Preplanned Studies

E-Cigarette Use Behavior and Influencing Factors Among People Aged 15 Years and Above — Beijing Municipality, China, 2016–2023

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Summary

What is already known about this topic?

The electronic cigarette (e-cigarette) market in China has been gradually expanding. Substantial evidence indicates that e-cigarettes pose considerable health risks to the human body.

What is added by this report?

The prevalence of e-cigarette ever use among Beijing residents aged ≥15 years ranged from 5.7% to 8.6% during 2016–2023, while current use ranged from 1.6% to 2.7%, with both metrics peaking in 2021. Current smokers who had attempted to quit within the past year showed the highest odds of e-cigarette use.

What are the implications for public health practice?

The public are not fully aware of the academic and clinical controversies regarding e-cigarettes' effectiveness for smoking cessation and may underestimate their health risks. There is an urgent need for targeted knowledge campaigns and for the provision of more accessible smoking cessation services.

ABSTRACT

Introduction: Substantial evidence indicates that electronic cigarettes (e-cigarettes) pose considerable health risks to the human body. There is a lack of surveillance data regarding adult e-cigarette use behavior in Beijing.

Methods: This study utilizes the 2016–2023 Beijing Adult Tobacco Survey data to assess the current status, changing trends, and influencing factors of e-cigarette use among urban and rural residents aged ≥15 years across 16 districts of Beijing Municipality. All statistical analyses incorporated complex sampling weights.

Results: The prevalence of e-cigarette ever use among Beijing residents aged ≥15 years was 5.7%, 8.1%, 8.6%, and 6.9% in 2016, 2019, 2021, and 2023, respectively, while current use prevalence was 1.6%, 2.1%, 2.7%, and 1.8%, respectively. Males, younger individuals, those with higher educational attainment, and those living alone demonstrated greater odds of e-cigarette use. Current smokers who had attempted to quit within the past 12 months showed the highest odds of use, followed by current smokers without quit attempts and former smokers who had quit for less than 12 months.

Conclusions: The public are not fully aware of the academic and clinical controversies regarding e-cigarettes' effectiveness for smoking cessation and may underestimate their health risks. There is an urgent need for targeted knowledge campaigns addressing these misconceptions and for the provision of more accessible smoking cessation services.

Both e-cigarette liquids and aerosols contain a variety of carcinogens, toxic and hazardous substances that pose considerable health risks to the human body (*1*). In 2018, the number of electronic cigarette (e-cigarette) users aged 15 years and above in China reached 10.35 million (*2*). The prevalence of past 30-day e-cigarette use among Chinese adults increased from 1.3% in 2015–2016 to 1.6% in 2018–2019 (*3*). Beijing, the first city in China to introduce tobacco control legislation, has not yet included e-cigarettes in its ban on smoking in public places, and there is a lack of population monitoring data on e-cigarette use. This study utilizes the 2016–2023 Beijing Adult Tobacco Survey (BATS) data to assess the current status and changing trends of e-cigarette use among Beijing residents aged ≥15 years, and to explore its correlation with cigarette smoking, in order to provide a basis for future tobacco control policies.

The four waves of BATS employed consistent methodology, targeting urban and rural residents aged ≥15 years across 16 districts of Beijing Municipality, China (excluding the Economic and Technological

Development Area). We utilized a stratified multi-stage cluster sampling approach, selecting 50 sub-districts (townships) and 100 residence (village) committees. From 2016–2019, we sampled 100 households from each residence (village) committee, increasing to 120 households per committee in 2021 and 2023. Survey investigators conducted household visits during which one individual aged ≥15 years was randomly selected from each household to participate. Face-to-face interviews were administered using portable electronic devices. The questionnaire, adapted from the China Adult Tobacco Survey, assessed respondents' demographic characteristics, smoking status, e-cigarette use patterns, cessation attempts, secondhand smoke exposure, and knowledge and attitudes regarding tobacco products. All analyses incorporated complex sampling weights, with final weights calculated separately for each survey wave. These comprised sampling weights, non-response adjustment weights, and post-stratification weights. Utilizing a pooled cross-sectional design, we merged key variables from all four survey waves into a unified dataset. As each wave was independently sampled and weighted from the same population, the final weights remained unaltered across waves. Multiple logistic regression models were constructed to identify factors associated with e-cigarette use, with survey year incorporated as a dummy variable. Comprehensive methodological details have been previously documented (*4*).

Analysis variables included: 1) e-cigarette ever use: respondents self-reported having used e-cigarettes at least once; 2) e-cigarette current use: respondents currently using e-cigarettes daily or non-daily; 3) current smokers: respondents currently smoking cigarettes daily or non-daily; 4) quitters: respondents who formerly smoked but currently do not; 5) time of cessation: duration since quitting as reported in response to "How long have you quit smoking"; and 6) living alone: household registry indicating a single-person household. All statistical analyses were performed using the *survey* package in R software (version 4.4.1, The R Foundation, Indianapolis, IN, United States) (*5*).

From the four waves of the BATS, 9,372, 8,534, 10,551, and 10,727 valid respondents were included in the analyses. After weighting, this sample was representative of the resident population aged ≥15 years in Beijing. Among them, 20.5% were current smokers, 7.3% were quitters, and 72.1% were never smokers. The prevalence of e-cigarette ever use was 5.7%, 8.1%, 8.6%, and 6.9% in 2016, 2019, 2021, and 2023, respectively, while current use rates were 1.6%, 2.1%, 2.7%, and 1.8%, respectively. Both metrics peaked in 2021 before subsequently declining. The between-year differences in ever use rates were statistically significant. E-cigarette use was higher among younger individuals, those with higher educational attainment, individuals in occupations other than healthcare providers or educators, and those living alone. E-cigarette use was most prevalent among current smokers who had attempted to quit within the past 12 months, followed by current smokers without quit attempts, and those who had ceased smoking within the past 12 months. Prevalence was lowest among individuals who had quit smoking for ≥12 months and those who had never smoked (Table 1).

Multivariate logistic regression analyses revealed that age ≥25 years (compared to 15–24 years) was negatively associated with ever using e-cigarettes [odds ratio (*OR*)=0.641, 95% confidence interval (*CI*): 0.423, 0.971 for the 25–44 group, *OR*=0.290, 95% *CI*: 0.192, 0.438 for the 45–64 group, and *OR*=0.189, 95% *CI*: 0.114, 0.311 for the 65+ group], while age ≥ 45 years (compared to 15–24 years) was negatively associated with current e-cigarette use (*OR*=0.210, 95% *CI*: 0.113, 0.391 for the 45–64 group, and *OR*=0.062, 95% *CI*: 0.019, 0.208 for the 65+ group). Compared to never smokers, current smokers and quitters demonstrated strong positive correlations with both ever (*OR*=111.173, 95% *CI*: 64.341, 192.093 for current smokers with past-year quit attempts, *OR*=70.142, 95% *CI*: 43.077, 114.213 for current smokers without quit attempts, *OR*=60.087, 95% *CI*: 30.730, 117.487 for past-year quitters, and *OR*=23.101, 95% *CI*: 13.520, 39.473 for long-time quitters), and current e-cigarette use (*OR*=147.017, 95% *CI*: 62.794, 344.208 for current smokers with past-year quit attempts, *OR*=82.758, 95% *CI*: 34.771, 196.968 for current smokers without quit attempts, *OR*=38.863, 95% *CI*: 12.332, 122.471 for past-year quitters, and *OR*=26.275, 95% *CI*: 9.851, 70.078 for long-time quitters). The odds of ever e-cigarette use were significantly higher among those living alone (*OR*=1.299, 95% *CI*: 1.037, 1.627), though this association was not statistically significant for current e-cigarette use. Regarding temporal trends, after controlling for other variables, e-cigarette ever use was significantly lower in 2016 (*OR*=0.729, 95% *CI*: 0.538, 0.987) and higher in 2021 (*OR*=1.409, 95% *CI*: 1.092, 1.818) than in 2023, and current e-cigarette use exhibited a similar trend, though not statistically significant (Tables 2–3).

TABLE 1. Comparisons of demographic and e-cigarette use behaviors.

Characteristics	*N* (%)	E-cig ever use (%, 95% *CI*)	E-cig current use (%, 95% *CI*)
Total	39,184 (100)	7.3 (6.7, 8.0)	2.0 (1.7, 2.4)
Survey year			
2016	9,372 (25)	5.7 (4.4, 6.9)	1.6 (1.1, 2.1)
2019	8,534 (25)	8.1 (6.8, 9.5)	2.1 (1.5, 2.8)
2021	10,551 (25)	8.6 (7.3, 9.8)	2.7 (2.0, 3.3)
2023	10,727 (25)	6.9 (5.7, 8.0)	1.8 (1.0, 2.5)
χ^2		73.87	32.27
P		0.006	0.120
Gender			
Male	17,810 (51.5)	12.6 (11.4, 13.9)	3.4 (2.8, 4)
Female	21,374 (48.5)	1.6 (1.1, 2.1)	0.6 (0.3, 0.9)
χ^2		1753.6	382.29
P		<0.001	<0.001
Age (years)			
15–24	1,172 (20.7)	7.9 (5.9, 10.0)	2.3 (1.3, 3.3)
25–44	1,1753 (42.3)	9.3 (8.1, 10.4)	3.0 (2.4, 3.7)
45–64	1,6342 (27.5)	5.5 (4.8, 6.1)	0.9 (0.7, 1.1)
65+	9,917 (9.5)	2.7 (2.2, 3.2)	0.2 (0.1, 0.3)
χ^2		268.44	222.31
P		<0.001	<0.001
Educational level			
Primary school and below	4,641 (6.7)	3.0 (1.2, 4.8)	1.2 (-0.5, 2.9)
Secondary school	1,0896 (21.1)	5.0 (4.2, 5.8)	0.6 (0.4, 0.8)
High school	8,833 (20.4)	7.7 (6.4, 8.9)	1.7 (1.2, 2.3)
Undergraduate and above	13,572 (51.8)	8.4 (7.4, 9.4)	2.7 (2.2, 3.3)
χ^2		176.96	148.18
P		<0.001	<0.001
Occupation			
Doctor/Teacher	1,295 (4.6)	2.8 (1.5, 4.1)	0.7 (0.2, 1.2)
Other occupations	21,512 (72.6)	8.5 (7.7, 9.3)	2.5 (2.1, 2.9)
Retired/unemployed	16,277 (22.8)	4.5 (3.6, 5.3)	1.0 (0.3, 1.6)
χ^2		219.24	91.774
P		<0.001	<0.001
Smoking status			
Current smoker, without quit attempts within 12 months	6,259 (15.7)	26.1 (23.3, 28.9)	7.2 (5.5, 8.9)
Current smoker, with quit attempts within 12 months	1,873 (4.8)	36.2 (32.2, 40.3)	12.3 (9.1, 15.4)
Ex-smoker, quit for less than 12 months	501 (1.7)	26.2 (17.9, 34.6)	4.6 (1.5, 7.7)
Ex-smoker, quit for at least 12 months	3,115 (5.6)	8.7 (6.6, 10.8)	1.7 (0.8, 2.7)
Never smoker	27,375 (72.1)	0.7 (0.4, 1.0)	0.2 (0.1, 0.3)
χ^2		7731.4	2340.2
P		<0.001	<0.001
Living alone			
No	28,156 (14.7)	6.8 (6.1, 7.5)	1.9 (1.5, 2.3)
Yes	10,995 (85.3)	10.2 (8.8, 11.6)	2.8 (2.1, 3.5)
χ^2		82.626	18.724
P		<0.001	0.018

Abbreviation: *CI*=confidence interval.

TABLE 2. Univariate and multivariate analyses of e-cigarette ever use among people aged ≥15 in Beijing.

Characteristics	*OR* (95% *CI*)	*P*	Adjusted *OR* (95% *CI*)†	*P*
Gender				
Male	Ref		Ref	
Female	0.114 (0.081, 0.162)	<0.001	1.09 (0.762, 1.560)	0.636
Age (years)				
15–24	Ref		Ref	
25–44	1.184 (0.846, 1.658)	0.323	0.641 (0.423, 0.971)	0.036
45–64	0.670 (0.501, 0.895)	0.007	0.290 (0.192, 0.438)	<0.001
≥65	0.324 (0.230, 0.456)	<0.001	0.189 (0.114, 0.311)	<0.001
Educational level*				
Primary school and below	Ref		Ref	
Secondary school	1.694 (0.979, 2.929)	0.059	0.993 (0.467, 2.112)	0.985
High school	2.683 (1.510, 4.768)	<0.001	1.809 (0.812, 4.032)	0.146
Undergraduate and above	2.962 (1.550, 5.658)	0.001	2.040 (0.914, 4.550)	0.081
Occupation				
Doctor/Teacher	Ref		Ref	
Other occupations	3.216 (1.998, 5.176)	<0.001	1.676 (0.953, 2.948)	0.073
Retired/unemployed	1.623 (0.946, 2.784)	0.078	1.702 (0.859, 3.375)	0.127
Smoking status				
Never smoker	Ref		Ref	
Current smoker, without quit attempts within 12 months	49.125 (31.005, 77.834)	<0.001	70.142 (43.077, 114.213)	<0.001
Current smoker, with quit attempts within 12 months	79.049 (48.779, 128.103)	<0.001	111.173 (64.341, 192.093)	<0.001
Ex-smoker, quit for less than 12 months	49.458 (25.917, 94.383)	<0.001	60.087 (30.730, 117.487)	<0.001
Ex-smoker, quit for at least 12 months	13.238 (7.754, 22.598)	<0.001	23.101 (13.520, 39.473)	<0.001
Living alone				
No	Ref		Ref	
Yes	1.552 (1.294, 1.861)	<0.001	1.299 (1.037, 1.627)	0.023
Survey year				
2023	Ref		Ref	
2016	0.813 (0.607, 1.088)	0.162	0.729 (0.538, 0.987)	0.041
2019	1.197 (0.929, 1.542)	0.164	1.146 (0.879, 1.495)	0.312
2021	1.266 (0.996, 1.609)	0.054	1.409 (1.092, 1.818)	0.009

Abbreviation: *CI*=confidence interval; *OR*=odds ratio; Ref=reference.
* In the univariate analysis, educational level assessment was restricted to participants aged ≥25 years.
† Adjusted *OR*: multivariate logistic regression model *OR*, adjusting for all other variables in the table.

DISCUSSION

In the present study, the prevalence of e-cigarette use among adult smokers in Beijing during 2016–2023 ranged from 26%–36%, substantially higher than the 12.8% reported in a 2015 study, reflecting the significant expansion of the e-cigarette market over the past decade (*6*). Our findings demonstrate that both ever use and current use rates peaked in 2021 before subsequently declining. After controlling for other variables, the odds of e-cigarette ever use was 0.73 times lower in 2016 than in 2023 (*P*=0.041), and 1.41 times higher in 2021 than in 2023 (*P*=0.009). Similarly, the 2023 China Youth Tobacco Survey documented a significant decrease in e-cigarette use among secondary school students compared to 2021 levels (*7*). This decline coincided with the implementation of comprehensive regulatory policies during 2021–2022, including the third amendment to the *Regulations for the Implementation of the Tobacco*

TABLE 3. Univariate and multivariate analyses of e-cigarette current use among people aged ≥15 in Beijing.

Characteristics	*OR* (95% *CI*)	*P*	Adjusted *OR* (95% *CI*)†	*P*
Gender				
Male	Ref		Ref	
Female	0.171 (0.105, 0.279)	<0.001	1.998 (1.109, 3.598)	0.021
Age (years)				
15–24	Ref		Ref	
25–44	1.318 (0.784, 2.214)	0.295	0.822 (0.488, 1.384)	0.458
45–64	0.375 (0.227, 0.619)	<0.001	0.210 (0.113, 0.391)	<0.001
≥65	0.091 (0.045, 0.184)	<0.001	0.062 (0.019, 0.208)	<0.001
Educational level*				
Primary school and below	Ref		Ref	
Secondary school	0.516 (0.113, 2.358)	0.392	0.629 (0.136, 2.912)	0.551
High school	1.449 (0.309, 6.798)	0.637	1.208 (0.256, 5.697)	0.810
Undergraduate and above	2.325 (0.565, 9.557)	0.241	1.467 (0.378, 5.697)	0.578
Occupation				
Doctor/teacher	Ref		Ref	
Other occupations	3.675 (1.801, 7.498)	<0.001	1.8 (0.856, 3.786)	0.121
Retired/unemployed	1.447 (0.515, 4.065)	0.481	2.01 (0.641, 6.302)	0.230
Smoking status				
Never smoker	Ref		Ref	
Current smoker, without quit attempts within 12 months	43.366 (20.583, 91.368)	<0.001	82.758 (34.771, 196.968)	<0.001
Current smoker, with quit attempts within 12 months	78.191 (37.658, 162.354)	<0.001	147.017 (62.794, 344.208)	<0.001
Ex-smoker, quit for less than 12 months	26.953 (9.541, 76.143)	<0.001	38.863 (12.332, 122.471)	<0.001
Ex-smoker, quit for at least 12 months	9.936 (4.068, 24.269)	<0.001	26.275 (9.851, 70.078)	<0.001
Living alone				
No	Ref		Ref	
Yes	1.471 (1.065, 2.032)	0.020	1.084 (0.732, 1.606)	0.685
Survey year				
2023	Ref		Ref	
2016	0.895 (0.521, 1.54)	0.688	0.825 (0.459, 1.484)	0.520
2019	1.192 (0.692, 2.051)	0.525	1.113 (0.636, 1.945)	0.707
2021	1.510 (0.907, 2.515)	0.112	1.570 (0.952, 2.589)	0.077

Abbreviation: *CI*=confidence interval; *OR*=odds ratio; Ref=reference.
* In the univariate analysis, educational level assessment was restricted to participants aged ≥25 years.
† Adjusted *OR*: multivariate logistic regression model *OR*, adjusting for all other variables in the table.

Monopoly Law in 2021, which mandated that e-cigarettes and other novel tobacco products be regulated according to provisions governing conventional cigarettes. Additionally, the 2022 *Measures for the Administration of Electronic Cigarettes* prohibited the sale of all flavored e-cigarettes and devices with self-added atomizers. Although Beijing has yet to incorporate e-cigarettes into its public smoking control regulations as Shenzhen has done, these national regulatory measures may have contributed to the observed reduction in e-cigarette marketing and consumption.

Our findings revealed distinct demographic patterns among e-cigarette users, with males, younger individuals, and those with higher educational attainment demonstrating significantly greater odds of e-cigarette use. This demographic profile—with the exception of gender — presents an inverse relationship to the characteristics typically associated with conventional cigarette smokers (*4*). These patterns

align with observations from a 2012 U.S. survey examining emerging e-cigarette adoption trends (*8*). Through the lens of Diffusion of Innovation Theory, which posits that adoption rates of novel technologies are influenced by relative advantage, compatibility, complexity, trialability, and observability (*9*), these demographic differences become interpretable. Younger, more educated individuals typically possess enhanced access to information channels regarding e-cigarettes (observability) and demonstrate greater susceptibility to peer network influences and evolving social norms (relative advantage). Furthermore, the financial and cognitive barriers to acquiring and using e-cigarettes present fewer obstacles for these demographic groups (reduced complexity and trialability).

Our analysis reveals that cigarette smoking status represents the strongest predictor of e-cigarette use. The odds of ever using e-cigarettes among current smokers with quit attempts within the past 12 months were 111.17 times higher than never smokers, while current smokers without quit attempts, recent quitters (≤12 months), and long-term quitters (>12 months) exhibited odds ratios of 70.14, 60.09, and 23.1, respectively. Similarly, the odds of current e-cigarette use among these groups were 147.02, 82.76, 38.86, and 26.27 times higher than never smokers, respectively. This pattern aligns precisely with findings from the United States National Health Interview Survey (NHIS) data (*10*). On one hand, these results reflect a strong association between cigarette smoking and e-cigarette use. On the other hand, the fact that smokers with quit attempts use e-cigarettes more than those without quit attempts, and that recent quitters use e-cigarettes more than long-term quitters, suggests that a substantial proportion of smokers — particularly younger, more educated individuals living alone — utilize e-cigarettes as smoking cessation aids. To date, e-cigarettes' effectiveness for smoking cessation remains controversial (*11*), and their health risks may be underestimated by the public. There is an urgent need for targeted educational campaigns and improved accessibility to evidence-based cessation services.

Conflicts of interest: No conflicts of interest.

Ethical statement: Ethical approval was obtained from the Beijing Center for Disease Prevention and Control (BJCDC) Institutional Review Board (Approval No. 2019-10).

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