



OPEN ACCESS

# Awareness and prevalence of e-cigarette use among Chinese adults: policy implications

Lin Xiao <sup>1</sup>, Xi Yin,<sup>2</sup> Xinbo Di,<sup>1</sup> Yi Nan,<sup>1</sup> Tianchu Lyu,<sup>1</sup> Yiqun Wu,<sup>3</sup> Xinhua Li<sup>4</sup>

<sup>1</sup>Tobacco Control Office, Chinese Center for Disease Control and Prevention, Beijing, China

<sup>2</sup>China office, World Health Organization, Geneva, GE, Switzerland

<sup>3</sup>ThinkTank Research Center for Health Development, Beijing, China

<sup>4</sup>Chinese Center for Disease Control and Prevention, Beijing, China

## Correspondence to

Dr Lin Xiao, Tobacco Control Office, Chinese Center for Disease Control and Prevention, Beijing, China; xiaolin201304@126.com

Received 23 July 2020

Revised 22 September 2020

Accepted 28 October 2020

## ABSTRACT

**Objective** To assess the awareness and prevalence of electronic cigarettes (e-cigarettes) and associated factors among Chinese adults (15 years and older).

**Method** This study examined data from Global Adults Tobacco Survey China Project, which was nationally representative and used stratified multiphase cluster randomised sampling design. Data were collected in 2018 through a household survey with in-person interviews using tablet computers. Complex sampling weighted analysis method was used.

**Results** 48.5% of Chinese adults had heard of e-cigarettes. The proportions of Chinese adults who had ever used, had used in the last 12 months, and currently used e-cigarettes were 5.0%, 2.2% and 0.9%, respectively; people in the 15–24 years group showed the highest rates of ever use, last 12-month use and current use at 7.6%, 4.4%, and 1.5%, respectively. Among males, higher e-cigarette use was associated with 15–24 years age group, college/university or above education, and daily use of combustible cigarettes. Among all e-cigarette users, 90.6% also used combustible cigarettes. The most common reason for e-cigarette use was smoking cessation (46.2%) while among ever smokers, 9.5% of ever e-cigarette users had quit smoking and 21.8% of never e-cigarette users had quit smoking (adjusted OR 0.454, 95% CI 0.290 to 0.712).

**Conclusion** Prevalence of e-cigarettes among Chinese adults had increased since 2015, especially among young people aged 15–24. The high level of dual use and lower quit rate among e-cigarette users indicated e-cigarettes had not shown cessation utility at the population level in China. Regulation of e-cigarettes is needed to protect youth and minimise health risks.

## BACKGROUND

Since 2003,<sup>1</sup> electronic cigarettes (e-cigarettes) have swept across the world, with sales having increased from US\$20 million in 2008 to US\$15 billion in 2018.<sup>2,3</sup> Although the long-term health effects of e-cigarette use are not yet clear, many studies have shown that e-cigarettes can expose users to toxic chemicals, including nicotine, carbonyl compounds and volatile organic compounds, which are known to have adverse health effects for both users and non-users.<sup>4–7</sup> E-cigarettes on their own are associated with increased risk of cardiovascular diseases, lung disorders and adverse effects on the development of the fetus during pregnancy.<sup>8,9</sup> Despite that the number and level of known toxicants generated by the typical use of unadulterated electronic cigarettes are on average lower than in cigarette smoke, the levels of toxicants can vary enormously across

and within brands and sometimes reach higher levels than in tobacco smoke.<sup>10</sup> Dual use of e-cigarettes and combustible cigarettes, which is the use pattern of a considerable number of e-cigarette users,<sup>11–13</sup> is increasingly found to be associated with critical short-term and long-term adverse health impacts.<sup>14–18</sup> It is of great public health concern that children and adolescents are increasingly taking up the use of e-cigarettes in some countries.<sup>19–21</sup> The addictive nature of nicotine can lead to dependence and may harm adolescents' brain development.<sup>22</sup> There is also a growing body of evidence showing that non-smoking adolescents who use e-cigarettes increase their chance of starting to smoke cigarettes.<sup>23–25</sup>

Although most e-cigarettes are currently consumed in countries such as the USA and the UK,<sup>26</sup> e-cigarette use may be growing rapidly in China for various reasons, including the large number of smokers, the growing concerns about harms of cigarette smoking, the implementation of stronger subnational smoke-free legislations, the aggressive marketing activities of e-cigarettes, and the lack of strong laws and regulations over e-cigarettes. Thus, monitoring the use of e-cigarettes among both youth and adults is important to inform public health policies on e-cigarettes and tobacco control in general. According to iiMedia, a third-party data mining and analysis organisation for new industries, the total domestic sales revenue of e-cigarettes was ¥3.2 billion (US\$0.46 billion) in 2015 and had increased to ¥5.06 billion (US\$720 million) in 2018 and ¥7.86 billion (US\$1.12 billion) in 2019. In 2020 and 2021, it was expected to reach ¥8.38 billion (US\$1.2 billion) and over ¥9 billion (US\$1.29 billion), respectively.<sup>27,28</sup> Several studies have been conducted in China using city-level data and have provided valuable insights into the awareness and use of e-cigarettes. For example, International Tobacco Control Survey in China, which was conducted in 10 cities, found that less than a third of Chinese adults were aware of e-cigarettes and 2% had tried the product.<sup>29</sup> Zhao *et al* looked at the prevalence of e-cigarettes in 14 major Chinese cities and analysed the correlates of e-cigarette awareness and use among urban residents.<sup>30</sup> Huang *et al* examined the awareness and use patterns of e-cigarettes, as well as the associated factors of e-cigarette use in five Chinese cities.<sup>31</sup> Zhao *et al* examined the perception of e-cigarette use among adult users in Shanghai.<sup>32</sup> At the national level, Xiao *et al* assessed the prevalence of e-cigarettes among middle school students using data from China's Youth Tobacco Survey, and examined the factors associated with awareness and use.<sup>33</sup> Wang *et al* used a mobile app survey and analysed the perception and use



©World Health Organization 2021. Licensee BMJ.

**To cite:** Xiao L, Yin X, Di X, *et al*. *Tob Control* Epub ahead of print: [please include Day Month Year]. doi:10.1136/tobaccocontrol-2020-056114

of e-cigarettes by different smoking status of young Chinese adults.<sup>34</sup> Our study used the most recent nationally representative household survey data from 2018 and examined the awareness and prevalence of e-cigarettes, as well as reasons, patterns and associated factors of e-cigarette use among Chinese adults (15 years and older). We also examined the change in e-cigarette prevalence between 2015 and 2018.

## METHODOLOGY

### Study design and participants

Data used in this paper were from Global Adult Tobacco Survey China Project, which used a global standardised methodology and was conducted in 2018 by Chinese Center for Disease Control and Prevention.<sup>35</sup> A multistaged, geographically clustered sample design was used to produce nationally representative data. In total, 200 counties/districts from 31 provincial-level administrative jurisdictions of Mainland China were sampled. Nationally, a household survey method was used, with a total of 24 370 households sampled by randomly selecting one individual from each participating household to complete the survey. The investigators used a handheld digital tablet to collect data through in-person interviews.

The subjects of this survey were Chinese residents aged 15 and older who used the household as their primary residence in the previous month before the survey. The survey excluded those

who lived collectively in places like student dormitories, nursing homes, military camps, prisons or hospitals.

### Measures

Awareness of e-cigarette was measured by the question: 'Before today, have you ever heard of electronic cigarettes?' If the answer was 'yes', then 'Where did you hear about electronic cigarette?' was asked. 'Have you ever, even once, used an electronic cigarette?', 'During the past 12 months, have you ever, even once, used an electronic cigarette?' and 'Do you currently use electronic cigarettes daily, less than daily, or not at all?' were asked to measure e-cigarette use. In addition, 'What was the main reason that you used electronic cigarettes?' was asked for those who used e-cigarettes. And information on family income was collected in four income levels: 'less than ¥29 999', '¥30 000–¥49 999', '¥50 000–99 999', and '¥100 000 and above'. Perception of harms around smoking was measured by three questions: 'Based on what you know or believe, does smoking tobacco cause stroke?', 'Based on what you know or believe, does smoking tobacco cause heart disease?' and 'Based on what you know or believe, does smoking tobacco cause lung cancer?' If a participant answered 'yes' for all three questions, this indicator was coded 'yes'; and 'no' if otherwise.

### Statistical analysis

Due to the complex sample design for the survey, each responding unit was assigned a unique survey weight that was used to produce estimates of population parameters. The 2018 population data from the National Statistics Bureau of China were used for poststratification. All computations were performed using the SAS V.9.4 complex survey data analysis procedure. Percentage or proportion was used for descriptive statistics. Logistic regression was conducted to explore factors associated with current e-cigarette use and the association between e-cigarette use and smoking cessation. A  $p < 0.05$  was considered statistically significant. The survey passed the review of the Ethical Committee of the Chinese Center for Disease Control and Prevention.

## RESULTS

### Demographic characteristics

Out of a total of 24 370 selected households, 3193 empty households were eliminated. Finally, 19 640 households completed the survey and a total of 19 376 people completed the individual survey. The overall response rate was 91.5%. The surveyed 19 376 individuals represented 1 156 987 000 males and females aged 15 and above in China. Of these, 50.6% were male and 49.4% were female; 59.9% were from urban areas and 40.1% were from rural areas. Among surveyed participants, 34.0% had middle school as their highest level of education, 32.6% attained elementary school education. People with high school education accounted for 16.4% and those with college/university or above education were 17.0% (table 1).

### Awareness of e-cigarettes

In 2018, 48.5% of adults aged 15 and older had heard of e-cigarettes (95% CI, 46.0% to 51.0%), with the proportion higher among males (59.1%) than females (37.7%), higher among young people (69.9% for participants aged 15–24) than other age groups (62.5% for people aged 25–44, 37.2% for people aged 45–64, and 16.9% for people aged 65 and older), higher among people with higher education (77.0% of those with college/university or above) than with lower education (61.7% for those with high school education, 48.0% of those with

**Table 1** Distribution of Chinese adults  $\geq 15$  years old by selected demographic characteristics

Demographic characteristics	Weighted		Number of adults (in Thousands)	Un-weighted Number of adults
	Percentage	(95% CI)		
Overall	100		1 156 987	19 376
Gender				
Male	50.6	(49.6, 51.7)	585 988	9 109
Female	49.4	(48.3, 50.4)	570 999	10 267
Age (year)				
15–24	13.9	(12.6, 15.3)	160 774	930
25–44	37.8	(36.3, 39.3)	436 993	5 128
45–64	34.7	(33.2, 36.1)	400 930	8 652
65+	13.7	(12.8, 14.6)	158 289	4 666
Residence				
Urban	59.9	(53.7, 65.7)	692 544	11 023
Rural	40.1	(34.3, 46.3)	464 443	8 353
Educational level				
Elementary school and below	32.6	(30.3, 34.8)	323 930	7 531
Middle school	34.0	(32.4, 35.6)	338 205	5 745
High school graduate	16.4	(15.3, 17.7)	163 644	2 721
College and above	17.0	(14.8, 19.5)	169 266	2 430
Smoking status				
Never smoker	66.7	(65.5, 68.0)	771 994	12 863
Current smoker	26.6	(25.4, 27.8)	307 580	4 959
Daily smoker	23.2	(22.0, 24.5)	268 904	4 384
Occasionally smoker	3.3	(2.9, 3.8)	38 677	575
Former smoker	6.7	(6.1, 7.3)	77 390	1 553
Income(yuan)				
<30 000	41.1	(37.5, 44.8)	448 062	8 971
30 000–49 999	23.9	(21.9, 25.9)	260 457	4 225
50 000–99 999	22.3	(20.1, 24.6)	243 479	3 566
100 000 and above	12.6	(10.3, 14.9)	137 711	1 746

**Table 2** Percentage of Chinese adults  $\geq 15$  years old who had heard of e-cigarettes by selected demographic characteristics

Demographic characteristics	Heard of e-cigarettes		P value
	Percentage	(95% CI)	
Overall	48.5	(46.0, 51.0)	
Gender			<0.0001
Male	59.1	(56.2, 61.9)	
Female	37.7	(35.1, 40.4)	
Age (year)			<0.0001
15–24	69.9	(65.7, 73.9)	
25–44	62.5	(59.1, 65.8)	
45–64	37.2	(34.6, 39.9)	
65+	16.9	(14.7, 19.4)	
Residence			<0.0001
Urban	56.3	(53.2, 59.3)	
Rural	37.0	(33.8, 40.3)	
Educational level			<0.0001
Elementary school and below	17.1	(15.4, 18.9)	
Middle school	48.0	(45.1, 50.8)	
High school	61.7	(58.2, 65.0)	
College/university or above	77.0	(73.7, 80.0)	
Smoking status			<0.0001
Never smoker	42.8	(40.1, 45.5)	
Current smoker	62.3	(59.1, 65.5)	
Daily smoker	62.5	(59.0, 66.0)	
Occasionally smoker	61.1	(54.7, 67.5)	
Former smoker	51.3	(47.6, 55.0)	
Income(yuan)			<0.0001
<30 000	36.1	(33.5, 38.7)	
30 000–49 999	48.7	(45.1, 52.3)	
50 000–99 999	58.2	(54.1, 62.4)	
100 000 and above	66.7	(61.7, 71.8)	

middle school education, and 17.1% of those with elementary school or below education), higher among urban residents (56.3%) than rural residents (37.0%) and higher among current smokers (62.3%) than never smokers (42.8%). Regarding the information sources of hearing of e-cigarettes, the most common source was friends (63.9%), followed by internet (44.8%) and television (42.7%); other sources were relatively less common, including shops (18.6%), newspapers/magazines (12.4%) and radio (7.4%) (table 2).

### Use of e-cigarettes

#### Current use

In 2018, an estimated 0.9% (95% CI 0.7% to 1.2%) of adults aged 15 years and older currently used e-cigarettes, with 1.6% among males and 0.1% among females. Among current users, 10.7% used e-cigarettes daily. Looking into the specific age group of 15–24 years, current use rate was 1.5% (95% CI 0.8% to 2.8%), with males at 2.7% and females at 0.3%. An estimated 2.2% (95% CI 1.4% to 3.3%) of participants with college/university or above education currently used e-cigarettes, compared with 0.2% (95% CI 0.1% to 0.4%) of those with elementary school or below education. The rate in urban areas was 1.1% (95% CI 0.8% to 1.5%), compared with 0.5% in rural areas (95% CI 0.3% to 0.8%). Among daily smokers of combustible cigarettes, current e-cigarette use rate was 3.2% (95% CI 2.4% to 4.1%), while it was only 0.1% among never smokers (95% CI 0.0% to 0.2%) (table 3). Since the rate of current e-cigarette use

among female participants was too low, logistic regression was used to explore the factors associated with current use among male participants. As shown in table 4, among male participants, being in the 15–24 age group, having a college/university or above education, and using combustible cigarettes daily were associated with a higher rate of e-cigarette use. There was no association between e-cigarette use and place of residence (urban vs rural) or income levels. In addition, among current e-cigarette users, 90.6% of them used both e-cigarettes and combustible cigarettes.

#### Last 12 months and ever use

To reflect a more complete picture of e-cigarette use, the data on ever use and use in the last 12 months were collected. In 2018, an estimated 2.2% (95% CI 1.8% to 2.6%) of adults aged 15 years and above reported having used e-cigarettes in the last 12 months and an estimated 5.0% (95% CI 4.4% to 5.6%) reported having ever used e-cigarettes. It is worth noting that as high as 13.5% (95% CI 9.8% to 17.2%) of young males (aged 15–24) reported having ever used e-cigarettes, and 16.6% (95% CI 14.7% to 18.5%) of all daily smokers had ever used e-cigarettes (table 3).

#### Reasons for using e-cigarettes

The most common reason for e-cigarette use was smoking cessation, with 46.2% (95% CI 35.9% to 56.5%) of current users saying they used e-cigarettes to quit smoking 11.7% (95% CI 6.0% to 17.4%) of current users reported that they used e-cigarettes because they were less harmful, and 10.5% (95% CI 1.9% to 19.1%) of users indicated e-cigarettes were fashionable, and 9.2% (95% CI 1.6% to 16.8%) reported that they used e-cigarettes because they liked the flavours. From the most common to the least common, these reasons were chosen in the same order by ever users and last 12-month users. Among people aged 15–24 who currently used e-cigarettes, the main reason for using e-cigarettes was smoking cessation (43.4%), followed by believing it was fashionable (27.9%).

#### Role of e-cigarettes in smoking cessation at population level

Among ever smokers, 9.5% of ever e-cigarette users had quit smoking, while the proportion of never e-cigarette users who had quit smoking was 21.8%. Controlling variables such as gender, education level, age group, urban/rural residence, income and perception of harms around smoking by logistic regression, e-cigarette users had a lower quitting rate compared with non-e-cigarette users (adjusted OR 0.454, 95% CI 0.290 to 0.712).

### DISCUSSION

Between 2015 and 2018, awareness of e-cigarettes among Chinese adults had increased from 40.5% to 48.5%. Current use of e-cigarettes had almost doubled, from 0.5% to 0.9%, and ever-use had increased from 3.1% to 5.0%.<sup>36</sup> Among current users, the percentage of daily user increased from 3.1% in 2015 to 10.7% in 2018. These rates indicate that between 2015 and 2018, there were an additional 4.4 million current users of e-cigarettes, bringing the total number of current adult e-cigarette users in China to over 10 million. Among them, an estimated 1.1 million people used e-cigarettes daily.

There is an increasing body of evidence showing that young people who use e-cigarettes, who have never smoked before and are considered low risk for later taking up smoking, increase their chance of smoking combustible cigarettes later in life by two to four folds.<sup>23–25</sup> It is particularly concerning that children

**Table 3** Percentage of Chinese adults  $\geq 15$  years old who used e-cigarettes by selected demographic characteristics

Demographic characteristics	Ever users of e-cigarettes		Users of e-cigarettes in the past 12 months		Current users of e-cigarettes	
	Percentage	(95% CI)	Percentage	(95% CI)	Percentage	(95% CI)
Overall	5.0	(4.4, 5.6)	2.2	(1.8, 2.6)	0.9	(0.7, 1.2)
Gender						
Male	9.3	(8.3, 10.4)	4.1	(3.4, 4.8)	1.6	(1.2, 2.1)
Female	0.5	(0.3, 0.7)	0.2	(0.1, 0.5)	0.1	(0.1, 0.4)
Age (year)						
15–24	7.6	(5.8, 10.1)	4.4	(3.0, 6.5)	1.5	(0.8, 2.8)
25–44	6.2	(5.3, 7.3)	2.9	(2.3, 3.6)	1.2	(0.8, 1.7)
45–64	3.9	(3.4, 4.6)	1.2	(1.0, 1.6)	0.6	(0.5, 0.9)
65+	1.5	(1.1, 2.0)	0.2	(0.1, 0.4)	0.1	(0.0, 0.3)
Residence						
Urban	5.3	(4.7, 6.1)	2.5	(2.1, 3.0)	1.1	(0.8, 1.5)
Rural	4.4	(3.7, 5.3)	1.6	(1.2, 2.3)	0.5	(0.3, 0.8)
Educational level						
Elementary school and below	1.6	(1.2, 2.1)	0.4	(0.3, 0.7)	0.2	(0.1, 0.4)
Middle school	4.9	(4.2, 5.7)	1.5	(1.1, 1.9)	0.6	(0.4, 0.9)
High school	7.0	(5.4, 9.0)	2.9	(1.9, 4.5)	0.9	(0.5, 1.6)
College/university or above	7.2	(5.7, 9.0)	4.0	(3.0, 5.3)	2.2	(1.4, 3.3)
Smoking status						
Never smoker	0.5	(0.2, 0.7)	0.2	(0.1, 0.4)	0.1	(0.0, 0.2)
Current smoker	15.9	(14.2, 17.6)	7.1	(5.9, 8.2)	3.0	(2.3, 3.8)
Daily smoker	16.6	(14.7, 18.5)	7.1	(5.7, 8.4)	3.2	(2.4, 4.1)
Occasionally smoker	10.6	(6.6, 14.6)	7.0	(3.3, 10.6)	1.7	(0.4, 2.9)
Former smoker	6.6	(4.3, 9.0)	1.8	(0.0, 3.7)	0.4	(0.0, 0.7)
Income(yuan)						
<30 000	4.2	(3.3, 5.0)	1.5	(1.0, 2.1)	0.6	(0.3, 0.8)
30 000–49 999	4.7	(3.7, 5.6)	1.8	(1.1, 2.5)	0.8	(0.3, 1.3)
50 000–99 999	6.4	(5.1, 7.8)	3.0	(1.9, 4.0)	0.9	(0.4, 1.3)
100 000 and above	6.2	(4.6, 7.7)	3.8	(2.5, 5.0)	2.3	(1.3, 3.3)

and adolescents are increasingly taking up the use of e-cigarettes in some countries<sup>19–21</sup> and this concern is merited in China as shown in this study. We found the rates of e-cigarette use among young people aged 15–24 by measures of current use and ever use were consistently higher than among other age groups. This age group had also shown the most significant increase in prevalence since 2015. Similar to Western countries,<sup>37</sup> China's e-cigarette marketers target the younger generation.<sup>38</sup> E-cigarette companies often promote their products as fashionable accessories and emphasise their products' modern and stylish design.<sup>38</sup> The perception among young people that e-cigarette use was fashionable suggests that marketing of e-cigarettes may have played a role in such belief and in the higher use rates among young people. Previous studies have also revealed that flavours had played an important role in the increase of e-cigarette use among youths.<sup>39–40</sup> Many of these same flavours for e-cigarettes are available in China, such as tobacco, mint/menthol, coffee, fruit or candy.<sup>41</sup> Thus, effectively regulating and limiting flavours, probably through the issuance of national product standards for e-cigarettes, as well as national laws or regulations banning the marketing (including advertising, promotion and sponsorship) of e-cigarettes are urgently needed in China to prevent further increase of e-cigarette use among young people.

In August 2018, the State Tobacco Monopoly Administration and the State Administration for Market Regulation coissued a notice banning e-cigarette sales to minors.<sup>42</sup> In November 2019, the two government agencies coreleased another notice,

further urging e-cigarette manufactures and sellers to stop selling and advertising e-cigarettes through online channels.<sup>43</sup> In early November of 2019, eight government agencies, including National Health Commission, Propaganda Department of the Communist Party of China, Ministry of Education, State Administration for Market Regulation, National Radio and Television Administration, State Tobacco Monopoly Administration, Central Committee of the Communist Youth League and All-China Women's Federation jointly issued a notice on further strengthening youth tobacco control work.<sup>44</sup> In this notice, relevant agencies were discouraged to promote e-cigarettes as a cessation tool. The notice also promoted the prohibition of e-cigarette use in public places and reiterated the ban of e-cigarette sales to minors, especially through the Internet. However, how these policies are being implemented and their effects are unclear. For example, according to iiMedia, many e-cigarette companies had turned to offline sales and marketing channels, such as convenience stores and shopping mall stores.<sup>28</sup> Future studies can examine the effects of these policies and offer learnings to other countries regarding policy interventions to prevent youth from using e-cigarettes.

Our study showed the association between e-cigarette use and daily use of combustible cigarettes among male users. This was consistent with previous studies.<sup>30–33</sup> For example, Wang *et al*<sup>34</sup> found that both current and former smokers had a higher OR of knowing and using e-cigarettes than never smokers.<sup>33</sup> Zhao *et al*<sup>30</sup> found that among male, current smokers, those who smoked

**Table 4** Factors associated with current e-cigarette use among men

Demographic characteristics	Current e-cigarettes users			OR	(95% CI)	P value
	Percentage	(95% CI)				
Age (year)						
15–24	2.7	(1.0, 4.3)	14.4	(3.5, 59.6)	0.0003	
25–44	2.1	(1.4, 2.8)	5.2	(1.4, 18.3)	0.0116	
45–64	1.2	(0.8, 1.7)	3.9	(1.1, 14.2)	0.0421	
65+	0.2	(0.0, 0.4)	1.0			
Residence						
Urban	2.0	(1.4, 2.6)	1.5	(0.9, 2.5)	0.1289	
Rural	1.1	(0.6, 1.5)	1.0			
Educational level						
Elementary school and below	0.5	(0.2, 0.8)	1.0			
Middle school	1.3	(0.7, 1.8)	1.7	(0.8, 3.7)	0.1998	
High school	1.7	(0.8, 2.6)	2.3	(1.0, 5.3)	0.0559	
College/university or above	3.6	(2.1, 5.1)	5.8	(2.2, 14.9)	0.0003	
Smoking status						
Daily smoker	3.2	(2.4, 4.1)	22.3	(5.7, 87.6)	<0.0001	
Occasionally smoker	0.9	(0.1, 1.7)	3.4	(0.8, 15.4)	0.1074	
Former smoker	0.4	(0.0, 0.8)	1.9	(0.3, 12.7)	0.5233	
Never smoker	0.3	(0.0, 0.7)	1.0			
Income(yuan)						
<30 000	1.1	(0.6, 1.6)	1.0			
30 000–49999	1.5	(0.5, 2.6)	1.0	(0.5, 2.2)	0.9694	
50 000–99999	1.6	(0.8, 2.5)	0.8	(0.4, 1.8)	0.6595	
100 000 and above	3.5	(1.8, 5.2)	1.7	(0.8, 3.6)	0.1383	

more than 15 cigarettes per day were more likely to use e-cigarettes.<sup>30</sup> Similarly, our study found a high percentage of dual use: 90.6% of current e-cigarette users used both e-cigarettes and combustible cigarettes. This is also consistent with findings from previous studies.<sup>31–33</sup> Additionally, we found that the most common reason for using e-cigarettes was smoking cessation among people of all age groups who currently used e-cigarettes. Wang *et al*<sup>34</sup> also found current smokers who had tried to quit were much more likely to use e-cigarettes than never smokers.<sup>30</sup> Zhao *et al*<sup>32</sup> found that male current smokers, who tried to quit in the past 12 months, were more likely to use e-cigarettes.<sup>33</sup>

Although there are some studies indicating e-cigarettes might be helpful for smokers to quit smoking combustible cigarettes, scientific evidence regarding the effectiveness of e-cigarettes as a smoking cessation aid is still being debated.<sup>45–47</sup> In its 2019 report on the global tobacco epidemic,<sup>48</sup> WHO stated that there is ‘insufficient independent evidence to support the use of e-cigarettes as a population-level tobacco cessation intervention to help people quit conventional tobacco use.’ In our research, although the most common reason of e-cigarette use in China was for cessation, never e-cigarette users had a much higher rate of quitting than ever e-cigarette users. This finding, along with the high percentage of dual users (90.6%) shown in our study, indicates that e-cigarettes had not shown cessation efficacy at the population level in China. Government agencies are currently discouraged to promote e-cigarettes as a cessation tool, but there is no regulation prohibiting e-cigarette manufactures and sellers from claiming or promoting the cessation utility of their products.

China remains the world’s largest tobacco producer and consumer.<sup>35</sup> In 2018, 26.6% of Chinese adults (aged 15 and older) currently smoked. In 2019, the Chinese government published the Healthy China 2030 Action Plan, specifying

tobacco control actions to decrease the smoking prevalence among people aged 15 and older to below 20% by 2030.<sup>49</sup> Achieving this target requires effective measures to help smokers quit and prevent children and young people from becoming smokers. The increase in e-cigarette use among Chinese adults, especially among younger adults, and the high prevalence of dual use have made the tobacco control situation even more complex. Without effective regulations, e-cigarette use could exacerbate the nicotine addiction epidemic, which may erode progress made in tobacco control. The findings of this paper call for policies such as banning the marketing of e-cigarettes, enforcing the ban of sales to minors and the ban of e-cigarette advertising and sales on the Internet, prohibiting the claim or promotion of the cessation utility of e-cigarettes before solid evidence is available, and regulating flavours to minimise the risks of e-cigarettes at the population level, especially among young people.

### Limitations

In the household survey, one individual was randomly selected for each household to complete the survey. Because of urbanisation, many young people had moved to larger cities and as a result, young people were under-represented in the sample, especially in rural areas. To account for this, weighting and post-stratification adjustment were used in this study. In addition, this survey excluded those who lived collectively in places such as student dormitories, nursing homes, military camps, prisons or hospitals, there may be few college students covered by the survey. Our study showed that people with a college/university or above education level were more likely to use e-cigarettes. The prevalence of e-cigarettes among people aged 15–24 shown in our study might be underestimated.

## What this paper adds

- ▶ This paper describes the awareness and prevalence of e-cigarettes and analysed the associated factors of e-cigarette use among Chinese adults, using nationally representative data.
- ▶ Consistent with the trend of increasing e-cigarette use in some other countries, our paper reveals an increase of e-cigarette use between 2015 and 2018 in China, especially among young people aged 15–24.
- ▶ Considering the findings on the high percentage of dual users and the lower quit rate of ever e-cigarette users compared with never e-cigarette users, we raise questions on the effectiveness of e-cigarettes on smoking cessation at the population level.
- ▶ Our findings suggest future research areas and call for effective regulations to protect youth and minimise the risks of e-cigarettes on public health. Finally, the study offers national-level data analysis that can be compared across countries.

**Acknowledgements** We thank all the experts of the United States Centre for Disease Control and Prevention (US CDC) for providing guidance and assistance. Our appreciation also goes to the national project office and provincial survey teams for their important work.

**Contributors** LX and XY drafted the paper; XD, TL and YN took responsibility of the data analysis and literature review; YW help to revised the draft to improve the quality of this paper; XL supervise the whole process and provided his suggestion for this paper.

**Funding** The 2018 Global Tobacco Adult Survey China Project was funded by WHO (WPCHN1814405).

**Competing interests** None declared.

**Patient consent for publication** Not required.

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

**Data availability statement** All data relevant to the study are included in the article or uploaded as online supplemental information. All of the paper text can be published.

**Open access** This is an open access article distributed under the terms of the Creative Commons Attribution-Non commercial IGO License (CC BY-NC 3.0 IGO), which permits use, distribution, and reproduction for non-commercial purposes in any medium, provided the original work is properly cited. In any reproduction of this article there should not be any suggestion that WHO or this article endorse any specific organization or products. The use of the WHO logo is not permitted. This notice should be preserved along with the article's original URL.

## ORCID iD

Lin Xiao <http://orcid.org/0000-0002-5052-6663>

## REFERENCES

- 1 Fox News. China's e-cigarette inventor fights for financial rewards. Available: <https://www.foxnews.com/world/chinas-e-cigarette-inventor-fights-for-financial-rewards> [Accessed 10 Nov 2018].
- 2 Statista. Electronic cigarettes (e-cigarettes) dollar sales worldwide from 2008 to 2017. Available: <https://www.statista.com/statistics/493214/global-e-cigarettes-dollar-sales/> [Accessed 11 Nov 2018].
- 3 Tobacco Tactics. E-Cigarettes. Available: <https://www.tobaccotactics.org/index.php/E-cigarettes> [Accessed 11 Nov 2018].
- 4 U.S. Department of Health and Human Services. *E-Cigarette use among youth and young adults. A report of the surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2016.
- 5 Callahan-Lyon P. Electronic cigarettes: human health effects. *Tob Control* 2014;23 Suppl 2:ii36–40.
- 6 Dinakar C, O'Connor GT. The health effects of electronic cigarettes. *N Engl J Med* 2016;375:1372–81.
- 7 Lee M-S, LeBouf RF, Son Y-S, *et al*. Nicotine, aerosol particles, carbonyls and volatile organic compounds in tobacco- and menthol-flavored e-cigarettes. *Environ Health* 2017;16:42.
- 8 Fernandez E. *Institut Catal d'Oncologia, Exposure to Aerosols from Smoking-proxy Electronic Inhaling Systems: a Systematic Review, unpublished report*. Fernandez, 2016.
- 9 Hess IM, Lachireddy K, Capon A. A systematic review of the health risks from passive exposure to electronic cigarette vapour. *Public Health Res Pract* 2016;26:2621617.
- 10 Visser WGL, Klerx W, Hernandez L, *et al*. The health risks of using e-cigarettes, 2015. Available: <http://www.rivm.nl/bibliotheek/rapporten/2015-0144.pdf>
- 11 Truth Initiative; Available. E-Cigarettes: facts, STATs and regulations. Available: <https://truthinitiative.org/research-resources/emerging-tobacco-products/e-cigarettes-facts-stats-and-regulations> [Accessed 11 Nov 2019].
- 12 McNeill A, Brose LS, Calder R, *et al*. *Vaping in England: an evidence update including mental health and pregnancy, March 2020: a report commissioned by public health England*. London, UK: Public Health England, 2020.
- 13 Owusu D, Huang J, Weaver SR, *et al*. Patterns and trends of dual use of e-cigarettes and cigarettes among U.S. adults, 2015-2018. *Prev Med Rep* 2019;16:101009.
- 14 National Academies of Sciences, Engineering, and Medicine. Public health consequences of e-cigarettes. Washington, DC: The National Academies press. available, 2018. Available: <https://doi.org/10.17226/24952>
- 15 Osei AD, Mirbolouk M, Orimoloye OA, *et al*. Association between e-cigarette use and chronic obstructive pulmonary disease by smoking status: behavioral risk factor surveillance system 2016 and 2017. *Am J Prev Med* 2020;58:336–42.
- 16 Osei AD, Mirbolouk M, Orimoloye OA, *et al*. Association between e-cigarette use and cardiovascular disease among never and current Combustible-Cigarette smokers. *Am J Med* 2019;132:949–54.
- 17 Bozier J, Chivers EK, Chapman DG, *et al*. The evolving landscape of e-cigarettes: a systematic review of recent evidence. *Chest* 2020;157:1362–90.
- 18 Goniewicz ML, Smith DM, Edwards KC, *et al*. Comparison of nicotine and toxicant exposure in users of electronic cigarettes and Combustible cigarettes. *JAMA Netw Open* 2018;1:e185937.
- 19 Perikleous EP, Steiropoulos P, Paraskakis E, *et al*. E-Cigarette use among adolescents: an overview of the literature and future perspectives. *Front Public Health* 2018;6:86.
- 20 Cullen KA, Ambrose BK, Gentzke AS, *et al*. Notes from the Field: Use of Electronic Cigarettes and Any Tobacco Product Among Middle and High School Students - United States, 2011-2018. *MMWR Morb Mortal Wkly Rep* 2018;67:1276–7.
- 21 Palipudi KM, Mbulo L, Morton J, *et al*. Awareness and current use of electronic cigarettes in Indonesia, Malaysia, Qatar, and Greece: findings from 2011-2013 global adult tobacco surveys. *Nicotine Tob Res* 2016;18:501–7.
- 22 US Department of Health and Human Services. *The health consequences of smoking—50 years of progress*. Atlanta, GA: US Department of Health and Human Services, CDC, 2014.
- 23 Berry KM, Fetterman JL, Benjamin EJ, *et al*. Association of electronic cigarette use with subsequent initiation of tobacco cigarettes in US youths. *JAMA Netw Open* 2019;2:e187794.
- 24 Chaffee BW, Watkins SL, Glantz SA. Electronic cigarette use and progression from experimentation to established smoking. *Pediatrics* 2018;141:e20173594.
- 25 Conner M, Grogan S, Simms-Ellis R, *et al*. Do electronic cigarettes increase cigarette smoking in UK adolescents? Evidence from a 12-month prospective study. *Tob Control* 2018;27:365–72.
- 26 Conference of the Parties of the WHO FCTC. *Electronic nicotine delivery systems and electronic non-nicotine delivery systems (ENDS/ENNDS)*. FCTC/COP/7/11, 2016.
- 27 Tsinghua University Public Health and Technical Monitoring Project Team. *China's E-cigarette Industry Monitoring Status Report*, 2019.
- 28 iiMedia. China Electronic-Cigarette industry market operation monitoring report, 2020. Available: <https://www.iimedia.cn/c460/71055.html>
- 29 Gravely S, Fong GT, Cummings KM, *et al*. Awareness, trial, and current use of electronic cigarettes in 10 countries: findings from the ITC project. *Int J Environ Res Public Health* 2014;11:11691–704.
- 30 Zhao L, Mbulo L, Palipudi K, *et al*. Awareness and use of e-cigarettes among urban residents in China. *Tob Induc Dis* 2019;17:53.
- 31 Huang Y, Duan Z, Wang Y, *et al*. Use of electronic nicotine delivery systems (ends) in China: evidence from citywide representative surveys from five Chinese cities in 2018. *Int J Environ Res Public Health* 2020;17:2541.
- 32 Zhao D, Zuo Y, Urmi DS, *et al*. Perception of e-cigarette use among adult users in China: a Mixed-method study. *Int J Environ Res Public Health* 2020;17:2754.
- 33 Xiao L, Parascandola M, Wang C, *et al*. Perception and current use of e-cigarettes among youth in China. *Nicotine Tob Res* 2019;21:1401–7.
- 34 Wang X, Zhang X, Xu X, *et al*. Electronic cigarette use and smoking cessation behavior among adolescents in China. *Addict Behav* 2018;82:129–34.
- 35 Li X. *China adult tobacco survey 2018 report*. Beijing, China: People's Medical Publishing House, 2020.

- 36 Liang X. *China adult tobacco survey 2015 report*. Beijing, China: People's Medical Publishing House, 2016.
- 37 Grana RA, Ling PM. "Smoking revolution": a content analysis of electronic cigarette retail websites. *Am J Prev Med* 2014;46:395–403.
- 38 Jiang N, Ho SY, Lam TH. Electronic cigarette marketing tactics in mainland China. *Tob Control* 2017;26:230–2.
- 39 Brown R, Bauld L, de Lacy E, *et al*. A qualitative study of e-cigarette emergence and the potential for renormalisation of smoking in UK youth. *Int J Drug Policy* 2020;75:102598.
- 40 Cullen KA, Gentzke AS, Sawdey MD, *et al*. E-Cigarette use among youth in the United States, 2019. *JAMA* 2019;322:2095–103.
- 41 Yao T, Jiang N, Grana R, *et al*. A content analysis of electronic cigarette manufacturer websites in China. *Tob Control* 2016;25:188–94.
- 42 Notice of the state administration of market supervision and administration of the state tobacco monopoly on the Prohibition of the sale of e-cigarettes to minors. Available: <https://hi.tobacco.gov.cn/main/content/30/25354.html> [Accessed 7 Sep 2018].
- 43 Notice on further protection of minors from e-cigarettes. Available: [http://www.gov.cn/gongbao/content/2020/content\\_5488930.htm](http://www.gov.cn/gongbao/content/2020/content_5488930.htm) [Accessed 30 Oct 2019].
- 44 National Health Commission. Notice on further strengthening tobacco control work among young people. Available: [http://www.gov.cn/xinwen/2019-11/08/content\\_5450004.htm](http://www.gov.cn/xinwen/2019-11/08/content_5450004.htm) [Accessed 8 Nov 2019].
- 45 Malas M, van der Tempel J, Schwartz R, *et al*. Electronic cigarettes for smoking cessation: a systematic review. *Nicotine Tob Res* 2016;18:1926–36.
- 46 Khoudigian S, Devji T, Lytvyn L, *et al*. The efficacy and short-term effects of electronic cigarettes as a method for smoking cessation: a systematic review and a meta-analysis. *Int J Public Health* 2016;61:257–67.
- 47 El Dib R, Suzumura EA, Akl EA, *et al*. Electronic nicotine delivery systems and/or electronic non-nicotine delivery systems for tobacco smoking cessation or reduction: a systematic review and meta-analysis.[published correction appears in *BMJ Open*. 2020 Jan 10;10(1):e012680corr1]. *BMJ Open* 2017;7:e012680.
- 48 World Health Organization. Who report on the global tobacco epidemic, 2019. Available: [https://www.who.int/tobacco/global\\_report/en/](https://www.who.int/tobacco/global_report/en/) [Accessed 19 May 2019].
- 49 The CPC Central Committee and the State Council issued the outline of "healthy China 2030". Available: [http://www.gov.cn/zhengce/2016-10/25/content\\_5124174.htm](http://www.gov.cn/zhengce/2016-10/25/content_5124174.htm) [Accessed 25 Oct 2016].