E-cigarette use among adults in China: findings from repeated cross-sectional surveys in 2015–16 and 2018–19

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Summary

Background The use of e-cigarettes among adults is increasing globally. Since 2018, policies in China have restricted e-cigarette use; however, little information is available on the national trend in e-cigarette use before regulations were implemented. Therefore, we sought to estimate the trend in e-cigarette use in China before policy implementation and explored associated factors.

Methods We assessed two nationally representative cross-sectional datasets from the China Chronic Disease and Nutrition Surveillance (CCDNS) surveys initiated in 2015 (June, 2015, to May, 2016) and 2018 (August, 2018, to June, 2019). The surveys were done at 298 national disease surveillance points in 31 provinces in mainland China, and used a multistage, stratified, cluster-randomised sampling design, recruiting community-based Chinese adults aged 18 years and older. Within the standard CCDNS survey, face-to-face questionnaire interviews were used to collect self-report data on e-cigarette use in the preceding 30 days. E-cigarette users were those who self-reported e-cigarette use on 1 day or more in the past 30 days. Prevalence estimates of past 30-day e-cigarette use were weighted to represent the Chinese adult population accounting for the complex sampling design. Populations for the years 2015–16 and 2018–19 were standardised with the 2010 population census to gain comparable estimates. Multivariable logistic regression models adjusted for age, sex, urban or rural residence, household income, occupation, and education level were applied to identify factors associated with the likelihood of e-cigarette use among the total population, ever smokers (current and former), and never smokers across both surveys.

Findings Our study included 189 306 Chinese adults from the 2015 survey (100 405 [53·0%] women; mean age 43·6 years [SD 14·6]) and 184 475 Chinese adults from the 2018 survey (102 373 [55·5%] women; mean age 43·4 years [13·9]). The weighted prevalence of past 30-day e-cigarette use among Chinese adults increased from 1·3% (95% CI 1·1–1·5%) in 2015–16 to 1·6% (95% CI 1·4–1·8%) in 2018–19 (an increase of 0·3% [95% CI 0·1–0·6]; Rao-Scott χ^2 p=0·0086). Based on weighted proportion data, e-cigarette users were predominantly men (97·4% [95% CI 96·7–98·1] in 2015–16 and 97·0% [95·4–98·6] in 2018–19) and current conventional smokers (93·0% [90·7–95·2] in 2015–16 and 96·2% [95·1–97·3] in 2018–19). Across both surveys, the odds of e-cigarette use were significantly associated with obesity (odds ratio 1·6 [95% CI 1·3–2·1]; p=0·0007), awareness of smoking hazards (1·2 [1·0–1·4]; p=0·022), and smoking status (in current smokers, 135·2 [87·7–208·6]; and in former smokers, 33·5 [21·3–52·7]; p<0·0001). Among current smokers, the odds were increased with daily cigarette consumption (2·1 [1·5–2·8]; p<0·0001), smoking more than 20 cigarettes per day (1·8 [1·5–2·3]; p<0·0001), and an attempt to quit smoking (within the past 12 months, 1·9 [1·5–2·4]; and before the past 12 months, 1·5 [1·3–1·9]; p<0·0001). In never smokers, the odds were increased in those aware of the hazards of smoking (2·4 [1·2–4·7]; p=0·011).

Interpretation E-cigarette use in China remains low but has increased substantially between 2015 and 2019. Our study identified increased e-cigarette use among subpopulations, and use patterns, that warrant further attention from public health policy makers in China.

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For the Chinese translation of the abstract see Online for appendix 1

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Introduction

E-cigarettes are battery-operated devices that electronically heat a solution to create an inhalable aerosol, which can contain nicotine.[1] E-cigarettes are promoted as a smoking cessation device, as a potentially less harmful way to self-administer nicotine than conventional cigarettes.[2,3] Evidence from high-income countries suggests that e-cigarettes are increasing rapidly in popularity, particularly in young populations.[4–6] However, with reports of e-cigarette-associated lung injury in 2019, the US Centers for Disease Control and Prevention recommended that youths, young adults, and women who are pregnant should not use e-cigarettes or vaping products that contain nicotine or tetrahydrocannabinol.

For the **recommendations of the US Centers for Disease Control and Prevention on use of e-cigarette and vaping products** see https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html

Research in context

Evidence before this study

We searched PubMed, the China National Knowledge Internet, Wanfang Data, and official websites of the Chinese Government for reports on e-cigarette use in China published up to June 1, 2020, with language restricted to English and Chinese. In 2015, the prevalence of current use of e-cigarettes in China was 0·5%, reported by the Global Adult Tobacco Survey (GATS) of e-cigarette use in China. In 2018, GATS reported a prevalence of current use of e-cigarettes of 0·9%. However, no studies or reports provided a detailed demographic, location-specific pattern of increased use, or identified factors that influenced e-cigarette use in China, which might differ from patterns in other countries, among the total population or subpopulations.

Added value of this study

Based on two large, nationally representative cross-sectional surveys involving 189 306 people in 2015 and 184 475 people in 2018, we used past 30-day e-cigarette use as the definition of current e-cigarette use and assessed how e-cigarette use in mainland China changed from 2015 to 2018. We also assessed the patterns in e-cigarette use in China according to sex, age group, region (urban or rural), occupation, annual household income, education level, smoking status, awareness of smoking hazards, and obesity. Our study showed that among Chinese adults aged 18 years and older, the estimated prevalence of past 30-day e-cigarette use significantly increased from 1·3% (95% CI 1·1–1·5%) in 2015 to 1·6% (1·4–1·8%) in 2018 in mainland China. Our study also identified increased use in men, young adults, smokers, urban residents, those with low educational status, and individuals with obesity.

Implications of all the available evidence

Our study confirmed an increased prevalence of e-cigarette use, irrespective of different definitions of current e-cigarette use. Evidence from our study indicates that in China, tobacco control campaign strategies need to be adapted, given the concerning trends of increased e-cigarette use in young adults, and the population with obesity, and the increased likelihood of use among never smokers who are aware of the hazards of smoking. These findings highlight the importance of urgent efforts by public health communities and policy makers to develop tailored, subpopulation-specific policy and public education strategies, and provide baseline evidence on the implications of 2018 upgrades to tobacco-free regulations in China.

Although China produced about 80% of the world's e-cigarettes in 2015, the prevalence of e-cigarette use among youth and adults was low among the Chinese population.[7,8] The China data of the Global Adult Tobacco Survey (GATS) in 2015 showed that 40·5% of the population aged 15 years and older had heard of e-cigarettes, and 3·1% had tried e-cigarettes at least once in their lifetime.[9] Furthermore, the International Tobacco Control Policy Evaluation Project in China revealed that the percentage of smokers who had heard of e-cigarettes increased from 29% (wave 3 survey; 2009) to 60% (wave 5 survey; 2014) and the percentage of smokers who had tried e-cigarettes at least once increased from 2% (wave 3 survey; 2009) to 11% (wave 5 survey; 2014).[10] However, the sample sizes of previous studies has limited the power to generalise results across urban and rural areas.

See Online for appendix 2

Since 2018, China implemented a strict national regulation policy to protect youth from e-cigarette use, and banned online selling of e-cigarettes on Nov 1, 2019.[11,12] Cities in mainland China—for instance, Shenzhen and Chengdu—have also revised tobacco control regulations to include e-cigarettes.[13,14] However, knowledge remains limited regarding the characteristics of e-cigarette users and trend in e-cigarette use in China before the regulations were implemented.

In the present study, to provide important baseline data, we sought to establish the trend in e-cigarette use in China before policy implementation, and explore associated factors, using cross-sectional data from the 2015 and 2018 China Chronic Disease and Nutrition Surveillance (CCDNS) surveys.

Methods

Study design and participants

We used two cross-sectional datasets of the CCDNS surveys initiated in 2015 (data collection from June, 2015, to May, 2016) and 2018 (August, 2018, to June, 2019). The CCDNS study was designed to assess the national profile of chronic diseases, related risk factors, and nutritional status among residents in 31 provinces of mainland China, via 298 national disease surveillance points. The Chinese Center for Disease Control and Prevention (China CDC; Beijing, China) has been organising consecutive surveys every 3–5 years since 2004.[15] The CCDNS study uses a multistage stratified cluster-randomised sampling design (appendix 2 p 2) and eligible participants are community-based Chinese residents aged 18 years and older who have been living in their current residence for at least 6 months in the 12 months before the survey. Exclusion criteria are: living for less than 6 months with the selected family in the preceding 12 months, currently not living at home, pregnancy, patients with stroke or other severe diseases that limit mobility, current hospitalisation, and having cognitive, language, or mental disorders that prevent participation. The CCDNS study was approved by the institutional review board of China CDC (approval number 201519-A) and the ethical review committee of the National Center for Chronic and Noncommunicable Disease Control and Prevention, China CDC (approval number 201819). All participants of the CCDNS study consented in writing.

Procedures

China CDC designed the standardised CCDNS study protocol, provided centralised training to provincial and local CDC staff, and developed an encrypted information collection and management platform that integrated sampling, questionnaire administration, identity verification, quality control, sample transportation, laboratory results upload, and progress monitoring. Trained local CDC staff reported sampling information, did face-to-face questionnaire interviews and physical measurements, collected blood and urine samples, and did on-site haemoglobin tests and site-centralised blood glucose tests. They administered questionnaires using portable application devices that recorded the interview process for data quality control, uploaded data to the encrypted platform, and recorded the transportation status of blood and urine samples from the site to a central laboratory via a WeChat-based mini-application. Provincial CDC staff provided secondary training to the local CDC staff, approved the sampling process, and supervised the data quality process by site visits, physical measurement calibration, and examining the interview recordings. The stringent quality control measures have been described previously.[16,17]

CCDNS 2015 was the first of the surveillance surveys to introduce e-cigarette-related questions in the face-to-face questionnaire on smoking behaviour (appendix 2 pp 3–4). CCDNS 2015 and 2018 defined past 30-day e-cigarette users as those who self-reported e-cigarette use on 1 day or more in the past 30 days. Frequent e-cigarette use was defined as use on 20 days or more in the past 30 days. Questionnaire design for conventional cigarette smoking status referred to the GATS,[18] and therefore categorised participants as ever smokers (current and former smokers) and never smokers. Current smokers were classified into daily smokers and occasional smokers (appendix 2 pp 3–4). Awareness of smoking hazards was defined as those who answer yes to the question, "To your knowledge, can smoking cause the following diseases? Stroke, heart attack, lung cancer". The mean number of cigarettes smoked per day was assessed among current smokers. We defined obesity as a body-mass index (BMI) of 30 kg/m² or greater using WHO criteria. Urban residency was defined as living in urban subdistricts and rural residency as living in rural townships. Education status was defined as primary or less, secondary level, and tertiary level. Occupation was defined as office, shop, or non-manual work; agricultural work; factory, construction, or manual work; retired; and unemployed. Annual household income was defined by quartiles of household income in 2015, with cutoff points of ¥15 000, ¥30 000, and ¥60 000. E-cigarette awareness was defined as those who answer yes to the question, "Have you ever heard about the electronic cigarette?" We compared the prevalence of e-cigarette use by education and annual household income levels between urban and rural residents in 2015–16 and 2018–19. We also compared age-specific e-cigarette use and awareness between overall and current smokers in 2015–16 and 2018–19.

Statistical analysis

Weighted proportions of the study sample, prevalence of e-cigarette use, and prevalence of e-cigarette awareness were calculated accounting for the complex sampling weight, stratification, and clusters. Populations for the years 2015–16 and 2018–19 were standardised with the 2010 population census of the National Bureau of Statistics of China to gain comparable estimates. The weighted prevalence of past 30-day e-cigarette use and daily e-cigarette use was estimated in the total population and in subgroups classified by age, sex, urban or rural residency, education level, occupation, annual household income, smoking status, awareness of smoking hazards, and obesity, for the years 2015–16 and 2018–19. Weighted proportions of e-cigarette users were assessed by sex, daily and frequent e-cigarette use, conventional cigarette use, and former and never smoker status. The Taylor series linearisation method was used to estimate variance. The Rao-Scott χ^2 test was used to compare prevalence rates between the years. Unweighted frequencies of e-cigarette use are also reported to represent the study sample. Multiariable logistic regression was used to examine the association of the odds of past 30-day e-cigarette use with conventional cigarette smoking status, awareness of smoking hazards, obesity, cigarette use pattern (frequency and quantity), and attempts to quit smoking. Four models were built to assess factors applicable among the total population, ever smokers (current and former), and never smokers, combining the populations of both surveys. All models were adjusted for age, sex, urban or rural residence, household income, occupation, and education level.

Sensitivity analyses of weighted prevalence rates were done to compare the prevalence distribution of e-cigarette use with regard to analysed factors between participants with and without a BMI measurement (appendix 2 pp 8–9).

The sampling scheme and exclusion of individuals are shown in appendix 2 (p 2). Participants who did not answer questions related to smoking or e-cigarette use were excluded and we did not impute missing data. All p values were two-tailed and 0·05 was the threshold for statistical significance. All analyses were done in SAS (version 9.4) and data was visualised in R software (version 4.0.0).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Our study included 189 306 participants of the CCDNS 2015 survey, and 184 475 participants of the CCDNS 2018 survey; the characteristics of the study population are shown in table 1 (overall response rate: 95·8% in 2015–16 and 94·8% in 2018–19; calculation shown in appendix 2 [p 5]). Across both surveys, 83 participants (<0·1%) did not answer questions related to e-cigarette use or smoking status and were excluded from the eligible study population. The mean age of participants in

	2015–16			2018–19			2015–16 *vs* 2018–19	
	Unweighted frequency of e-cigarette users among survey participants	Weighted proportion*	Weighted prevalence*	Unweighted frequency of e-cigarette users among survey participants	Weighted proportion*	Weighted prevalence*	Change in prevalence	p value†
Total population	1725/189 306	13 523 904/1 045 079 516	1·3% (1·1 to 1·5)	1777/184 475	16 877 811/1 051 380 392	1·6% (1·4 to 1·8)	0·3% (0·1 to 0·6)	0·0086
Age, years‡								
18–29	280/17 256	25·1% (24·0 to 26·1)	2·0% (1·7 to 2·4)	242/9925	25·5% (24·4 to 26·7)	2·7% (2·1 to 3·3)	0·8% (0·1 to 1·6)	0·036
30–39	291/23 130	20·6% (19·9 to 21·3)	1·7% (1·4 to 2·1)	268/18 482	20·5% (19·8 to 21·1)	1·8% (1·5 to 2·2)	0·1% (–0·4 to 0·7)	0·63
40–49	414/41 715	22·0% (21·5 to 22·6)	0·9% (0·7 to 1·1)	413/33 409	21·9% (21·3 to 22·5)	1·3% (1·1 to 1·5)	0·4% (0·1 to 0·7)	0·0034
50–59	433/45 756	15·3% (14·8 to 15·8)	1·0% (0·9 to 1·1)	469/48 252	15·2% (14·7 to 15·7)	1·1% (0·9 to 1·2)	0·1% (–0·1 to 0·2)	0·48
60–69	252/41 435	9·5% (9·0 to 10·0)	0·6% (0·5 to 0·7)	327/49 870	9·5% (9·1 to 9·9)	0·7% (0·6 to 0·8)	0·1% (–0·1 to 0·2)	0·38
≥70	55/20 014	7·4% (6·7 to 8·2)	0·2% (0·1 to 0·3)	58/24 537	7·4% (6·9 to 7·9)	0·2% (0·1 to 0·3)	0·0% (–0·1 to 0·1)	0·62
Sex								
Male	1634/88 901	50·6% (50·1 to 51·0)	2·5% (2·2 to 2·8)	1684/82 102	50·5% (49·8 to 51·2)	3·1% (2·7 to 3·5)	0·7% (0·2 to 1·2)	0·0097
Female	91/100 405	49·4% (49·0 to 49·9)	0·1% (0·0 to 0·1)	93/102 373	49·5% (48·8 to 50·2)	0·1% (0·0 to 0·2)	0·0% (–0·0 to 0·1)	0·32
Region§								
Urban	828/76 980	51·7% (47·5 to 55·9)	1·6% (1·3 to 1·9)	853/75 181	51·7% (47·4 to 56·0)	2·1% (1·7 to 2·5)	0·5% (0·1 to 0·9)	0·026
Rural	897/112 326	48·3% (44·1 to 52·5)	1·0% (0·8 to 1·1)	924/109 294	48·3% (44·0 to 52·6)	1·1% (1·0 to 1·2)	0·2% (–0·0 to 0·4)	0·057
Occupation								
Office, shop, or non-manual	762/70 857	47·2% (44·6 to 49·8)	1·7% (1·4 to 1·9)	759/67 638	48·6% (46·4 to 50·7)	1·8% (1·5 to 2·1)	0·2% (–0·2 to 0·6)	0·39
Agriculture	651/85 591	35·6% (32·4 to 38·9)	0·8% (0·7 to 0·9)	675/80 862	33·8% (31·1 to 36·5)	1·0% (0·9 to 1·2)	0·2% (0·0 to 0·3)	0·048
Factory, construction, or manual	106/7249	5·8% (5·1 to 6·5)	2·1% (1·5 to 2·7)	110/5825	4·9% (4·4 to 5·5)	3·3% (2·1 to 4·5)	1·6% (0·3 to 3·0)	0·015
Retired	124/17 153	5·3% (4·5 to 6·1)	0·7% (0·5 to 1·0)	147/20 451	5·3% (4·4 to 6·1)	1·0% (0·7 to 1·2)	0·2% (–0·1 to 0·5)	0·22
Unemployed	82/8456	6·1% (5·5 to 6·6)	1·1% (0·7 to 1·4)	86/9699	7·4% (6·7 to 8·2)	2·3% (1·2 to 3·4)	1·3% (0·1 to 2·6)	0·034
Annual household income								
Q1 (≤¥15 000)	276/38 326	14·7% (13·4 to 16·0)	0·9% (0·7 to 1·1)	251/32 270	13·0% (11·8 to 14·2)	1·4% (0·9 to 1·9)	0·6% (0·0 to 1·1)	0·048
Q2 (¥15 000–30 000)	361/40 206	19·6% (18·3 to 20·9)	1·2% (1·0 to 1·3)	323/32 033	15·3% (14·3 to 16·3)	1·2% (0·9 to 1·4)	0·1% (–0·3 to 0·4)	0·68
Q3 (¥30 000–60 000)	476/44 290	25·3% (24·1 to 26·4)	1·5% (1·2 to 1·7)	391/36 816	20·9% (19·7 to 22·1)	1·5% (1·2 to 1·9)	0·1% (–0·3 to 0·4)	0·70
Q4 (>¥60 000)	347/29 150	19·6% (17·4 to 21·9)	2·0% (1·4 to 2·6)	360/29 557	21·3% (19·1 to 23·5)	2·2% (1·7 to 2·7)	0·2% (–0·6 to 1·0)	0·66
Unwilling to disclose	265/37 334	20·8% (19·4 to 22·3)	0·8% (0·6 to 1·0)	452/53 799	29·5% (27·2 to 31·8)	1·6% (1·3 to 1·9)	0·8% (0·4 to 1·1)	<0·0001

(Table 1 continues on next page)

	2015–16			2018–19			2015–16 *vs* 2018–19	
	Unweighted frequency of e-cigarette users among survey participants	Weighted proportion*	Weighted prevalence*	Unweighted frequency of e-cigarette users among survey participants	Weighted proportion*	Weighted prevalence*	Change in prevalence	p value†
(Continued from previous page)								
Education level								
Primary or less	1137/150 591	68·2% (65·7 to 70·7)	1·0% (0·8 to 1·1)	1199/147 526	64·7% (62·2 to 67·2)	1·2% (1·1 to 1·4)	0·3% (0·1 to 0·5)	0·012
Secondary	389/24 462	17·0% (15·7 to 18·2)	2·1% (1·7 to 2·4)	366/23 999	17·6% (16·7 to 18·5)	2·3% (1·7 to 2·9)	0·4% (–0·2 to 1·1)	0·20
Tertiary	199/14 253	14·8% (13·2 to 16·5)	2·0% (1·4 to 2·6)	212/12 950	17·7% (15·7 to 19·7)	2·4% (1·8 to 3·0)	0·3% (–0·6 to 1·2)	0·46
Smoking status								
Ever smoker	1681/62 353	32·9% (32·2 to 33·6)	3·8% (3·4 to 4·3)	1738/56 624	31·0% (30·0 to 31·9)	5·1% (4·5 to 5·7)	1·4% (0·6 to 2·1)	0·0005
Former smoker	97/12 608	5·3% (5·0 to 5·6)	1·2% (0·7 to 1·6)	87/11 818	4·8% (4·5 to 5·0)	0·8% (0·5 to 1·0)	–0·4% (–1·0 to 0·2)	0·16
Current smoker	1584/49 745	27·5% (26·9 to 28·2)	4·4% (3·8 to 5·0)	1651/44 806	26·2% (25·4 to 27·0)	5·9% (5·1 to 6·6)	1·7% (0·8 to 2·6)	0·0003
Daily use	1510/45 125	24·5% (23·8 to 25·2)	4·6% (3·9 to 5·2)	1565/40 822	23·5% (22·7 to 24·3)	6·1% (5·3 to 6·9)	1·7% (0·7 to 2·7)	0·0006
Occasional use	74/4620	3·0% (2·8 to 3·2)	2·6% (1·8 to 3·5)	86/3984	2·7% (2·5 to 2·9)	3·7% (2·5 to 4·9)	1·4% (–0·2 to 2·9)	0·094
Never smoker	44/126 953	67·1% (66·4 to 67·8)	0·0% (0·0 to 0·1)	39/127 851	69·0% (68·1 to 70·0)	0·0% (0·0 to 0·1)	–0·0% (–0·0 to 0·0)	0·32
Awareness of smoking hazards								
Yes	810/64 661	36·9% (35·2 to 38·6)	1·4% (1·2 to 1·6)	914/76 060¶	45·0% (43·4 to 46·5)	1·8% (1·5 to 2·1)	0·4% (0·1 to 0·7)	0·017
No	915/124 645	63·1% (61·4 to 64·8)	1·2% (1·0 to 1·4)	863/108 397¶	55·0% (53·5 to 56·6)	1·4% (1·2 to 1·7)	0·3% (–0·1 to 0·6)	0·10
Obesity (BMI ≥30 kg/m²)‖								
Yes	144/11 452	6·6% (6·2 to 6·9)	1·8% (1·4 to 2·2)	176/12 974	7·9% (7·6 to 8·3)	3·1% (2·2 to 4·1)	1·3% (0·3 to 2·3)	0·010
No	1507/170 629	93·4% (93·1 to 93·8)	1·2% (1·1 to 1·4)	1539/166 272	92·1% (91·7 to 92·4)	1·5% (1·3 to 1·7)	0·3% (0·0 to 0·5)	0·047

Data are n/N (%), where n=e-cigarette users and N=total population; or % (95% CI). BMI=body-mass index. *Populations for the years 2015–16 and 2018–19 were standardised with the 2010 census standard population estimation obtained from the National Bureau of Statistics of China. †From Rao-Scott χ^2 test. ‡Mean age of total participants was 43·6 years (SD 14·6) in 2015–16 and 43·4 years (13·9) in 2018–19; mean age of e-cigarette users was 46·3 years (13·8) in 2015–16 and 48·0 years (13·7) in 2018–19. §Urban refers to residency in urban subdistricts and rural to residency in rural townships for at least 6 months before the time of investigation. ¶18 participants did not answer the question related to awareness of smoking hazards in 2018–19. ||BMI values for 7225 and 5229 participants were missing in 2015–16 and 2018–19, respectively; a sensitivity analysis comparing the prevalence of past 30-day e-cigarette use in patients with and without BMI values is shown in appendix 2 (pp 8–9).

Table 1: **Demographic distribution of past 30-day e-cigarette users aged 18 years and older in China, 2015–16 and 2018–19**

2015–16 was 43·6 years (SD 14·6), and 100 405 (53·0%) were women; mean age in 2018–19 was 43·4 years (13·9), and 102 373 (55·5%) participants were women.

In 2015–16, the estimated weighted prevalence of past 30-day e-cigarette use was 1·3% (95% CI 1·1–1·5) among the Chinese adult population (table 1). Weighted prevalence was higher in men (2·5% [2·2–2·8]) than in women (0·1% [0·0–0·1]). Additionally, prevalence of e-cigarette use was highest in people aged 18–29 years, in urban residents, in those with secondary or tertiary education status, in those with highest annual income (>¥60 000), in factory, construction, and manual workers, and in the population with obesity. Awareness of smoking hazards was also associated with a slightly higher prevalence of e-cigarette use than no awareness. In terms of smoking status, the highest prevalence of e-cigarette use was estimated among ever smokers (3·8% [3·4–4·3]), current smokers (4·4% [3·8–5·0]), and daily smokers (4·6% [3·9–5·2]).

E-cigarette use in 2018–19 followed a similar pattern. However, use among the Chinese adult population increased to 1·6% (95% CI 1·4–1·8%), representing an increase in prevalence of 0·3% (95% CI 0·1–0·6; p=0·0086) from 2015–16 to 2018–19. Significant increases in e-cigarette use between 2015–16 and 2018–19 were also observed in people aged 18–29 years and 40–49 years, in men, in urban residents, in those with a primary or lower education level, in factory, construction, and manual workers, agricultural workers, and unemployed people, and in those with the lowest annual income or those

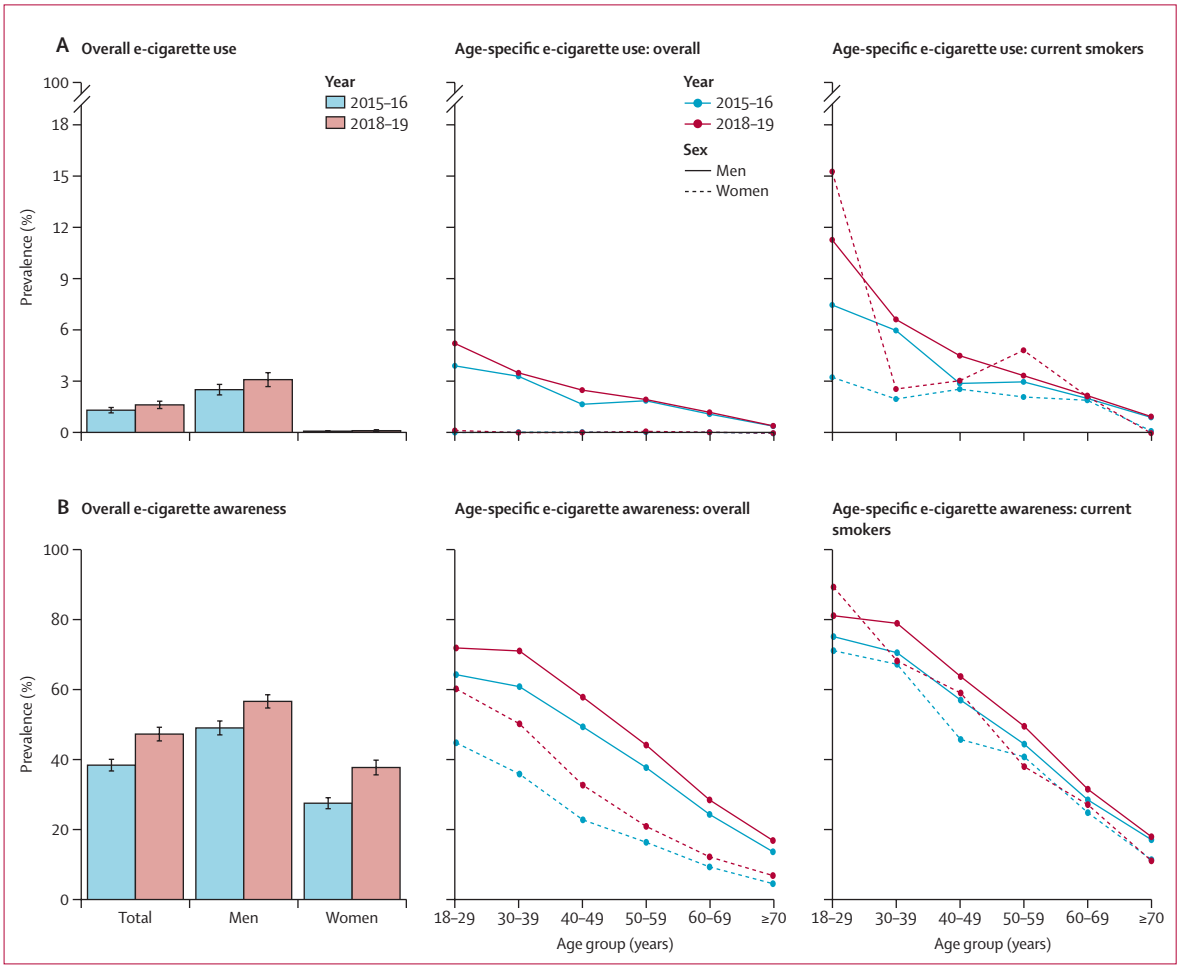

Figure 1: **Prevalence of past 30-day e-cigarette use (A) and e-cigarette awareness (B) in 2015–16 and 2018–19 among Chinese adults, overall and in current smokers**

Data represent weighted estimates from the China Chronic Disease and Nutrition Survey 2015 (n=189 306) and 2018 (n=184 475). Populations for the years 2015–16 and 2018–19 were standardised with the 2010 population census to gain comparable estimates. Error bars show 95% CIs. The unweighted denominators were much greater than 50 for all subgroups apart from current female smokers aged 18–29 years; in this subgroup, the unweighted denominator was 61 in 2015–16 and 50 in 2018–19, and these results should be interpreted with caution. Among the total population, awareness of e-cigarettes significantly increased in 2018–19 compared with 2015–16 (p<0·0001). p values are shown in appendix 2 (p 12).

unwilling to disclose income. E-cigarette use significantly increased among ever smokers, current smokers, and daily smokers from 2015–16 to 2018–19 (table 1), with results replicated for daily e-cigarette use (appendix 2 pp 6–7). Those aware of smoking hazards, and the populations with and without obesity also showed significant increases in e-cigarette use (table 1). Figure 1 shows the age-specific prevalence of use and awareness of e-cigarettes by year and sex among the total population and current smokers. Among the total population, awareness of e-cigarettes increased from 2015–16 to 2018–19 in men and women across all age groups.

Figure 2 shows urban and rural disparities in the prevalence of e-cigarette use by education and annual household income levels in China in 2015–16 and 2018–19. In urban areas, e-cigarette use among people with a secondary or tertiary education was more prevalent than in those with a primary education or less; however, in rural areas, prevalence was similar between people with a tertiary education and those with a primary education or less, and highest in people with a secondary education (figure 2A). In 2015–16, e-cigarette use increased with annual household income in both urban and rural areas (figure 2B). However, in 2018–19, those with the lowest household income (≤¥15 000) showed high use of e-cigarettes versus other income groups in urban and rural areas (figure 2B, table 1).

In 2018–19, 97·0% (95% CI 95·4–98·6) of e-cigarette users were men (table 2). 96·2% (95·1–97·3) of the e-cigarette users were current conventional smokers, and 89·9% (87·4–92·4) used conventional cigarettes daily. An estimated 2·3% (1·6–3·0) of e-cigarette users were former smokers, while 1·5% (0·7–2·4) had never smoked. In 2015–16, e-cigarette users were predominantly

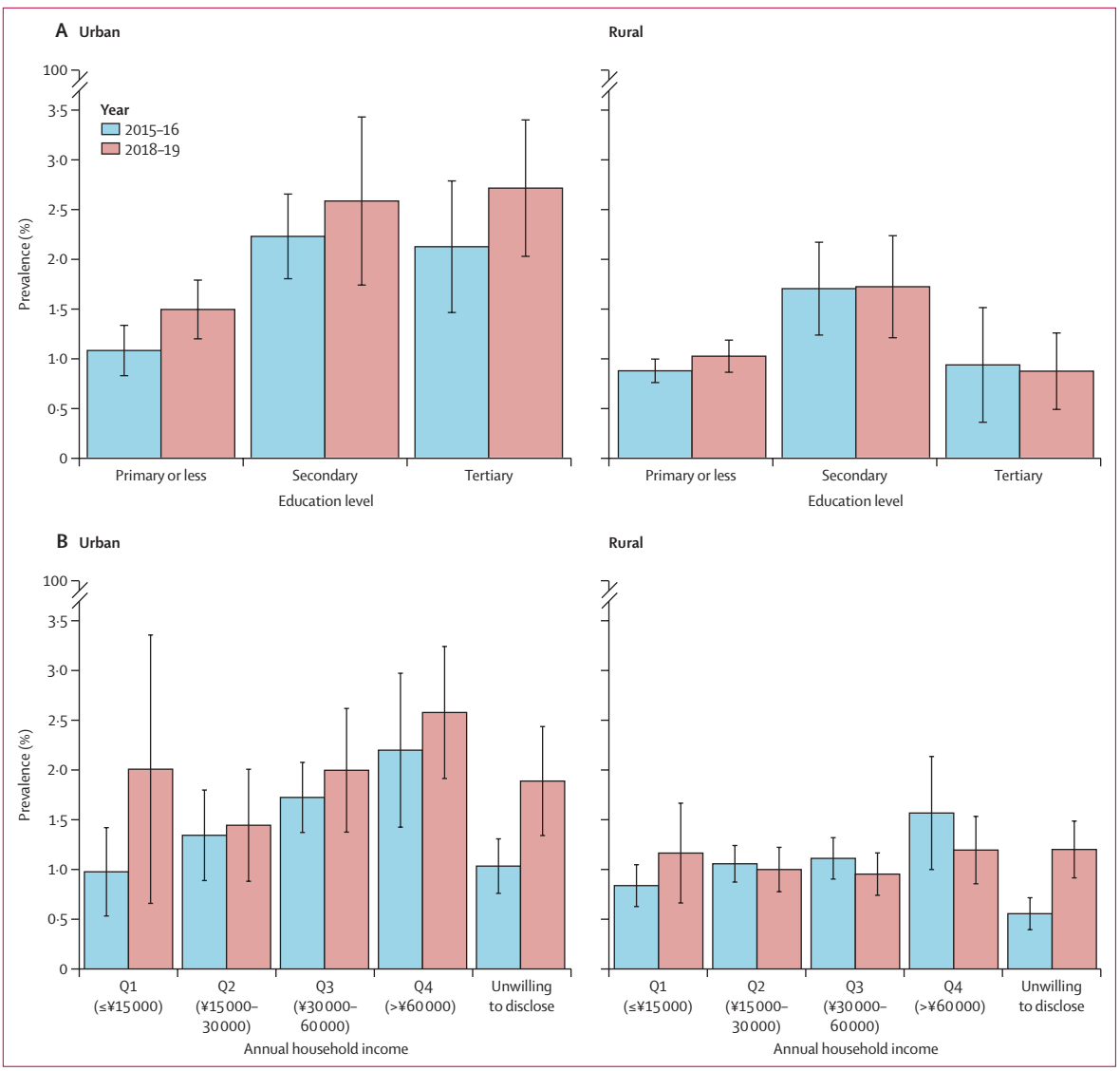

Figure 2: **Prevalence of past 30-day e-cigarette use in urban and rural areas in China by education level (A) and annual household income (B) in 2015–16 and 2018–19**

Data represent weighted estimates from the China Chronic Disease and Nutrition Survey 2015 (n=189 306) and 2018 (n=184 475). Populations for the years 2015–16 and 2018–19 were standardised with the 2010 population census to gain comparable estimates. Error bars show 95% CIs. p values are shown in appendix 2 (p 13).

men (97·4% [95% CI 96·7–98·1]) and current conventional smokers (93·0% [90·7–95·2]). Rates of conventional smoking (23·8% [19·2–28·3], daily smoking (86·8% [83·8–89·8]), former smoker status (4·8% [2·7–6·8]), and never smoker status (2·3% [1·5–3·1]) in e-cigarette users were similar to rates in 2018–19. The proportion of individuals using e-cigarettes on a daily basis increased from 23·8% (19·2–28·3) in 2015–16 to 26·7% (21·6–31·8) in 2018–19, which aligned with the increase in use among current smokers (appendix 2 p 7).

In our multivariable regression analysis of the total population of both surveys, e-cigarette use was significantly associated with obesity (odds ratio 1·6 [95% CI 1·3–2·1]; p=0·0007), awareness of smoking hazards (1·2 [1·0–1·4]; p=0·022), and smoking status (in current smokers, 135·2 [87·7–208·6]; and in former smokers, 33·5 [21·3–52·7]; p<0·0001) after adjusting for age, sex, urban or rural residency, household income, occupation, and education level (table 3). Among current smokers, e-cigarette use was significantly associated with obesity (1·6 [1·2–2·0]; p=0·0005), daily use of cigarettes (2·1 [1·5–2·8]; p<0·0001), smoking more than 20 cigarettes per day (1·8 [1·5–2·3]; p<0·0001), and an attempt to quit smoking (within the past 12 months, 1·9 [1·5–2·4]; and before the past 12 months, 1·5 [1·3–1·9]; p<0·0001). Among never smokers, the odds of e-cigarette use were increased in those aware of the

	2015–16 (n=1725)		2018–19 (n=1777)	
	Unweighted number	Weighted proportion*	Unweighted number	Weighted proportion*
Sex				
Male	1634	97·4% (96·7–98·1)	1684	97·0% (95·4–98·6)
Female	91	2·6% (1·9–3·3)	93	3·0% (1·4–4·6)
Daily e-cigarette use†	462	23·8% (19·2–28·3)	499	26·7% (21·6–31·8)
Frequency of e-cigarette use in the past 30 days				
<20 days	1189	73·3% (68·3–78·2)	1191	68·7% (63·6–73·8)
≥20 days	536	26·7% (21·8–31·7)	586	31·3% (26·2–36·4)
Dual-use with cigarette‡	1584	93·0% (90·7–95·2)	1651	96·2% (95·1–97·3)
Daily cigarette use	1510	86·8% (83·8–89·8)	1565	89·9% (87·4–92·4)
Occasional cigarette use	74	6·1% (4·2–8·1)	86	6·3% (4·3–8·3)
Exclusive e-cigarette use‡	141	7·0% (4·8–9·3)	126	3·8% (2·7–4·9)
Former smoker	97	4·8% (2·7–6·8)	87	2·3% (1·6–3·0)
Never smoker	44	2·3% (1·5–3·1)	39	1·5% (0·7–2·4)

Data are n or % (95% CI). *Populations for the years 2015–16 and 2018–19 were standardised with the 2010 population census to gain comparable estimates. †Defined as self-reported use on every day of the past 30 days. ‡Defined as self-reported e-cigarette use in the past 30 days and self-reported current use of conventional cigarettes. §Defined as use of e-cigarettes in the past 30 days without use of conventional cigarettes.

Table 2: **Characteristics of past 30-day e-cigarette users aged 18 years and older in China, 2015–16 and 2018–19**

	Odds ratio (95%CI)*	p value
Model 1: Among never smokers		
Awareness of smoking hazards		
No	1 (ref)	0·011
Yes	2·4 (1·2–4·7)	..
Obesity (BMI ≥30 kg/m²)		
No	1 (ref)	0·0058
Yes	2·4 (1·3–4·5)	..
Model 2: Among former smokers		
Awareness of smoking hazards		
No	1 (ref)	0·013
Yes	2·2 (1·2–4·2)	..
Model 3: Among current smokers		
Awareness of smoking hazards		
No	1 (ref)	0·061
Yes	1·2 (1·0–1·4)	..
Obesity (BMI ≥30 kg/m²)		
No	1 (ref)	0·0005
Yes	1·6 (1·2–2·0)	..
Smoking frequency		
Occasional use	1 (ref)	<0·0001
Daily use	2·1 (1·5–2·9)	..
Cigarette consumption		
<10 per day	1 (ref)	<0·0001
10–19 per day	1·1 (0·8–1·5)	..
20 per day*	1·2 (1·0–1·5)	..
>20 per day	1·8 (1·5–2·3)	..
Attempt to stop smoking		
Never attempted	1 (ref)	<0·0001
Within the past 12 months	1·9 (1·5–2·4)	..
Before the past 12 months	1·5 (1·3–1·9)	..

(Table 3 continues on next page)

hazards of smoking (2·4 [1·2–4·7]; p=0·011) and those with obesity (2·4 [1·3–4·5]; p=0·0058; table 3).

Patterns of e-cigarette use were generally similar between participants with and without BMI data across 2015–16 and 2018–19, with some variation according to region, occupation, household income, education level, and smoking status (pp 8–9). Proportions of e-cigarette users from 2015 to 2019 among former smokers and never smokers are shown in appendix 2 (pp 10–11). In e-cigarette users who were former smokers, the majority had a primary or lower level of education in 2018–19; whereas, most former smokers who used e-cigarettes had a secondary or tertiary level of education in 2015–16. The proportion of e-cigarette use among former smokers who were aware of the hazards of conventional smoking decreased from 2015–16 to 2018–19 (appendix 2 p 10). In 2015–16 and 2018–19, most e-cigarette users who had never smoked were men, aged 18–44 years, and used e-cigarettes occasionally. The proportion of never smokers who were aware of the hazards of conventional smoking markedly increased from 2015–16 to 2018–19 (appendix 2 p 11).

Discussion

To our knowledge, this large-scale study is the first to report on the prevalence of e-cigarette use and trend in use during recent years on a national level in China. Our study also provides valuable baseline data for evaluations of the effect of the regulations on e-cigarettes in China.[11,12] On the basis of two, nationally representative, cross-sectional surveys of the Chinese population, we estimated the prevalence of e-cigarette use to have increased from 1·3% to 1·6% during 2015–19. Applying our weighted prevalence values to the 2010 Chinese population gives an estimated 16·9 million Chinese adults who were using e-cigarettes in 2018–19, of whom 16·2 million were

current smokers and more than a quarter of a million were never smokers.

Our study showed that the patterns of e-cigarette use in China differed to those in other countries. Firstly, although prevalence increased, e-cigarette use in 2018–19 was still lower than the reported prevalence in some developed countries, such as France (3·7% in 2017), the UK (4·7% in 2017), and the USA (3·2% in 2016).[5,19] However, given the population size of China, we estimate 3·35 million individuals to have started using e-cigarettes in the adult population, among whom 3·20 million were men and 0·15 million were women. Therefore, the prevalence of e-cigarette use in China should be monitored in the future. Secondly, in contrast to results in Sweden and the USA,[20,21] Chinese populations with a high level of education or within the highest income bracket were the most likely to use e-cigarettes. The positive education and income gradients observed in our study imply that public knowledge remains low regarding the health hazards of nicotine or substances that might be contained in e-cigarettes. These patterns can also be explained by targeting of an early e-cigarette product at high-income individuals in China and exporting overseas to establish the brand as a luxury product.[22] However, our study also found that from 2015 to 2019, individuals with the lowest household income increased their use of e-cigarettes. This increase among people with low socioeconomic status could exacerbate health disparities.

Some patterns of e-cigarette use in China were similar to those in other countries. Firstly, the prevalence of past 30-day e-cigarette use was higher among young adults aged 18–29 years than other age groups, and the prevalence of use among young adults increased, from 2·0% in 2015–16 to 2·7% in 2018–19. Similar to perceptions in other countries,[4–6] e-cigarettes have gained popularity among adolescents and young adults in China.[7,23] Secondly, our study showed high levels of dual-use of e-cigarettes and conventional cigarettes among e-cigarette users in China. Therefore, the interaction or confounding effect of former or current cigarette use should be considered in future observational studies exploring the health effects of e-cigarettes. Thirdly, e-cigarette use was rare among individuals who had never smoked conventional cigarettes. Of 373 781 participants sampled across the country, only 83 e-cigarette users had never smoked. However, our study showed that never smokers who were aware of the hazards of smoking or who were obese were more likely to use e-cigarettes. Fourthly, obesity increased the odds of e-cigarette use. This finding might reflect attitudes among e-cigarette users in China and also the industry patents applied which were suggestive of weight loss.[24] This pattern has also been observed among adolescents in the USA.[25] Finally, our study shows that e-cigarettes are attractive to current smokers who want to quit smoking, and to frequent smokers who smoked daily, particularly those who smoked more than 20 cigarettes per day. However, evidence remains inconclusive on the association between e-cigarette use and successful cessation of conventional smoking.[26–28] Therefore, those attempting to stop smoking are encouraged to visit smoking cessation clinics.[29] A debate is ongoing on whether e-cigarettes serve predominantly to expose never smokers to nicotine, or to help current smokers stop smoking. Regulation of e-cigarettes could affect the health of up to 16·9 million in China. Therefore, public health communities should give increased attention to the short-term and long-term health effects of e-cigarette use and its regulation.

Importantly, our study raises a public health concern for young adults in China. The prevalence of e-cigarette use among adults aged 18–29 years increased from 2015 to 2019. The US Centers for Disease Control and Prevention recommended that young adults should not use e-cigarettes or vaping products that contain nicotine or tetrahydrocannabinol. The current regulations in China on e-cigarette sales and promotion were only designed to protect youth.[11,12] Given the steady increase in conventional cigarette smoking among young women in China[30] and the unclear evidence regarding the effect of e-cigarettes on fetal brain development,[31] health policy makers and public health practitioners should invest in prevention and control plans.

Several limitations need to be noted. Firstly, our study, similar to other observational studies, was unable to

	Odds ratio (95%CI)*	p value
(Continued from previous page)		
Model 4: Among the total population†		
Awareness of smoking hazards		
No	1 (ref)	0·022
Yes	1·2 (1·0–1·4)	..
Obesity (BMI ≥30 kg/m²)		
No	1 (ref)	0·0007
Yes	1·6 (1·3–2·1)	..
Smoking status		
Never smoker	1 (ref)	<0·0001
Current smoker	135·2 (87·7–208·6)	..
Former smoker	33·5 (21·3–52·7)	..

Multivariable analyses accounted for cluster-randomisation, stratification, and complex sampling weight. All models adjusted for age, sex, urban or rural residence, household income, occupation category, and education level. Factors with a significant association (p<0·05) are shown. In model 1, 13 values were missing on awareness of smoking hazards and 7941 values were missing on BMI. In model 2, 1 value was missing on awareness of smoking hazards. In model 3, 4 values were missing on awareness of smoking hazards, 3828 values were missing on BMI, 19 values were missing on cigarette consumption, and 21 values were missing on attempts to quit smoking among current smokers. In model 4, 18 values were missing on awareness of smoking hazards and 12 454 values were missing on BMI among the total survey population. BMI=body-mass index. *Standardised to the 2010 Chinese population. †Typical cigarette pack size.

Table 3: **Factors associated with past 30-day e-cigarette use among Chinese adults from 2015 to 2019**

distinguish the e-cigarette device, the substance being vaped, and the amount and type of exposure due to the constrained question design. This lack of distinction limited the ability of our study to evaluate health effects and infer causality. Secondly, social desirability bias or recall bias could be a limitation because e-cigarette use status was self-reported, and data on ever use or past use of e-cigarettes were not collected. The initiation date of e-cigarette use was also not requested, and thus we were unable to determine the order of initiation of conventional cigarette and e-cigarette use. Thirdly, the survey was designed for Chinese residents aged 18 years and older. Consequently, it underrepresents the younger population. The increase in e-cigarette use and awareness among current female smokers aged 18–29 years needs to be interpreted with caution due to the limited sample size. Fourthly, the prevalence of past 30-day e-cigarette use was higher than the current use estimated with the question "Do you currently use electronic cigarettes on a daily basis, less than daily, or not at all?", which was included in GATS. GATS reported the prevalence of current e-cigarette use in China to be 0·5% in 2015–16 and 0·9% in 2018–19 among people aged 15 years and older.[9,32] Although this increasing trend was also observed in our study, past 30-day e-cigarette use also captured a fraction of people who had tried e-cigarettes but were not self-deemed as a current user.

In conclusion, among adults in China in 2018–19, the estimated overall prevalence of past 30-day e-cigarette use was 1·6%, which represented an increase of 0·3% from 2015–16. The factors associated with e-cigarette use were male sex, young age, high-level education and high income status, conventional smoking, and obesity. Future studies and surveys on e-cigarette use in China will be crucial to improve understanding of the trends and potential effects of regulations.

Contributors

MaZ, XL, LimW, ZZ, and MeZ had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. MaZ, PY, ZZ, XiuZ, and XX conceived and designed the study. All authors acquired, analysed, or interpreted data. ZZ, MeZ, PY, and MaZ drafted the manuscript. GFG, XX, XL, and JW critically revised the manuscript for intellectual content. ZZ statistically analysed the data. XL, GFG, MaZ, LihW, and LimW obtained funding. CL, XiaZ, YZ, and ZH provided administrative, technical, or material support. MaZ, XL, and GFG supervised the study.

Declaration of interests

We declare no competing interests.

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References

1 Public Health England. E-cigarettes: an evidence update. A report commissioned by Public Health England. August, 2015. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733022/Ecigarettes_an_evidence_update_A_report_commissioned_by_Public_Health_England_FINAL.pdf (accessed March 12, 2020).

2 Grana R, Benowitz N, Glantz SA. E-cigarettes: a scientific review. *Circulation* 2014; **129:** 1972–86.

3 Glantz SA, Bareham DW. E-cigarettes: use, effects on smoking, risks, and policy implications. *Annu Rev Public Health* 2018; **39:** 215–35.

4 Dockrell M, Morrison R, Bauld L, McNeill A. E-cigarettes: prevalence and attitudes in Great Britain. *Nicotine Tob Res* 2013; **15:** 1737–44.

5 Dai H, Leventhal AM. Prevalence of e-cigarette use among adults in the United States, 2014–2018. *JAMA* 2019; **322:** 1824–27.

6 Cullen KA, Gentzke AS, Sawdey MD, et al. E-cigarette use among youth in the United States, 2019. *JAMA* 2019; **322:** 2095.

7 Xiao L, Parascandola M, Wang C, Jiang Y. Perception and current use of e-cigarettes among youth in China. *Nicotine Tob Res* 2019; **21:** 1401–07.

8 Feng G, Nan Y, Jiang Y. Prevalence of e-cigarette in China: preliminary findings from two surveys. *Tob Induc Dis* 2018; **16** (suppl 1)**:** A271.

9 Chinese Center for Disease Control and Prevention. Report on adult tobacco in China. 2015. http://www.tcrc.org.cn/UploadFiles/2016-03/318/201603231215175500.pdf (accessed Aug 4, 2020; in Chinese).

10 International Tobacco Control Policy Evaluation Project. ITC China project report: findings from wave 1 to wave 5 (2006–2015). October, 2017. https://itcproject.s3.amazonaws.com/uploads/documents/ITC_China_Project_Report_Waves_1_to_5_2006-2015_Octo.pdf (accessed March 12, 2020).

11 State Administration for Market Regulation and State Tobacco Monopoly Administration. Notice on prohibiting the sale of electronic cigarettes to minors. Aug 31, 2018. http://www.gov.cn/fuwu/2018-08/31/content_5317952.htm (accessed March 12, 2020).

12 State Administration for Market Regulation and State Tobacco Monopoly Administration. Notice on further protecting minors from electronic cigarettes. Nov 1, 2019. http://gkml.samr.gov.cn/nsjg/xyjgs/201911/t20191101_308077.html (accessed March 12, 2020)

13 Standing Committee of the Shenzhen Municipal People's Congress. Announcement of the sixth Shenzhen Municipal People's Congress Standing Committee (no. 152). June 28, 2019. http://www.szrd.gov.cn/szrd_zyfb/szrd_zyfb_cwhgb/201908/t20190829_18185737.htm (accessed March 12, 2020).

14 Chengdu Municipal Justice Bureau. Regulations on smoking control in public places in Chengdu (revised draft). May 23, 2019. http://www.chengdu.gov.cn/chengdu/home/lfzj_detail.shtml?method=appDataDetail&groupId=139&appId=5148&dataId=2437279 (accessed March 12, 2020)

15 Wang L, Gao P, Zhang M, et al. Prevalence and ethnic pattern of diabetes and prediabetes in China in 2013. *JAMA* 2017; **317:** 2515–23.

16 Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. *JAMA* 2013; **310:** 948–59.

17 Zhou M, Astell-Burt T, Bi Y, et al. Geographical variation in diabetes prevalence and detection in China. *Diabetes Care* 2015; **38:** 72–81.

18 Kalsbeek WD, Bowling JM, Hsia J, Mirza S, Palipudi KM, Asma S. The Global Adult Tobacco Survey (GATS): sample design and related methods. 2010. http://www.asasrms.org/Proceedings/y2010/Files/307559_58832.pdf (accessed Aug 14, 2020).

19 Laverty AA, Filippidis FT, Vardavas CI. Patterns, trends and determinants of e-cigarette use in 28 European Union member states 2014–2017. *Prev Med* 2018; **116:** 13–18.

20 Hedman L, Backman H, Stridsman C, et al. Association of electronic cigarette use with smoking habits, demographic factors, and respiratory symptoms. *JAMA Netw Open* 2018; **1:** e180789.

21 Popova L, Ling PM. Alternative tobacco product use and smoking cessation: a national study. *Am J Public Health* 2013; **103:** 923–30.

22 Feldman E, Yue C. E-cigarette regulation in China: the road ahead. Faculty Scholarship at Penn Law, paper 1704. 2016. http://scholarship.law.upenn.edu/faculty_scholarship/1704 (accessed March 12, 2020).

23 Wang X, Zhang X, Xu X, Gao Y. Perceptions and use of electronic cigarettes among young adults in China. *Tob Induc Dis* 2019; **17:** 17.

24 Singh H, Kennedy RD, Lagasse LP, Czaplicki LM, Cohen JE. E-cigarettes and weight loss-product design innovation insights from industry patents. *Nicotine Tob Res* 2018; **20:** 1010–14.

25 Delk J, Creamer MR, Perry CL, Harrell MB. Weight status and cigarette and electronic cigarette use in adolescents. *Am J Prev Med* 2018; **54:** e31–35.

26 Kalkhoran S, Glantz SA. E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med* 2016; **4:** 116–28.

27 WHO. WHO report on the global tobacco epidemic 2019. July 26, 2019. https://www.who.int/tobacco/global_report/en/ (accessed March 16, 2020).

28 WHO. WHO study group on tobacco product regulation. WHO technical report series, no. 1015. 2019. https://apps.who.int/iris/bitstream/handle/10665/329445/9789241210249-eng.pdf?ua=1 (accessed March 16, 2020).

29 Lin H, Xiao D, Liu Z, Shi Q, Hajek P, Wang C. National survey of smoking cessation provision in China. *Tob Induc Dis* 2019; **17:** 25.

30 Wang M, Luo X, Xu S, et al. Trends in smoking prevalence and implication for chronic diseases in China: serial national cross-sectional surveys from 2003 to 2013. *Lancet Respir Med* 2019; **7:** 35–45.

31 Sailer S, Sebastiani G, Andreu-Férnández V, García-Algar O. Impact of nicotine replacement and electronic nicotine delivery systems on fetal brain development. *Int J Environ Res Public Health* 2019; **16:** e5113.

32 Chinese Center for Disease Control and Prevention, WHO, US Centers for Disease Control and Prevention, RTI International. Global Adult Tobacco Survey (GATS) China fact sheet (2018). May 23, 2019. https://www.who.int/docs/default-source/wpro---documents/countries/china/2018-gats-china-factsheet-cn-en.pdf?sfvrsn=3f4e2da9_2 (accessed March 12, 2020; in Chinese).