Electronic cigarette use among adults in 14 countries: A cross-sectional study

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Summary

Background The tobacco product landscape continues to change. No recent data for electronic cigarette (e-cigarette) use have been reported for multiple countries based on nationally representative surveys. We examined prevalence of e-cigarette use and variations by sociodemographic characteristics in 14 countries using Global Adult Tobacco Survey (GATS) data between Jan 1, 2015, and Dec 31, 2018.

Methods GATS is a nationally representative household survey of tobacco use among adults aged ≥15 years. The analytic sample size ranged from 4347 in Senegal to 74,037 in India. Prevalence of current e-cigarette use was stratified by sociodemographic subgroups. Age-standardized prevalence was estimated according to world 2000−2025 standard population. Significant differences in adjusted prevalence across sociodemographic subgroup was determined by p value for marginal effect contrast in multivariable logistic regression models.

Findings More than 50% of adults in Russia, Romania, and Ukraine and additionally more than 30% of adults in China, Costa Rica, Uruguay, Mexico, and Philippines were aware of e-cigarettes. Crude prevalence of current e-cigarette use ranged from 0.02% (95% CI 0.01%−0.04%) in India to 3.5% (2.9%−4.2%) in Russia. Prevalence was <1% in nine countries. Approximately 18.3 million adults currently used e-cigarettes across the 14 countries. Men had a significantly higher prevalence of current e-cigarette use than women in eight countries. Additionally, higher adjusted prevalence was observed in some countries among young adults aged 15−24 years, urban residents, and adults with higher education levels and higher wealth index.

Interpretation The study provides needed baseline data on e-cigarette awareness and use. Continued surveillance is essential to inform interventions and policies to prevent initiation and enhance cessation support.

Funding None.

Keywords: Prevalence; Electronic cigarettes; E-cigarettes; Global; Adults; Country

Introduction

Tobacco use is a major preventable cause of premature death and disease. More than 8 million people in the world die each year from diseases related to tobacco use, and over 80% of the 1.3 billion tobacco users live in low-income and middle-income countries (LMICs).[1] The annual global cost of health care and lost productivity due to tobacco use exceeds US$1 trillion.[2] Although the global prevalence of smoking tobacco has decreased significantly overall during the past three decades, the use of new and emerging tobacco products has increased.[3] Electronic cigarettes (e-cigarettes, also known as "e-cigs," "vapes," "e-hookahs," "vape pens," and "electronic nicotine delivery systems") include a diverse group of devices that allow users to inhale an aerosol into the lung typically containing nicotine.

It has been acknowledged that e-cigarettes contain fewer toxic chemicals than regular cigarettes, and so are likely to be less hazardous to the user's health.[3] However, most e-cigarettes contain nicotine which is highly addictive and is a health danger for pregnant adults, fetuses, adolescents, and young adults.[4] Besides nicotine, e-cigarette aerosol can also contain cancer-causing chemicals, volatile organic compounds, and heavy metals. Furthermore, as an additive in some

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Research in context

Evidence before this study

Since the mid-2000s, the tobacco and nicotine product landscape has been expanded to include a variety of new products including electronic cigarettes (e-cigarettes). We searched PubMed and Medline for primary research studies published in English between Jan 1, 2015, and Oct 30, 2021, using combinations of "prevalence", "adults", the 14 countries included in the present study, and "electronic cigarettes", "e-cigarette", "e-cigs," "vapes," "e-hookahs," "vape pens," "electronic nicotine delivery systems," or "ENDS". We only identified one study that examined the prevalence of e-cigarette use by sociodemographic characteristics among Chinese adults in 2018 based on the nationally representative data.

Added value of this study

Emerging tobacco products, including e-cigarettes, present a challenge for the goal of establishing a tobacco-free generation. The present study reported prevalence of awareness of and use of e-cigarettes and examined variations across 14 countries and sociodemographic groups, which can serve as baseline data for surveillance, evaluation, and interventions. Higher adjusted prevalence of current e-cigarette use was observed in certain countries among men, young adults aged 15–24 years, urban residents, and adults with higher education levels and higher wealth index. To our knowledge, this is the first study that reports the prevalence in 13 of these countries based on the nationally representative samples.

Implications of all the available evidence

We found that more than 18 million adults reported current use of e-cigarettes in the 14 countries and there were considerable variations in use across countries and population subgroups with certain sociodemographic characteristics. Although continued progress has been made globally in curbing the tobacco use epidemic, efforts are warranted to address the shifting landscape with introduction of new and emerging tobacco products, including e-cigarettes. Opportunities exist for countries to develop and implement evidence-based policies and strategies related to the use of e-cigarettes. Continued surveillance and monitoring of e-cigarettes and other new and emerging tobacco products is essential for informing tobacco control policy, planning, regulation, and practice worldwide.

tetrahydrocannabinol (THC)-containing e-cigarettes, vitamin E acetate has been linked to the outbreak of e-cigarette or vaping product use-associated lung injury (EVALI) in the autumn of 2019.[4]

Given the progress made towards a tobacco-free generation, continued surveillance of e-cigarette use is essential to providing evidence for developing, sustaining, and strengthening tobacco control at the country level. As the tobacco product landscape continues to change along with the marketing of products such as e-cigarettes, evidence has begun to show the uptake of new products in various LMICs.[3,5] Examining the use of emerging tobacco products like e-cigarettes is important to inform tobacco control policies. During 2011–2013, data from the Global Adult Tobacco Survey (GATS) showed prevalence of current e-cigarette use in Indonesia, Malaysia, Qatar, and Greece.[5] Since then, as countries grapple with new products, e-cigarette data were collected in GATS in more countries for the first time as a standardized component of tobacco surveillance. An efficient and systematic surveillance mechanism is essential to monitor and manage the global tobacco epidemic and provide evidence for e-cigarette regulations. However, only one study reported the prevalence of e-cigarette use by sociodemographic groups among Chinese adults in 2018 based on the nationally representative data.[6] In the present study, we examined the prevalence of e-cigarette use and variations by sociodemographic characteristics among adults aged ≥15 years in 14 countries that collected GATS data between 2015-2018.

Methods

Data source

GATS is a nationally representative household survey of noninstitutionalized adults aged ≥15 years to monitor tobacco use and related tobacco control indicators in multiple countries, including smoking and smokeless tobacco, cessation, secondhand smoke, economics, media, and knowledge and perceptions towards tobacco use. The cross-sectional survey measures smoking, smokeless tobacco use, cessation, secondhand smoke exposure, economics, media, as well as knowledge, attitudes and perceptions towards tobacco use.[7] It is designed to produce national and regional estimates based on the standard protocol, sample design, and data collection method. The GATS interview consists of the Household Questionnaire and the Individual Questionnaire. Both questionnaires are conducted using electronic data collection devices. GATS samples are randomly selected through multistage cluster sampling methods to ensure adequate coverage of the entire target population.[7] Field Interviewers administer the Household Questionnaire to one adult household member and one individual in the household is randomly selected to complete the Individual Questionnaire. Survey sample weights were created with nonresponse and post-stratification adjustments to provide nationally representative estimates for adults aged ≥15 years. GATS provides a standard core questionnaire and optional questions, including e-cigarette use and awareness, for countries to choose.[7] We analyzed the e-cigarette data collected in

GATS between Jan 1, 2015, and Dec 31, 2018, from 14 countries, including Bangladesh, China, Costa Rica, Ethiopia, India, Mexico, Philippines, Romania, Russia, Senegal, Turkey, Ukraine, Uruguay, and Vietnam. The response rate ranged from 64.4% in Ukraine to 98.2% in Russia.[8] Because deidentified data from public sources were used, this research was considered exempt from institutional review board approval.

Outcomes and sociodemographic variables

The major study outcome is the prevalence of current use of e-cigarettes. Adults who answered "daily" or "less than daily" to the question "Are you currently using electronic cigarettes daily, less than daily, or not at all?" were defined as currently using e-cigarettes. Other outcome variables include ever use and awareness of e-cigarettes. Ever use of e-cigarettes was dichotomized based on the answer (yes/no) to the question "Have you ever, even once, used an electronic cigarette?" Awareness of e-cigarettes was classified according to the answer (yes/no) to the question "Before today, have you ever heard of electronic cigarettes?"

Sociodemographic characteristics included age (15–24, 25–44, and ≥45 years), sex, residential area (urban and rural), education level, and wealth index. To ensure larger sample sizes and reliable prevalence estimates for population subgroups, education level was divided into two categories: no or primary education (1st-7th grade), and secondary education (8th-12th grade) or higher. The wealth index scores at the individual level were calculated based on the ownership of household assets and consumer goods. The distribution of wealth index was then divided into quintiles. We combined the quintiles categories (lowest, low, and middle; high and highest) so reliable prevalence of outcome variables can be presented by wealth index.

Statistical analysis

Description statistics in SUDAAN 11.0.1 (RTI International, Research Triangle Park, North Carolina) accounting for sample weights and other designing variables were used to get weighted crude prevalence of current and ever use of e-cigarettes and e-cigarette awareness and the 95% confidence intervals (CI) based on Taylor series variance estimation. The prevalence of current e-cigarette use was stratified by sociodemographic groups. Prevalence estimates were suppressed if they did not meet the National Center for Health Statistics (NCHS) data reporting criteria that consider the effective sample size, degree of freedom, and the absolute and relative widths of the Korn and Graubard confidence interval.[9] To control for the impact of age distribution on prevalence in different countries, age-standardized prevalence of current e-cigarette use for each country were estimated according to the age distribution of the world 2000-2025 standard

population projected by the World Health Organization (WHO).[10] Differences in the adjusted prevalence of current e-cigarette use across the sociodemographic groups were determined based on the contrast of marginal effect between groups adjusting for age, sex, residence, education level, and wealth index quintile in multivariable logistic regression models. The adjusted prevalence difference was considered statistically significant if the two-sided p value was <0.05.

The analytic sample ranged from 4,347 adults in Senegal to 74,037 adults in India. Half of the countries (Bangladesh, China, Ethiopia, India, Mexico, Philippines, and Russia) collected e-cigarettes data among over 10,000 adults aged ≥15 years. We excluded adults who did not respond to the question of current e-cigarette use. The proportion of missing data excluded varied from 0.02% in Vietnam to 0.34% in Turkey.

Role of the funding source

There was no funding source for this study. All authors had full access to all the data in the study and the final responsibility for the decision to submit for publication.

Results

More than 50% of adults aged ≥15 years in Russia (79.9%; 95% CI, 78.2%–81.4%), Romania (76.5%; 95% CI, 74.3%–78.5%), and Ukraine (50.9%; 95% CI, 48.5%–53.3%) and additionally more than 30% of adults in China (48.5%; 95% CI, 46.0%–51.0%), Costa Rica (47.5%; 95% CI, 45.6%–49.4%), Uruguay (45.3%; 95% CI, 42.7%–47.9%), Mexico (35.3%; 95% CI, 33.6%–37.1%), and Philippines (31.7%; 95% CI, 29.7%–33.8%) were aware of e-cigarettes. The proportion of adults reported awareness of e-cigarettes was lowest in India (3.0%; 95% CI, 2.8%–3.3%), Ethiopia (4.0%; 95% CI, 3.3%–4.9%), and Bangladesh (6.4%; 95% CI, 5.5%–7.4%) (Table 1).

In general, the prevalence of ever use of e-cigarettes was also higher for the countries with a higher proportion of adults who were aware of the product (Cohen's kappa for agreement=0.75). For example, the prevalence of ever use of e-cigarettes was 14.2% (95% CI, 12.9%–15.7%) in Russia in 2016, 11.3% (95% CI, 10.1%–12.6%) in Romania in 2018, and 6.4% (95% CI, 5.6%–7.2%) in Ukraine in 2017. In contrast, the prevalence of ever use of e-cigarettes was only 0.1% (95% CI, 0.07%–0.13%) in India in 2016–2017, 0.2% (95% CI, 0.1%–0.3%) in Ethiopia in 2016, and 0.4% (95% CI, 0.3%–0.6%) in Bangladesh in 2017 (Table 1).

The crude prevalence of current e-cigarette use ranged from 0.02% (95% CI, 0.01%–0.04%) in India in 2016-17 to 3.5% (95% CI, 2.9%–4.2%) in the Russia in 2016 (Table 1). The median prevalence estimates were 0.8% in Philippines in 2015 and 0.9% in China in 2018. The overall prevalence of current e-cigarette was

Country (Year)	n*	Awareness of E-Cigarettes		Ever E-Cigarette Use		Current E-Cigarette Use	
		Prevalence[†] % (95% CI)	Population Count[‡]	Prevalence[†] % (95% CI)	Population Count[‡]	Prevalence[†] % (95% CI)	Population Count[‡]
Bangladesh (2017)	12,783	6.4 (5.5-7.4)	6,830,557	0.4 (0.3-0.6)	470,283	0.2 (0.1-0.4)	250,101
China (2018)	19,376	48.5 (46.0-51.0)	561,018,970	5.0 (4.4-5.6)	57,448,409	0.9 (0.7-1.2)	10,348,404
Costa Rica (2015)	8,607	47.5 (45.6-49.4)	1,735,139	4.1 (3.5-4.9)	150,723	1.3 (1.0-1.7)	46,664
Ethiopia (2016)	10,150	4.0 (3.3-4.9)	2,724,648	0.2 (0.1-0.3)	130,607	0.1 (0.03–0.2)	44,535
India (2016-17)	74,037	3.0 (2.8-3.3)	28,227,700	0.1 (0.07-0.13)	882,753	0.02 (0.01-0.04)	186,273
Mexico (2015)	14,664	35.3 (33.6-37.1)	30,918,551	5.0 (4.4-5.6)	4,364,056	0.6 (0.5-0.9)	560,199
Philippines (2015)	11,644	31.7 (29.7-33.8)	22,170,708	2.8 (2.3-3.3)	1,955,324	0.8 (0.6-1.0)	529,859
Romania (2018)	4,571	76.5 (74.3-78.5)	14,102,840	11.3 (10.1-12.6)	2,060,951	3.4 (2.7-4.2)	618,145
Russia (2016)	11,458	79.9 (78.2-81.4)	95,452,955	14.2 (12.9-15.7)	17,023,473	3.5 (2.9-4.2)	4,185,942
Senegal (2015)	4,347	14.1 (12.2-16.1)	1,100,981	0.5 (0.3-0.8)	35,387	0.1 (0.03–0.4)	8,083
Turkey (2016)	8,760	-[§]	-[§]	2.2 (1.8-2.6)	1,309,453	1.3 (1.1-1.7)	808,763
Ukraine (2017)	8,298	50.9 (48.5-53.3)	18,363,317	6.4 (5.6-7.2)	2,290,328	1.7 (1.3-2.1)	602,136
Uruguay (2017)	4,966	45.3 (42.7-47.9)	1,251,345	3.1 (2.6-3.8)	86,415	0.2 (0.1-0.5)	6,441
Vietnam (2015)	8,996	18.6 (17.4-19.7)	12,853,466	1.1 (0.8-1.3)	727,287	0.2 (0.1-0.4)	151,550

Table 1: **Prevalence of ever heard of and use of electronic cigarette use among adults aged ≥ 15 years in 14 countries, 2015-2018.**
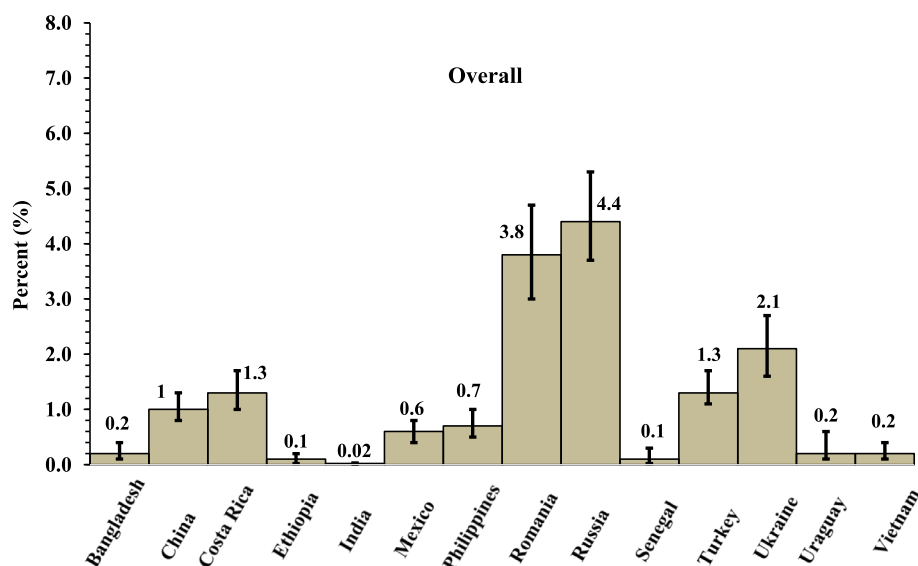
Abbreviation: CI = confidence interval.

* Unweighted sample size.
† Weighted crude prevalence.
‡ Weighted number.
§ No data.

Figure 1. Age-standardized prevalence of e-cigarette use among adults aged ≥ 15 years in 14 countries, 2015-2018. Error bars are 95% confidence intervals.

<1% in nine (Bangladesh, China, Ethiopia, India, Mexico, Philippines, Senegal, Uruguay, and Vietnam) of the 14 countries examined. There were approximately 18.3 million adults who currently used e-cigarettes across these 14 countries. Russia and China had the most adults who currently used e-cigarettes. Approximately 4.2 million adults aged ≥15 years in Russia reported current e-cigarette use in 2016. Although the prevalence was only 0.9% (95% CI, 0.7%–1.2%) in China in 2018, this corresponds to over 10.3 million adults who currently used e-cigarettes. The population counts in the two countries account for approximately 80% of the total estimated population in the 14 countries who currently used e-cigarettes (Table 1).
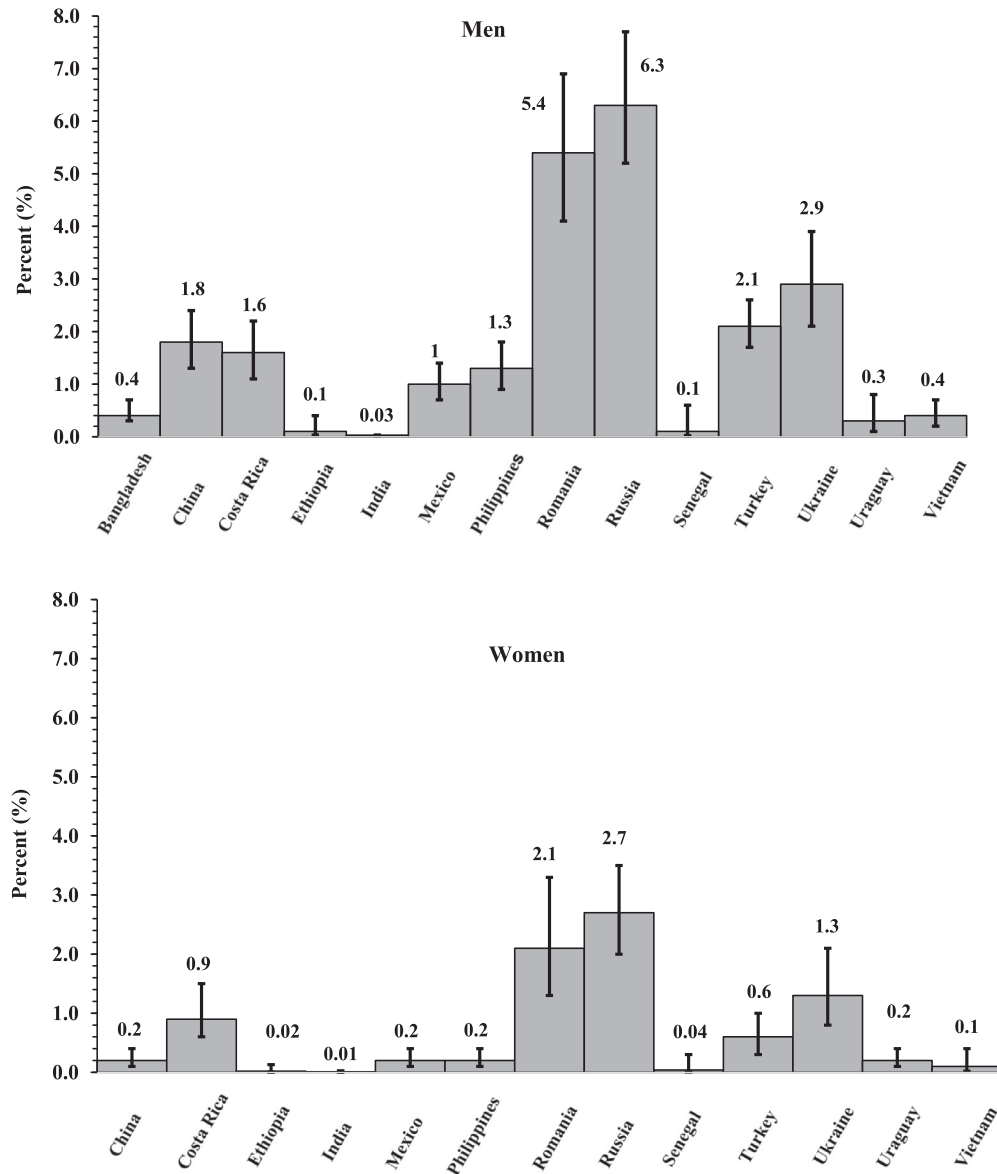
The age-standardized prevalence of current e-cigarette use was similar to the crude prevalence for all the countries except for Russia, Romania, and Ukraine, for which the age-standardized prevalence was 4.4% (95% CI, 3.7%–5.3%), 3.8% (95% CI, 3.0%–4.7%), and 2.1% (95% CI, 1.6%–2.7%) respectively (Figure 1). The differences between the crude and age-standardized prevalence in the three countries were because the age distributions of the national populations were different from the world standard population. The age-standardized prevalence of current e-cigarette use among men ranged from 0.03% (95% CI, 0.02%–0.06%) in India to 6.3% (95% CI, 5.2%–7.6%) in Russia. Six (Bangladesh, Ethiopia, India, Senegal, Uruguay, and Vietnam) of the 14 countries had a prevalence of less than one percent among men (Figure 2). The age-standardized prevalence among the 13 countries with reliable prevalence estimates for women varied from 0.01% (95% CI, 0.002%–0.03%) in India to 2.7% (95% CI, 2.0%–3.5%) in Russia. Over one percent of women currently used e-

cigarette after age-standardization in Romania, Russia, and Ukraine (Figure 2).

When adjusting for other sociodemographic characteristics in the models, men had significantly higher prevalence of current e-cigarette use than women in 8 (China, India, Mexico, Philippines, Romania, Russia, Turkey, and Ukraine) of 13 countries with reliable estimates for both sexes (Table 2). Young adults aged 15–24 years had higher adjusted prevalence than those aged 25 years and older in Costa Rica, Mexico, Russia, and Ukraine. The adjusted prevalence of current e-cigarette use was significantly higher among urban residents than those resided in rural areas in Bangladesh, Costa Rica, India, Mexico, Philippines, and Russia. Adults with no or primary education, had significantly lower adjusted prevalence than those with higher education levels in Bangladesh, China, India, Russia, and Ukraine. Those in the middle or lower wealth index quintiles had significantly lower adjusted prevalence than those in the higher quintiles in China, Mexico, and Philippines (Table 2).

Discussion

The use of e-cigarettes, and the increasing prevalence among young people in certain countries presents a challenge to achieving the goal of a tobacco-free generation. Our study provides evidence on prevalence of e-cigarette awareness and use in 14 countries that can serve as the baseline data for surveillance and evaluation activities in these countries. The data show that while over 30% adults in eight of 14 countries were aware of e-cigarettes, prevalence of current e-cigarette use among nine of 14 countries was below one percent. However,

Figure 2. Age-standardized prevalence of e-cigarette use among adults aged ≥ 15 years, by sex, 2015-2018.
Error bars are 95% confidence intervals.

approximately 18.3 million adults currently used e-cigarettes across these 14 countries, and higher adjusted prevalence of current e-cigarette use was observed in certain countries among men, young adults aged 15–24 years, urban residents, and adults with higher education levels, and higher wealth index.

A previous study[5] based on GATS data between 2011-2013 estimated that prevalence of currently e-cigarette use among adults aged ≥ 15 years was 0.3% in Indonesia, 0.8% in Malaysia, 0.9% in Qatar, and 1.9% in Greece.[5] GATS data show that more countries started to collect data on e-cigarettes after 2013. Only one study among Chinese adults aged ≥ 15 years found that the

prevalence of awareness, ever use, and current use of e-cigarettes was 48.5%, 5.0%, and 0.9% in 2018, respectively.[6] We included 14 countries that adopted the e-cigarette questions for the first time in GATS during 2015−2018 and found that the prevalence of current e-cigarette use ranged from 0.02% to 3.5% with the medians of 0.8% and 0.9% among these countries. Russia and Romania had the highest prevalence, with more than 11.0% of adults reporting ever use and over three percent of adults reporting current use of e-cigarettes. Similar to existing studies,[5,11] we found that for countries with high awareness, the prevalence of e-cigarette use is also relatively high. Awareness of e-cigarettes was also

Characteristics	Bangladesh (2017) n (%)*	Bangladesh Prevalence % (95% CI)	China (2018) n (%)*	China Prevalence % (95% CI)	Costa Rica (2015) n (%)*	Costa Rica Prevalence % (95% CI)	Ethiopia (2016) n (%)*	Ethiopia Prevalence % (95% CI)	India (2016-17) n (%)*	India Prevalence % (95% CI)	Mexico (2015) n (%)*	Mexico Prevalence % (95% CI)	Philippines (2015) n (%)*	Philippines Prevalence % (95% CI)
Sex														
Men	6,076 (48.6)	0.5 (0.3-0.8) (ref)	9,101 (50.7)	1.6 (1.2-2.1) (ref)	3,541 (50.2)	1.6 (1.1-2.3) (ref)	4,625 (49.9)	0.1 (0.03-0.3) (ref)	33,760 (51.1)	0.03 (0.02-0.06) (ref)	5,911 (47.9)	1.1 (0.7-1.6) (ref)	5,764 (49.9)	1.3 (1.0-1.9) (ref)
Women	6,702 (51.4)	—†	10,259 (49.3)	0.1 (0.1-0.4)§	5,062 (49.8)	0.9 (0.6-1.5)	5,522 (50.1)	0.04 (0.01-0.3)	40,244 (48.9)	0.01 (0.002-0.02)§	8,747 (52.1)	0.2 (0.1-0.4)§	5,848 (50.1)	0.2 (0.1-0.4)§
Age (years)														
15-24	2,345 (28.1)	0.2 (0.1-0.5) (ref)	930 (13.9)	1.5 (0.8-2.8) (ref)	1,376 (23.3)	2.5 (1.6-3.9) (ref)	2,750 (45.3)	0.1 (0.02-0.2) (ref)	13,321 (26.8)	0.02 (0.01-0.07) (ref)	2,645 (25.0)	1.6 (1.0-2.5) (ref)	2,331 (29.4)	0.6 (0.3-1.2) (ref)
25-44	6,394 (44.1)	0.4 (0.2-0.8)	5,121 (37.8)	1.2 (0.8-1.7)	3,048 (40.9)	1.1 (0.8-1.6)§	5,338 (36.1)	0.1 (0.01-0.3)	35,553 (43.3)	0.02 (0.01-0.05)	5,988 (40.2)	0.5 (0.3-0.8)§	4,952 (41.7)	1.0 (0.7-1.4)
≥45	4,039 (27.8)	0.02 (0.01-0.08)	13,309 (48.3)	0.5 (0.3-0.7)	4,179 (35.8)	0.6 (0.4-1.1)§	2,059 (18.6)	0.1 (0.01-0.6)	25,130 (31.9)	0.01 (0.005-0.04)	6,025 (34.9)	0.2 (0.1-0.5)§	4,329 (28.9)	0.6 (0.3-1.0)
Residential area														
Urban	6,352 (25.1)	0.8 (0.4-1.5) (ref)	11,010 (59.8)	1.1 (0.8-1.5) (ref)	4,255 (74)	1.5 (1.1-2.1) (ref)	5,062 (24.1)	0.2 (0.1-0.6) (ref)	26,481 (34.5)	0.05 (0.03-0.09) (ref)	7,571 (78.7)	0.8 (0.5-1.1) (ref)	4,610 (46.7)	1.3 (0.9-1.9) (ref)
Rural	6,426 (74.9)	0.04 (0.02-0.10)§	8,350 (40.2)	0.5 (0.3-0.8)	4,348 (26)	0.6 (0.3-0.9)§	5,085 (75.9)	0.02 (0.003-0.2)	47,523 (65.5)	0.01 (0.002-0.02)§	7,087 (21.3)	0.2 (0.1-0.4)§	7,002 (53.3)	0.2 (0.1-0.4)§
Education Level														
No or primary	9,916 (78.3)	0.1 (0-0.2) (ref)	8,622 (33.9)	0.2 (0.1-0.4) (ref)	6,260 (65.7)	1.3 (0.9-1.7) (ref)	6,961 (72.7)	0.1 (0.01-0.2) (ref)	46,925 (63.8)	0.01 (0.002-0.02) (ref)	11,175 (68.1)	0.5 (0.3-0.8) (ref)	3,692 (26.1)	0.3 (0.2-0.7) (ref)
Secondary or higher	2,862 (21.7)	0.8 (0.4-1.6)§	10,717 (66.1)	1.2 (1.0-1.6)§	2,306 (34.3)	1.4 (0.9-2.1)	3,167 (27.3)	0.1 (0.03-0.4)	27,020 (36.2)	0.05 (0.02-0.08)§	3,416 (31.9)	0.9 (0.6-1.4)	7,918 (73.9)	0.9 (0.7-1.3)
Wealth Index quintile														
Lowest, low, or middle	7,669 (61.7)	0.06 (0.02-0.18) (ref)	12,303 (58.2)	0.5 (0.4-0.8) (ref)	5,190 (49.5)	0.9 (0.6-1.4) (ref)	6,239 (78.1)	0.05 (0.01-0.2) (ref)	45,483 (66.6)	0.01 (0.004-0.03) (ref)	8,795 (45.7)	0.3 (0.1-0.5) (ref)	6,976 (52.7)	0.3 (0.2-0.4) (ref)
High or highest	5,109 (38.3)	0.5 (0.3-0.9)	7,057 (41.8)	1.4 (1.0-1.9)§	3,413 (50.5)	1.6 (1.1-2.4)	3,908 (21.9)	0.1 (0.04-0.5)	28,521 (33.4)	0.04 (0.02-0.07)	5,863 (54.3)	1.0 (0.7-1.4)§	4,636 (47.3)	1.3 (0.9-1.9)§

Characteristics	Romania (2018) n (%)*	Romania Prevalence % (95% CI)	Russia (2016) n (%)*	Russia Prevalence % (95% CI)	Senegal (2015) n (%)*	Senegal Prevalence % (95% CI)	Turkey (2016) n (%)*	Turkey Prevalence % (95% CI)	Ukraine (2017) n (%)*	Ukraine Prevalence % (95% CI)	Uruguay (2017) n (%)*	Uruguay Prevalence % (95% CI)	Vietnam (2015) n (%)*	Vietnam Prevalence % (95% CI)
Sex														
Men	2,097 (48.4)	5.0 (3.9-6.4) (ref)	4,783 (45.3)	5.4 (4.5-6.5) (ref)	1,960 (48.5)	0.2 (0.03-0.9) (ref)	4,419 (49.8)	2.1 (1.7-2.7) (ref)	3,763 (45.4)	2.5 (1.8-3.4) (ref)	2,186 (47.6)	0.3 (0.1-0.7) (ref)	3,983 (48.5)	0.4 (0.2-0.7) (ref)
Women	2,451 (51.6)	1.8 (1.2-2.8)§	6,665 (54.7)	1.9 (1.5-2.5)§	2,382 (51.5)	0.05 (0.01-0.3)	4,311 (50.2)	0.6 (0.3-1.0)§	4,529 (54.6)	1.0 (0.6-1.5)	2,773 (52.4)	0.2 (0.1-0.4)	5,011 (51.5)	0.1 (0.02-0.4)
Age (years)														
15-24	340 (11.7)	3.9 (2.3-6.7) (ref)	949 (12.5)	9.7 (7.5-12.5) (ref)	1,187 (33.9)	0.2 (0.04-1.3) (ref)	1,433 (21.3)	1.7 (1.1-2.6) (ref)	537 (11.7)	4.2 (2.7-6.5) (ref)	549 (19.9)	0.5 (0.1-1.6) (ref)	1,147 (23)	0.1 (0.02-0.9) (ref)
25-44	1,271 (38.2)	6.3 (4.7-8.3)	3,968 (37.8)	4.6 (3.9-5.5)	1,944 (41.6)	0.1 (0.01-0.4)	4,196 (40.5)	2.0 (1.5-2.5)	2,348 (37.3)	2.4 (1.7-3.3)	1,638 (34)	0.2 (0.1-0.5)	3,497 (41.9)	0.3 (0.1-0.6)
≥45	2,937 (50.1)	1.0 (0.7-1.6)§	6,531 (49.6)	1.1 (0.8-1.5)§	1,211 (24.5)	—†	3,101 (38.2)	0.5 (0.3-0.8)§	5,407 (51.0)	0.6 (0.4-0.9)§	2,772 (46.1)	0.1 (0.05-0.4)	4,350 (35.1)	0.2 (0.1-0.6)
Residential area														
Urban	2,301 (56.7)	3.5 (2.6-4.6) (ref)	6,125 (75)	4.0 (3.3-4.8) (ref)	2,198 (49.9)	0.2 (0-0.9) (ref)	7,785 (92.1)	1.3 (1.1-1.7) (ref)	4,137 (69.4)	1.9 (1.4-2.5) (ref)	4,736 (94.8)	0.2 (0.1-0.5) (ref)	4,419 (33.8)	0.2 (0.1-0.4) (ref)
Rural	2,247 (43.3)	3.2 (2.2-4.5)	5,323 (25)	2.1 (1.5-2.9)§	2,144 (50.1)	0.02 (0.003-0.1)	945 (7.9)	1.2 (0.6-2.7)	4,155 (30.6)	1.2 (0.8-1.8)	223 (5.2)	—†	4,575 (66.2)	0.2 (0.1-0.5)
Education Level														

Table 2 (Continued)

Characteristics	Romania (2018)		Russia (2016)		Senegal (2015)		Turkey (2016)		Ukraine (2017)		Uruguay (2017)		Vietnam (2015)	
	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)	n (%)*	Prevalence† % (95% CI)
No or primary	1,768 (33.1)	2.2 (1.5-3.4) (ref)	1,547 (11.5)	2.2 (1.4-3.4) (ref)	3,706 (85.3)	0.1 (0.02-0.5) (ref)	3,485 (40.2)	0.6 (0.4-1.0) (ref)	837 (6.1)	0.1 (0.01-0.4) (ref)	1,987 (40)	0.1 (0.03-0.8) (ref)	6,067 (67.9)	0.11 (0.05-0.25) (ref)
Secondary or higher	2,711 (66.9)	3.9 (3.1-5.1)	9,751 (88.5)	3.7 (3.1-4.4)§	629 (14.7)	0.2 (0.02-1.1)	5,226 (59.8)	1.8 (1.4-2.3)	7,429 (93.9)	1.8 (1.4-2.3)§	2,967 (60)	0.3 (0.2-0.5)	2,918 (32.1)	0.5 (0.2-1.0)
Wealth Index quintile														
Lowest, low, or middle	2,737 (51.1)	2.5 (1.7-3.5) (ref)	7,311 (56.4)	2.9 (2.3-3.5) (ref)	2,602 (56.2)	—‡ (ref)	5,446 (61.9)	1.3 (1.0-1.7) (ref)	4,981 (44.6)	1.0 (0.6-1.5) (ref)	2,980 (57.1)	0.1 (0.1-0.3) (ref)	5,403 (60.7)	0.2 (0.1-0.4) (ref)
High or highest	1,811 (48.9)	4.3 (3.3-5.6)	4,137 (43.6)	4.3 (3.4-5.4)	1,740 (43.8)	0.2 (0.1-1.0)	3,284 (38.1)	1.5 (1.1-2.0)	3,311 (55.4)	2.2 (1.7-2.9)	1,979 (42.9)	0.4 (0.1-1.0)	3,591 (39.3)	0.3 (0.2-0.6)

Table 2: Sample distribution and prevalence of current e-cigarette use among adults aged ≥ 15 years in 14 countries, by demographic characteristics, 2015-2018.
Abbreviation: CI = confidence interval.
* Unweighted sample size and weighted percentage.
† Weighted crude prevalence.
‡ Data is not reliable based on the data suppression criteria that consider the effective sample size, degree of freedom, and the absolute and relative widths of the Korn and Graubard confidence interval.
§ Statistically significant different from the prevalence in reference group based on the contrast of marginal effect between groups adjusting for other sociodemographic factors in multivariable logistic regression model.

the greatest in Russia and Romania with over three quarters of adults being aware of e-cigarettes.

Variations in e-cigarette use across countries may be due to differences in availability and marketing of the products and differences in individuals' perceptions about the harm of e-cigarettes, peer influences, e-cigarette awareness, social norms and cultural factors, environmental and economic factors, and policy formation and enforcement. Given that over 18 million adults ages 15 and up in these 14 countries used e-cigarettes and that nicotine in e-cigarettes poses specific risks to fetal development and to brain development through approximately age 25,[4] continued monitoring of e-cigarette use is critical for developing evidence-based interventions and policies to prevent initiation of tobacco use and enhance cessation support.

Although there were no consistent findings across countries, we found disparities in the prevalence of current e-cigarette use across sociodemographic groups in certain countries. For example, current e-cigarette use was more prevalent among men than women in eight of 13 countries with reliable sex-stratified estimates. This finding was consistent with the prevalence patterns by sex among young adult workers[12] in the U.S., and study findings for adults in China, Qatar, and Poland,[5,6,13] but conflicts with the results of other studies[14,15] for which no sex differences were found in current or ever e-cigarette use. These differences may reflect the different e-cigarette use patterns by sex across the countries, years, or age groups. Some of the previous research may not have sufficient statistical power to detect differences by sex because e-cigarette use is not a common risk factor. The reason for differences by sex in e-cigarette use was inconclusive. A previous study[16] found that men tend to start using e-cigarettes because they are curious, want to quit smoking regular cigarettes, or have health concerns about regular cigarettes. Women tend to initiate e-cigarettes because of recommendations from friends and family. Men also reported more positive expectancies for e-cigarettes than women, including good taste, social facilitation, and increased energy.[16] Although we found that more men were using e-cigarettes than women in majority of the countries, e-cigarette distributors have started to target female users by selling slim, pink, glamorous, and fashionable e-cigarette devices.[17] Additional research based on GATS or other large population surveys is needed to better characterize patterns of e-cigarette use for both sexes.

The adjusted prevalence of current e-cigarette use was higher among young adults aged 15–24 years than those 25 years and older in Costa Rica, Mexico, Russia, and Ukraine. Since the mid-2000s, the tobacco and nicotine product landscape has been expanded to include a variety of new products, especially among young people.[3] The use of e-cigarettes has increased in certain countries among youth and young adults.[18,19] A previous study found that among young adults aware of e-

cigarettes, over half considered e-cigarettes as less harmful and over a quarter perceived them as less addictive than regular cigarettes.[20] Those who perceived e-cigarettes as less harmful or less addictive were more likely to use e-cigarettes.[20] Another reason that e-cigarette use prevalence was higher among young adults may be the considerable industry spending to market e-cigarettes. The commonly used themes in conventional tobacco product advertising, including independence, rebellion, and sexual attractiveness, are also used in e-cigarettes advertising.[21] Studies found that e-cigarette advertising exposure is associated with the initiation and continued use of e-cigarettes among youth.[22,23] Effective policy and environmental interventions to enforce tobacco advertising, promotion, and sponsorship bans based on the WHO MPOWER recommendation can protect vulnerable young people from e-cigarette marketing.[24] Future research is needed to further investigate the reasons for the differences in e-cigarette use by age.

We found that the prevalence of current e-cigarette use was higher among adults with higher education levels, and higher individual wealth index in certain countries. The previous studies reported mixed findings on education. For example, a study found that U.S. adults with less than a high school education were more likely to use e-cigarettes although they were less likely to be aware of e-cigarettes.[15] Another study among adults in Canada, U.S., U.K., and Australia found that those with a higher education level were more likely to currently use e-cigarettes.[25] Previous research also presented conflicting results on e-cigarette use by income.[5,12,25] Similar to the present study, a previous analysis based on GATS found higher prevalence of current e-cigarette use among adults of the highest wealth index than those of lower wealth index in Indonesia and Greece.[5] Adkison et al. found that prevalence of awareness and ever use of e-cigarettes were higher among adults of high income than adults of low income in the U.S. and U.K.[25] However, a study among U.S. adult workers[12] reported higher prevalence of current e-cigarette use among those of lower family income.[12] Theoretically adults with higher education or income may be more likely to be aware of e-cigarette and related adverse health consequences.[15] Therefore, variations in e-cigarette use by education or income can be in either direction. More research is needed to understand variation in e-cigarette use by education and income across countries.

While e-cigarettes have the potential to benefit non-pregnant adults who smoke if used as a complete substitute for regular cigarettes or other smoked tobacco products,[4] the evidence is insufficient to recommend e-cigarettes for smoking cessation in adults, including pregnant adults.[26] Adults who smoked regular cigarettes might otherwise have quit smoking due to evidence-based interventions using the WHO MPOWER framework,[24] such as restrictions on smoking in public,

increased cigarette prices, graphic warning labels, and hard-hitting media campaigns. To address the challenges posed by the emerging tobacco products including e-cigarettes, WHO recommends prioritizing the measures in accordance with the WHO Framework Convention on Tobacco Control (FCTC) and national law, which include preventing the initiation of emerging tobacco products; protecting people from exposure to their emissions; prohibiting advertising, promotion and sponsorship; regulation and the disclosure of the contents; and protecting tobacco-control policies and activities from all commercial and other vested interests.[27]

To limit the influence from the tobacco industry, including e-cigarette industry, WHO recommends that countries implement strategies outlined in Article 5.3 of the WHO FCTC, which include raising awareness about the addictiveness and harm of tobacco products and industry interference with tobacco control policies; establishing measures to limit interactions with the industry and ensure the transparency; rejecting partnership and non-binding or non-enforceable agreements with the industry; avoiding conflicts of interest for government officials; requiring that information provided by the industry be transparent and accurate; de-normalizing and regulating activities described as 'socially responsible' by the tobacco industry; not giving preferential treatment to the industry; and treating state-owned industry in the same way as other tobacco industry.[18] Successful cases in combating the influence of e-cigarette industry have been reported recently. For example, in the U.K., e-cigarettes are governed by the medicinal license through the Medicines and Healthcare products Regulatory Agency and the revised European Union Tobacco Products Directive.[28] In the U.S, the e-cigarette giant Juul Labs and the entire e-cigarette industry, have been under sharp regulatory focus.[29] In January 2020, the U.S. Food and Drug Administration issued a policy enforcement against certain unauthorized flavored cartridge-based e-cigarettes that appeal to kids, including fruit and mint flavors.[30] In June 2021, JULL agreed to a $40 million settlement with the state of North Carolina over its marketing practices.[29]

The present study examined prevalence of e-cigarette use in multiple countries. To our knowledge, the prevalence estimates were reported for the first time in 13 of these 14 countries based on nationally representative samples. The large sample sizes allow for stratified analyses by sociodemographic characteristics in each country. However, at least three limitations of this study merit further consideration. First, data collected in GATS are self-reported. Therefore, there may be recall or social desirability biases and the direction of the biases cannot be determined. Second, the wealth index was categorized based on the housing assets and the household consumer goods, so it was only a proxy measure of the household income. Third, GATS was

designed to assess tobacco use and related health behaviors at the national level; thus, we could not assess the prevalence of e-cigarette use that were representative at the province, district, or other subnational levels.

Over 18 million adults reported current using e-cigarettes in the 14 countries and considerable variations in e-cigarette use were observed across countries and population subgroups with certain sociodemographic characteristics. While continued progress has been made globally in curbing the tobacco use epidemic, efforts are warranted to address the shifting landscape with introduction of new and emerging tobacco products, including e-cigarettes. Progress in reducing e-cigarette use and addressing associated behaviors varies across countries. Opportunities exist for countries to develop and implement evidence-based policies and strategies related to the use of e-cigarettes. Continued surveillance and monitoring of e-cigarettes and other new and emerging tobacco products is critical to informing tobacco control policy, planning, regulation, and practice worldwide.

Contributors

LP, JM, and IBA conceived the original idea for the study. LP reviewed the literature and analyzed the data. All authors interpreted the results. LP drafted and revised the manuscript. JM, LM, AD, and IBA reviewed and edited the manuscript. LP and LM accessed and verified the underlying data. AD obtained funding for the article processing fee. All authors had full access to all the data in the study and the final responsibility for the decision to submit for publication.

Data sharing

Data are publicly available at https://www.cdc.gov/nchs/nhanes/index.htm. Additional information is available upon request.

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Declaration of interests

We declare no competing interests.

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