singh A, Bhatnagar N Refining a socio-economic status scale for use in community-based health research in India. J Postgrad Med 2015;61:77-83. DOI: 10.4103/0022-3859.150442. published online first: 2015/3/15.

38. Cao G, Cui Z, Ma Q, Wang C, Xu Y, Sun H, Ma Y Changes in health inequalities for patients with diabetes among middle-aged and elderly in China from 2011 to 2015. BMC Health Serv Res 2020;20:719. DOI: 10.1186/s12913-020-05609-4. published online first: 2020/8/8.

39. Almasi-hashiani A, Sepidarkish M, Safiri S, Khedmati Morasae E, Shadi Y, Omani-Samani R Understanding determinants of unequal distribution of stillbirth in Tehran, Iran: a concentration index decomposition approach. BMJ Open 2017;7:e013644. DOI: 10.1136/bmjopen-2016-013644. published online first: 2017/5/19.

40. Triaca LM, Dos Santos AMA, Tejada CAO Socioeconomic inequalities in obesity in Brazil. Econ Hum Biol 2020;39:100906. DOI: 10.1016/j.ehb.2020.100906. published online first: 2020/7/30.

41. Alves J, Kunst AE, Perelman J Evolution of socioeconomic inequalities in smoking: results from the Portuguese national health interview surveys. BMC Public Health 2015;15:311. DOI: 10.1186/s12889-015-1664-y. published online first: 2015/4/18.

42. Erreygers G Correcting the concentration index. J Health Econ 2009;28:504-515. DOI: 10.1016/j.jhealeco.2008.02.003. published online first: 2008/3/28.

43. Santero M, Melendi S, Hernández-Vásquez A, Irazola V Socio-economic inequalities in smoking prevalence and involuntary exposure to tobacco smoke in Argentina: analysis of three cross-sectional nationally representative surveys in 2005, 2009 and 2013. PLOS ONE 2019;14:e0217845. DOI: 10.1371/journal.pone.0217845. published online first: 2019/6/8.

44. Thomas S, Fayter D, Misso K, Ogilvie D, Petticrew M, Sowden A, Whitehead M, Worthy G Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. Tob Control 2008;17:230-237. DOI: 10.1136/tc.2007.023911. published online first: 2008/4/23.

45. Guo H, Quan G Tobacco control in China and the road to Healthy China 2030. Int J Tuberc Lung

Dis 2020;24:271-277. DOI: 10.5588/ijtld.19.0106. published online first: 2020/4/2.

46. Xu X, Zhang X, Hu TW, Miller LS, Xu M Effects of global and domestic tobacco control policies on cigarette consumption per capita: an evaluation using monthly data in China. BMJ Open 2019;9:e025092. DOI: 10.1136/bmjopen-2018-025092. published online first: 2019/6/22.

47. Gao S, Zheng R, Hu TW Can increases in the cigarette tax rate be linked to cigarette retail prices? Solving mysteries related to the cigarette pricing mechanism in China. Tob Control 2012;21:560-562. DOI: 10.1136/tobaccocontrol-2011-050027. published online first: 2012/10/19.

48. Hu TW, Mao Z, Shi J Recent tobacco tax rate adjustment and its potential impact on tobacco control in China. Tob Control 2010;19:80-82. DOI: 10.1136/tc.2009.032631. published online first: 2009/10/24.

49. Goodchild M, Zheng R Early assessment of China's 2015 tobacco tax increase. Bull World Health Organ 2018;96:506-512. DOI: 10.2471/BLT.17.205989. published online first: 2018/7/3.

50. Li Z, Yao Y, Han W, Yu Y, Liu Y, Tao Y, Kou C, Jiang L, Sun Q, Yin Y, Zhang H, Li B Smoking prevalence and associated factors as well as attitudes and perceptions towards tobacco control in Northeast China. Int J Environ Res Public Health 2015;12:8606-8618. DOI: 10.3390/ijerph120708606. published online first: 2015/7/25.

51. Li Z, Yao Y, Yu Y, et al Prevalence and associated factors of passive smoking among women in Jilin Province. China: A Cross-Sectional. study. Int J Environ Res Public Health 2015;12(11):13970-13980. DOI: 10.3390/ijerph121113970. published online first: 2015/11/4.

Figure 1. Change of age-adjusted prevalence of current smokers by socio-economic status and gender in 2011 and 2018.

Figure 2. Concentration curves for socio-economic status (SES) inequality in current smoking by gender in 2011 and 2018.

Table 1. Socio-demographic Characteristics of Participants in 2011 and 2018

Year (Participants [N])	Variables	%	Socio-economic Groups (%) by Quintile				
			1 (Lowest)	**2**	**3**	**4**	**5 (Highest)**
2011 (16 471)							
Gender	Women	51.68	20.26	20.75	20.09	19.66	19.23
	Men	48.32	19.73	19.19	19.89	20.37	20.82
Age (years)	< 60	55.45	13.66	18.90	20.84	21.77	24.83
	≥ 60	44.55	27.89	21.37	18.95	17.80	13.99
Region	East	34.58	13.49	15.61	18.06	22.80	30.04
	Middle	26.82	20.80	19.96	22.27	21.16	15.82
	West	30.47	27.31	25.10	20.25	15.72	11.63
	Northeast	8.13	17.75	19.69	19.77	20.34	22.45
2018 (19 367)							
Gender	Women	51.36	22.43	20.46	20.14	19.05	17.92
	Men	48.64	17.44	19.51	19.85	21.00	22.20
Age (years)	< 60	43.41	9.03	16.37	20.50	24.77	29.32
	≥ 60	56.59	28.42	22.78	19.62	16.34	12.85
Region	East	33.83	15.14	16.07	19.34	21.96	27.49
	Middle	27.14	19.40	18.04	20.66	22.98	18.91
	West	31.34	26.28	24.42	20.13	15.57	13.60
	Northeast	7.69	17.97	26.12	20.05	18.88	16.98

Note. in the % column and the Socio-economic Groups (%) by Quintile column, these figures refer to a percentage.

Table 2. Erreygers Normalised Concentration Indexes (ECI) by Gender and Region for Current Smoking in 2011 and 2018

Gender	Region	Age (Years)	ECI (95% Confidence Interval)	
			2011	2018
Women	East	< 60	−0.017 (−0.039 to 0.004)	−0.021 (−0.040 to −0.001)
		≥ 60	−0.055 (−0.092 to −0.019)	−0.047 (−0.071 to −0.024)
		all	−0.046 (−0.066 to −0.027)	−0.045 (−0.061 to −0.029)
	Middle	< 60	−0.023 (−0.041 to −0.004)	−0.014 (−0.032 to 0.004)
		≥ 60	−0.042 (−0.076 to −0.008)	−0.022 (−0.047 to 0.002)
		all	−0.042 (−0.061 to −0.024)	−0.03 (−0.045 to −0.014)
	West	< 60	−0.024 (−0.045 to −0.003)	−0.011 (−0.029 to 0.007)
		≥ 60	−0.036 (−0.065 to −0.007)	−0.017 (−0.038 to 0.003)
		all	−0.033 (−0.050 to −0.015)	−0.019 (−0.032 to −0.005)
	Northeast	< 60	−0.069 (−0.144 to 0.006)	−0.119 (−0.199 to −0.038)
		≥ 60	−0.187 (−0.294 to −0.080)	−0.133 (−0.212 to −0.054)
		all	−0.128 (−0.191 to −0.066)	−0.130 (−0.186 to −0.073)
	Total	< 60	−0.023 (−0.035 to −0.010)	−0.024 (−0.036 to −0.013)
		≥ 60	−0.066 (−0.100 to −0.032)	−0.034 (−0.047 to −0.020)
		all	−0.042 (−0.053 to −0.031)	−0.037 (−0.046 to −0.028)
Men	East	< 60	−0.106 (−0.166 to −0.046)	0.008 (−0.058 to 0.075)
		≥ 60	−0.086 (−0.154 to −0.018)	0.005 (−0.050 to 0.060)
		all	−0.076 (−0.121 to −0.031)	0.028 (−0.015 to 0.070)

Middle	< 60	−0.052 (−0.117 to 0.012)	−0.099 (−0.165 to −0.033)
	≥ 60	−0.140 (−0.208 to −0.072)	−0.039 (−0.096 to 0.018)
	all	−0.066 (−0.113 to −0.019)	0.009 (−0.035 to 0.053)
West	< 60	0.006 (−0.055 to 0.067)	−0.087 (−0.149 to −0.024)
	≥ 60	−0.162 (−0.226 to −0.099)	−0.076 (−0.129 to −0.022)
	all	−0.064 (−0.108 to −0.019)	−0.048 (−0.089 to −0.007)
Northeast	< 60	0.009 (−0.115 to 0.132)	−0.164 (−0.296 to −0.032)
	≥ 60	−0.148 (−0.292 to −0.003)	−0.091 (−0.211 to 0.029)
	all	−0.052 (−0.146 to 0.042)	−0.091 (−0.18 to −0.001)
Total	< 60	−0.046 (−0.066 to −0.027)	−0.067 (−0.103 to −0.031)
	≥ 60	−0.131 (−0.168 to −0.094)	−0.041 (−0.072 to −0.010)
	all	−0.076 (−0.101 to −0.050)	−0.018 (−0.042 to 0.005)

Figure 1

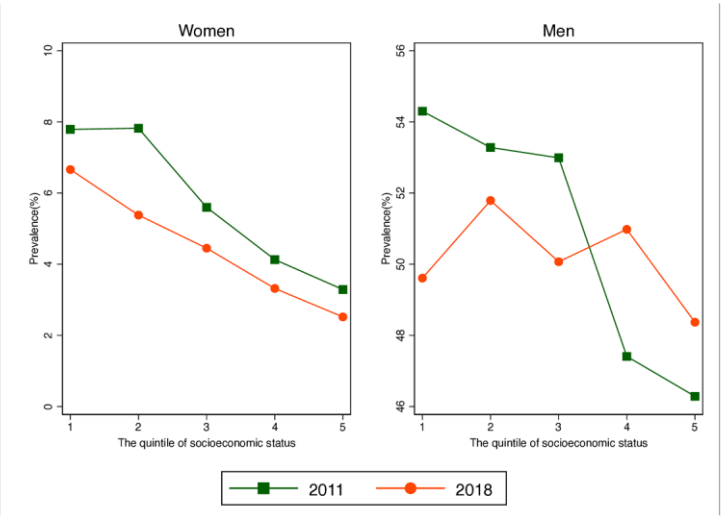

Figure 2