TRENDS IN ADOLESCENT CIGARETTE SMOKING IN CZECHIA: FINDINGS FROM THE HBSC STUDY 2014–2022

Ladislav Kážmér[1], Ondřej Šíba[1], Michal Kalman[2], Ladislav Csémy[1]
[1]National Institute of Mental Health, Klecany, Czech Republic
[2]Sts Cyril and Methodius Faculty of Theology, Olomouc University Social Health Institute, Palacký University Olomouc, Olomouc, Czech Republic

SUMMARY

Objectives: Regular monitoring of health-related behaviours among vulnerable populations is of public health importance. This study examines recent trends in adolescent cigarette smoking in Czechia following the marked changes reported in the mid-2010s.

Methods: Data from three recent rounds of the Health Behaviour in School-aged Children (HBSC) study conducted in Czechia in 2014, 2018 and 2022 were analysed. Temporal trends were assessed for two indicators of adolescent cigarette use: lifetime cigarette use and cigarette use in the last 30 days. Survey-adjusted binary logistic regression models were used to test changes between survey periods. In 2022, the prevalence of electronic cigarette use was additionally estimated using the same indicators.

Results: A continued decline in adolescent cigarette use was observed for both indicators, extending the downward trends reported in the mid-2010s into the 2020s. The decline was most pronounced between 2014 and 2018, with smaller but persistent decreases thereafter, particularly among older adolescents. However, the findings also highlight the substantial prevalence of electronic cigarette use. In 2022, more than one-third of 15-year-olds in Czechia reported lifetime electronic cigarette use (35.1% among boys and 36.6% among girls), and approximately one in five reported use in the last 30 days (19.6% among boys and 23.0% among girls).

Conclusions: While conventional cigarette use among adolescents continues to decline, electronic cigarette use represents an important component of contemporary adolescent smoking-related behaviour. In the long term, the phenomenon of electronic cigarettes may counteract intended trends in nicotine-related harms. These findings underscore the need for continued surveillance and prevention efforts in Czechia that address both conventional and emerging smoking-related products.

Key words: smoking, adolescence, prevalence, trends

Address for correspondence: L. Kážmér, National Institute of Mental Health, Topolová 748, 250 67 Klecany, Czech Republic. E-mail: ladislav.kazmer@nudz.cz

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INTRODUCTION

Adolescent smoking remains a significant public health concern. As adolescence is a formative period in the human lifespan, characterised by profound biological, psychological and social changes, adolescent individuals are particularly vulnerable to the risks associated with substance use, including smoking. Although not everyone who experiments with smoking necessarily becomes a regular daily user (1), nicotine – the primary addictive compound in tobacco – is considered a highly addictive substance, comparable to opioids and stimulants (2, 3). Early initiation of smoking is also a strong predictor of regular and intensive daily use in adulthood (4), and once addiction develops, cessation becomes difficult (5). Moreover, the adverse health effects of smoking show a clear dose-response relationship, increasing proportionally with both the duration and intensity of its use over an individual's lifetime (6).

In developed countries, the prevalence of adolescent smoking has undergone significant changes over recent decades. In many high-income European countries, particularly those in Northern, Western and Southern Europe, adolescent smoking has been continuously declining since the 2000s (7, 8). Similar downward trends have been observed in the United States (9), Canada (10, 11), and Australia (12), where continuous declines have occurred since the mid-1990s, extending throughout the 2000s and 2010s, and recently reaching the lowest levels recorded within their respective monitoring periods. In Czechia, however, the temporal trends have followed a different pattern. Adolescent smoking prevalence increased throughout the 1990s, reaching its peak in the late 2000s. In the mid-2010s, a steep decline in smoking prevalence was observed among Czech adolescents (13, 14), bringing rates back to levels similar to those recorded in the 1990s.

Despite the decline observed in the mid-2010s, adolescent smoking prevalence in Czechia remained relatively high compared with their counterparts in other European countries, particularly those in Northern, Southern and Western Europe (15, 16). At the same time, both the perceived availability of cigarettes and access to purchasing them remained relatively high. In 2016, approximately seven out of ten current smokers aged 13–15 years reported not being prevented from buying cigarettes in the past

30 days (14), despite being under the legal age. Similarly, in 2015, eight out of ten adolescents in Czechia aged 15–16 years perceived cigarettes as fairly or very easy to obtain, although some improvements in this regard have been reported in more recent years (8). Furthermore, alongside the changing patterns of conventional cigarette smoking, electronic cigarettes emerged on the Czech market during the 2010s, with growing awareness and experimentation among youth – a trend similarly observed in other developed countries (17, 18).

Given the changes in smoking prevalence among adolescents in Czechia reported in earlier studies, we continue this line of research and examine trends following the decline observed in the mid-2010. In particular, we build on the study by Salonna et al. (13) and analyse post-2014 trends using data from the Health Behaviour in School-aged Children (HBSC) study.

The specific research questions are as follows: after the 2014 Czech HBSC survey round, were there further statistically significant changes in the prevalence of adolescent cigarette use? If so, were these temporal trends homogeneous across genders, or do they differ between girls and boys? Trends are examined in greater detail across demographic subgroups defined by gender and age. For 2022, where data were available, we also analyse smoking rates alongside electronic cigarette use.

In the discussion, we compare our findings with results on adolescent smoking from other sources and examine the changing international position of Czech adolescents relative to other countries. Finally, we highlight plausible factors underlying the observed changes.

MATERIALS AND METHODS

Data

For this study, we used data from the last three HBSC surveys conducted in 2014, 2018 and 2022. Only the final Czech datasets that entered the HBSC international reports were used in the study.

Survey Sampling Design

The Czech HBSC surveys employed a stratified two-stage clustered sampling design. Czech NUTS II regions were used as strata to ensure adequate coverage of the target population. Within each stratum, schools served as primary sampling units (PSUs), and classes as secondary sampling units.

Due to the absence of explicit sampling probabilities and finite population corrections in the HBSC data, schools were used as the PSUs for variance estimation. This approach is commonly used in HBSC studies and was further supported by the empirical structure of the data. Specifically, within each age group, most schools contained only one sampled class; even though in the overall survey design each school typically contributed multiple classes (typically, one class for each age group). Comparisons of design effects across alternative PSU definitions showed minimal differences (< 7%) between school-level and class-level specifications, further justifying the use of schools as the primary units.

To account for the complex survey design, standard errors were estimated using the Taylor linearisation method (19, 20), which provides robust variance estimates in the presence of clustering and stratification in survey data. Post-stratification weights were applied to align with the known distribution of the target population.

Dependent Variables

Two measures of adolescent cigarette smoking were available in the HBSC data and were formally comparable across the three survey periods: lifetime cigarette use and cigarette use in the last 30 days. The following question was asked: "How many days (if any) have you smoked cigarettes?" Responses were recorded on a Likert-type scale ranging from "never" to "1–2 days", "3–5 days", "6–9 days", "10–19 days", "20–29 days", and "30 days (or more)". Respondents who reported smoking on at least one day were classified as lifetime cigarette users or last 30 days cigarette users, respectively.

Electronic Cigarette Use, HBSC 2022

In the 2022 HBSC survey, the use of electronic cigarettes (e-cigarettes) was also assessed. Respondents were asked how many days they had used e-cigarettes in their lifetime and in the last 30 days, respectively. Heat-not-burn products were excluded from this assessment. The same Likert-type response scale used for cigarettes was applied, ranging from "never" through "1–2 days" to "30 days (or more)".

Analogously, two prevalence measures were computed: lifetime e-cigarette use and e-cigarette use in the last 30 days. In addition, the prevalence of use of either e-cigarettes or conventional cigarettes was calculated.

Missing Responses

Overall, missing data on the dependent variables were very low, not exceeding 5% in any survey period or demographic subgroup. The proportion of missing values was somewhat higher in 2022 (< 5%) compared to 2014 (< 3%) and 2018 (< 2%). Cases with missing responses were excluded from all analyses using listwise deletion.

Demographic Subgroups Approach

Analyses were conducted separately for six demographic subgroups defined by the cross-classification of three target age groups (11-, 13- and 15-year-olds) with gender (boys vs. girls). This subgroup-specific approach enabled the examination of potential heterogeneity in prevalence trends, providing a more nuanced understanding of adolescent cigarette use. Gender and age are well-established moderators of smoking behaviour, and cross-classification by these variables allowed tailored estimation of period effects.

Statistical Analysis

The analyses comprised several consecutive steps:

- Prevalence rate estimation – period-specific prevalence point estimates were calculated for each demographic subgroup.
- Trend visualisation – subgroup-specific trends were presented in plots of prevalence estimates with corresponding 95% con-

fidence intervals, separately by gender and for the age groups of 13- and 15-year-olds.

- Formal testing – the statistical significance of between-period changes was assessed using survey-adjusted logistic regression models. These models accounted for the stratified clustered design and incorporated post-stratification weights to ensure unbiased effect estimates and robust standard errors.

This stepwise strategy provided both descriptive and inferential evidence on changes in adolescent cigarette use across the analysed time periods. Formal trend testing was limited to 13- and 15-year-olds, thus omitting 11-year-olds due to low prevalence of cigarette use in this youngest age group.

For formal testing in step 3, the logistic regression models were defined as follows:

$$\log \frac{\pi}{1-\pi} = \text{constant (period 2018)} + \beta_1 \text{ (period 2014)} + \\ + \beta_2 \text{ (period 2022)},$$

where π states for the prevalence (%) of given cigarette smoking measure. Survey period was included as a categorical predictor, with 2018 specified as reference category. This specification enabled estimation of two pre-planned contrasts (2014 vs. 2018 and 2022 vs. 2018), thereby formally testing changes in prevalence rates between consecutive survey periods. By structuring the analysis in this sequential manner, no additional adjustments for multiple testing were required.

In the logistic models, coefficients are estimated on the logit (log-odds) scale. Therefore, exponentiated coefficients (exp(β)) were reported to provide interpretable estimates in terms of odds. To enhance interpretability, model-implied estimates of prevalence rate differences were also computed, as these are more directly grasped by readers than odds ratios.

All statistical analyses were conducted using Stata, version 16 (StataCorp LLC, College Station, TX).

Sensitivity Check

As a sensitivity analysis of the data structure definition, three-level mixed-effects logistic regression models were additionally estimated within each demographic subgroup, with both schools and classes specified as hierarchical levels. As the multilevel models yielded no additional insights beyond corroborating the survey-adjusted analyses, their detailed outputs are not shown, and only the survey-adjusted results are reported for clarity.

RESULTS

Table 1 provides a basic description of the data structure, compiled from the three recent HBSC surveys conducted in Czechia since 2014.

Across survey periods, the Czech HBSC datasets varied in sample size. In 2014, the final dataset included 5,055 adolescent respondents, increasing to 11,564 in 2018 and 12,906 in 2022. Correspondingly, the number of participating schools (primary sampling units) varied from 93 in 2014 to 246 in 2022 (Table 1).

Despite these variations, each survey wave provided a sufficiently large and balanced sample, with proportional representation of boys and girls and the three target age groups (11-, 13- and 15-year-olds). When cross-classified by gender and age group, period-specific subsamples ranged from 738 (11-year-old boys in 2014) to 2,300 (13-year-old boys in 2022). Altogether, the compiled dataset comprised 29,525 respondents (14,761 boys and 14,764 girls) aged 11–15 years.

Table 2 presents point estimates of adolescent smoking prevalence rates. Two measures of cigarette smoking are presented: lifetime use and use in the last 30 days. A detailed series of period-specific data, cross-classified by gender and age group, is also provided for each demographic subgroup.

Comparing prevalence rates across periods reveals a consistent decrease in adolescent cigarette smoking, particularly between 2014 and 2018. This decline is evident for both smoking indicators – lifetime use and use in the last 30 days – and is consistent across genders and age groups. For example, among 15-year-old boys, the estimated prevalence of lifetime cigarette use decreased from 50.7% in 2014 to 37.2% in 2018, while use in the last 30 days declined from 17.8% to 15.5% over the same period. A similar pattern was observed among 15-year-old girls, with lifetime prevalence decreasing from 56.5% in 2014 to 41.2% in 2018 and use in

Table 1. *Sample structure by gender, age and period, HBSC 2014–2022, Czech Republic*

Gender	Age group	Period		
		2014	2018	2022
Boys	11-year-old	738	1,897	2,070
	13-year-old	818	1,990	2,300
	15-year-old	852	1,934	2,162
	Total boys	2,408	5,821	6,532
Girls	11-year-old	836	1,899	2,097
	13-year-old	903	1,964	2,176
	15-year-old	908	1,880	2,101
	Total girls	2,647	5,743	6,374
Total sample size		5,055	11,564	12,906
Number of schools (PSU)		93	227	246
Number of classes		271	664	720

PSU – primary sampling unit

Table 2. *Adolescent smoking prevalence estimates by gender, age and period, HBSC 2014–2022, Czech Republic*

Gender	Age group	Period		
		2014 (%)	2018 (%)	2022 (%)
Cigarette smoking – lifetime use				
Boys	11-year-old	9.2	4.6	5.0
	13-year-old	29.3	16.5	12.7
	15-year-old	50.7	37.2	30.2
Girls	11-year-old	5.7	2.4	3.2
	13-year-old	24.3	18.6	14.9
	15-year-old	56.5	41.2	31.6
Cigarette smoking – last 30 days use				
Boys	11-year-old	2.5	1.7	1.9
	13-year-old	7.7	5.1	4.8
	15-year-old	17.8	15.5	13.3
Girls	11-year-old	0.8	0.4	1.7
	13-year-old	6.8	6.6	6.4
	15-year-old	28.3	20.8	15.2

the last 30 days declining from 28.3% to 20.8%. Similar declines between 2014 and 2018 were also found among the younger age groups (11- and 13-year-olds) for both boys and girls (Table 2).

When comparing prevalence estimates between 2018 and 2022, further declines are observed in Table 2; however, these changes appear less pronounced and less consistent than those recorded between 2014 and 2018. For lifetime cigarette use, a continued decline in prevalence is apparent among 13- and 15-year-old adolescents, consistent across both genders. In contrast, among the youngest age group of 11-year-olds, a slight increase was observed in 2022. Similar patterns are found for cigarette use in the last 30 days, with a minor increase among 11-year-olds and small declines among 13- and 15-year-olds. The statistical significance of these changes is examined in the subsequent analytical steps.

To graphically illustrate the temporal trends, Figure 1ab presents plotted prevalence rates for the two measures of cigarette smoking, together with their corresponding 95% confidence intervals (95% CIs). The data for 13- and 15-year-old respondents are plotted separately by gender. Thus, in addition to depicting temporal patterns, the graphs also offer insight into evolving gender differences in adolescent smoking.

The graphs in Figure 1ab reveal three distinct trends. First, a dynamic decline in adolescent cigarette smoking across the analysed periods, as described above. Second, a higher prevalence of lifetime cigarette use among girls compared to boys, yet with overlapping 95% confidence intervals in each of the three HBSC survey periods. Third, for cigarette use in the last 30 days, a more pronounced temporal decline is observed among 15-year-old girls compared to their male counterparts, resulting in a reduction of girls' excess rates in this age group.

The statistical significance of temporal changes between the three analysed periods was tested using a series of survey-adjusted logistic regression models. These models were run separately for each gender and for the 13- and 15-year-old age groups, with prevalence rates from 2018 set as the reference category. The results are presented in Tables 3 and 4.

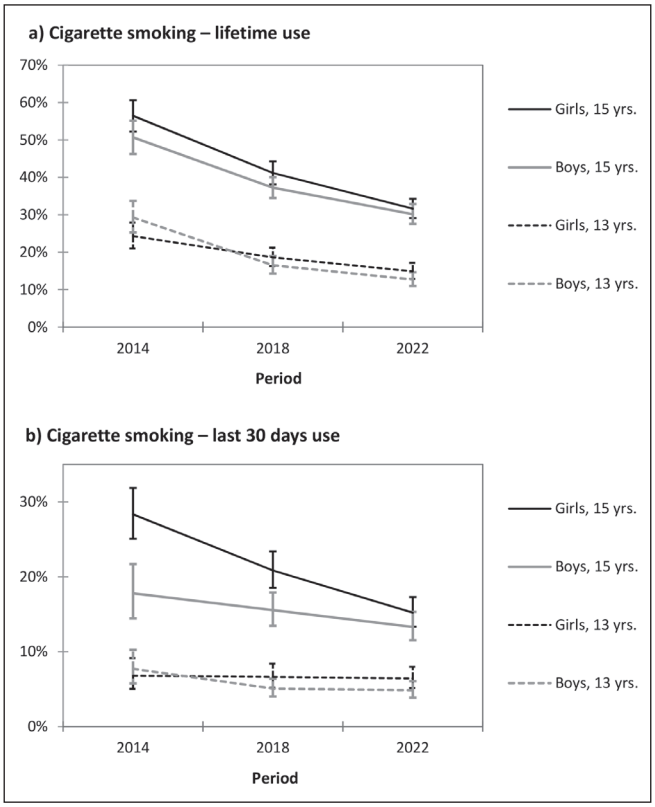

Fig. 1a, b. *Trends in adolescent cigarette smoking by gender and age, HBSC 2014–2022, Czech Republic.*

Table 3 presents the results of logistic regression models examining lifetime cigarette use. Exponentiated regression coefficients (odds ratios) are reported, together with the corresponding test statistics and 95% confidence intervals. Model-implied differences in prevalence rates, along with their 95% CIs, between the compared HBSC periods are also provided.

Overall, the results in Table 3 confirm the significance of the declines in lifetime cigarette use described above. Statistically

Table 3. *Changes in the prevalence of lifetime cigarette use among adolescents by gender and age, HBSC 2014–2022, Czech Republic*

Period	Exp (coef.)[a]	SE[b]	t-statistic	p-value	95% CI	Prevalence rate difference	95% CI
Boys, 13-year-old							
2014	2.10***	0.280	5.54	< 0.001	1.612; 2.724	0.128	0.080; 0.176
2022	0.74*	0.088	−2.57	0.011	0.583; 0.931	−0.038	−0.067; −0.009
Constant (Ref. 2018)	0.20[c]	0.017	–	–	0.167; 0.234	Reference period	
Boys, 15-year-old							
2014	1.73***	0.187	5.08	< 0.001	1.401; 2.141	0.134	0.082; 0.186
2022	0.73***	0.064	−3.63	< 0.001	0.613; 0.865	−0.071	−0.109; −0.033
Constant (Ref. 2018)	0.59c	0.036	–	–	0.527; 0.668	Reference period	
Girls, 13-year-old							
2014	1.40**	0.177	2.69	0.007	1.096; 1.797	0.057	0.015; 0.099
2022	0.77*	0.091	−2.25	0.025	0.605; 0.967	−0.037	−0.070; −0.005
Constant (Ref. 2018)	0.23[c]	0.019	–	–	0.194; 0.269	Reference period	
Girls, 15-year-old							
2014	1.85***	0.200	5.73	< 0.001	1.500; 2.291	0.153	0.101; 0.205
2022	0.66***	0.059	−4.67	< 0.001	0.555; 0.787	−0.095	−0.136; −0.055
Constant (Ref. 2018)	0.70[c]	0.045	–	–	0.616; 0.794	Reference period	

[a]Exponentiated logit coefficient (odds ratio); [b]linearised standard errors; [c]exponentiated constant estimates are the 2018 baseline odds.
Significant change compared to the 2018 reference period at the probability level: ***p < 0.001, **p < 0.01, *p < 0.05.

significant changes between periods were observed both for 2014 versus 2018 and for 2018 versus 2022.

For example, among 15-year-old boys, the odds of lifetime cigarette use were 1.73-fold higher (95% CI: 1.401–2.141) in 2014 compared to 2018, corresponding to 13.4 percentage points (95% CI: 8.2–18.6) higher prevalence in 2014. In 2022, a further decline by 7.1 percentage points (95% CI: 3.3–10.9) was recorded compared to 2018, with an odds ratio of 0.73 (95% CI: 0.613–0.865).

Similarly, among 15-year-old girls, the prevalence of lifetime cigarette use in 2014 was 15.3 percentage points (95% CI: 10.1–20.5) higher than in 2018, corresponding to an odds ratio of 1.85 (95% CI: 1.500–2.291). This decline continued in 2022,

Table 4. *Changes in the prevalence of cigarette use in the last 30 days among adolescents by gender and age, HBSC 2014–2022, Czech Republic*

Period	Exp (coef.)[a]	SE[b]	t-statistic	p-value	95% CI	Prevalence rate difference	95% CI
Boys, 13-year-old							
2014	1.56*	0.312	2.23	0.026	1.055; 2.314	0.026	0.001; 0.051
2022	0.95	0.165	−0.29	0.775	0.677; 1.338	−0.002	−0.018; 0.014
Constant (Ref. 2018)	0.05[c]	0.007	–	–	0.042; 0.068	Reference period	
Boys, 15-year-old							
2014	1.18	0.178	1.06	0.287	0.873; 1.581	0.022	−0.020; 0.064
2022	0.83	0.100	−1.52	0.128	0.659; 1.054	−0.022	−0.052; 0.007
Constant (Ref. 2018)	0.18[c]	0.016	–	–	0.156; 0.218	Reference period	
Girls, 13-year-old							
2014	1.03	0.212	0.13	0.896	0.685; 1.541	0.002	−0.024; 0.027
2022	0.97	0.170	−0.19	0.849	0.684; 1.366	−0.002	−0.023; 0.019
Constant (Ref. 2018)	0.07[c]	0.009	–	–	0.055; 0.092	Reference period	
Girls, 15-year-old							
2014	1.50***	0.169	3.61	< 0.001	1.203; 1.875	0.075	0.033; 0.116
2022	0.68***	0.074	−3.55	< 0.001	0.551; 0.843	−0.056	−0.088; −0.025
Constant (Ref. 2018)	0.26[c]	0.020	–	–	0.227; 0.305	Reference period	

[a]Exponentiated logit coefficient (odds ratio); [b]linearised standard errors; [c]exponentiated constant estimates are the 2018 baseline odds.
Significant change compared to the 2018 reference period at the probability level: ***p < 0.001, **p < 0.01, *p < 0.05.

with prevalence reduced by 9.5 percentage points compared to 2018 (95% CI: 5.5–13.6) and an odds ratio of 0.66 (95% CI: 0.555–0.787).

Table 4 presents the results for cigarette use in the last 30 days. Here, statistically significant changes between survey periods were observed only for two demographic subgroups: 15-year-old girls and 13-year-old boys.

Table 5 provides the data on the prevalence of electronic cigarette (e-cigarette) use – an additional measure surveyed in the 2022 HBSC period only. Both lifetime and last 30 days prevalence rates are shown, together with their corresponding 95% CIs, reported separately for the six demographic subgroups. In addition to e-cigarette use, an ex-post computed indicator combining either e-cigarette or conventional cigarette use is also presented for both time-span perspectives.

Similarly to the data on cigarette smoking presented in the previous Table 2, the results reveal a strong age gradient in e-cigarette use, with prevalence increasing markedly from the youngest (11-year-olds) to the oldest (15-year-olds). Among boys, lifetime e-cigarette use increases from 5.7% (95% CI: 4.6–7.0%) at age 11 to 35.1% (95% CI: 32.3–38.0%) at age 15; similar figures were observed among girls, ranging from 3.9% (95% CI: 3.0–5.0%) to 36.6% (95% CI: 34.1–39.1%). Corresponding increases were found also for last 30 days use, from around 2% among 11-year-olds to approximately 20% among 15-year-olds.

When combining e-cigarettes and conventional cigarettes, the prevalence estimates rise further, reaching 40.8% (95% CI: 37.9–43.8%) among 15-year-old boys and 43.1% (95% CI: 40.4–45.9%) among 15-year-old girls for lifetime use. For last 30 days prevalence, approximately one quarter of the 15-year-old adolescents engaged in either e-cigarette or conventional cigarette use: 22.5% (95% CI: 20.2–25.1%) for boys and 26.7% (95% CI: 24.3%–29.2%) for girls.

Table 5. *Adolescent e-cigarette prevalence by gender and age, HBSC 2022, Czech Republic*

Gender	Age group	E-cigarettes		E-cigarettes or conventional cigarettes[a]	
		Rate (%)	95% CI	Rate (%)	95% CI
Lifetime use					
Boys	11-year-old	5.7	4.6–7.0	7.4	6.1–8.8
	13-year-old	18.2	16.2–20.4	20.9	18.7–23.3
	15-year-old	35.1	32.3–38.0	40.8	37.9–43.8
Girls	11-year-old	3.9	3.0–5.0	4.8	3.8–6.0
	13-year-old	17.9	15.8–20.3	21.4	19.1–23.9
	15-year-old	36.6	34.1–39.1	43.1	40.4–45.9
Last 30 days use					
Boys	11-year-old	2.2	1.6–3.2	2.7	2.0–3.7
	13-year-old	9.0	7.6–10.7	9.9	8.4–11.7
	15-year-old	19.6	17.4–22.0	22.5	20.2–25.1
Girls	11-year-old	2.2	1.6–3.1	2.5	1.8–3.3
	13-year-old	10.2	8.5–12.1	11.2	9.6–13.2
	15-year-old	23.0	20.8–25.3	26.7	24.3–29.2

[a]Ex-post computed indicator combining previously reported prevalence data on e-cigarette and conventional cigarette use.

With respect to gender differences, these were small and varied across age groups. Among 11-year-olds, boys reported slightly higher lifetime and last 30 days e-cigarette use than girls; however, these differences diminished with increasing age and reversed among the oldest group. At age 15, girls slightly exceeded boys in e-cigarette use, both for lifetime (36.6% vs. 35.1%) and in last 30 days use (23.0% vs. 19.6%). A similar pattern was observed for the combined indicator of either e-cigarette or conventional cigarette use, where prevalence among 15-year-old girls (43.1% lifetime, 26.7% last 30 days) was somewhat higher than among boys (40.8% and 22.5%, respectively).

DISCUSSION

The study analysed recent trends in cigarette smoking among Czech adolescents using HBSC data from 2014, 2018 and 2022. Across the three survey rounds, a consistent decline in both lifetime and last 30 days cigarette use was observed, particularly among 13- and 15-year-olds. The largest decreases were evident between 2014 and 2018, but further declines continued through 2022. These reductions seem to be more pronounced among girls, narrowing the previously observed excess prevalence among girls compared with boys.

Our findings extend the earlier results reported by Salonna et al. (13), who documented a gradual decline in adolescent smoking rates after their peak in the mid-2000s, with a particularly steep drop between 2010 and 2014. Our analyses show that this drop persisted beyond 2014, demonstrating that Czechia has experienced a sustained downward trend in this respect for over a decade.

The trends observed in our HBSC data are consistent with those reported in the Czech rounds of the European School Survey Project on Alcohol and Other Drugs (ESPAD). The ESPAD findings confirm that cigarette smoking among Czech students aged 15–16 has reached historically low levels in recent periods, mirroring the declines documented in the HBSC. Specifically, the prevalence of cigarette use in the last 30 days among 15–16-year-olds declined continuously from 29.8% in 2015 to 23.6% in 2019 and further to 20.7% in 2024. In contrast, the prevalence in 2011 was as high as 42.3% (8, 21).

In a similar vein, data from the Czech rounds of the Global Youth Tobacco Survey (GYTS), conducted among adolescents aged 13–15 years, also indicate a continued decline in cigarette smoking after the mid-2010s. For example, the prevalence of cigarette smoking in the last 30 days decreased from 15.2% in 2016 to 11.2% in 2022 (22). For comparison, the prevalence reported in the 2011 GYTS was 30.6% – about twice as high as in 2016 and nearly three times higher than in 2022. This consistency across several independent data sources strengthens confidence in the validity of the downward trend observed in the HBSC data.

Decreases in adolescent smoking prevalence rates were also reflected in the relative international position of Czechia among HBSC participating countries. In the 2014 HBSC round, Czech adolescents still ranked within the upper quarter of countries with the highest cigarette smoking rates, but by 2022 their relative position had shifted closer to the international median. Specifically, for indicator of smoking in the last 30 days, Czech 15-year-olds moved from 9th place out of 39 examined countries in 2014 to 21st place out of 45 countries in the 2022 HBSC survey (23). A

notable shift was also observed for lifetime cigarettes use. Here, however, the Czech adolescents shifted from the upper decile in 2014 (i.e., from top 10%) to the upper third in 2022 (among 15-year-olds, from 4th place out of 41 countries in 2014 to 13th out of 45 in 2022) (23). Hence, with respect to the lifetime cigarette use, Czech adolescents still remain markedly above the international average.

Analogous results were observed in the recent ESPAD surveys (8), which showed a shift in the prevalence of lifetime cigarette use among Czech 15–16-year-olds from the highest rank in 2015 (1st among 32 countries) to a notably lower position, though still significantly above the ESPAD average in 2024 (14th out of 37 countries in ESPAD 2024). With respect to cigarette use in the last 30 days, Czechia moved from the highest fifth of countries in 2015 to the second highest fifth in 2024, reflecting a shift closer to the international median (8) and mirroring the relative improvement also observed in the HBSC rankings.

Apart from the decreasing trends in the prevalence of conventional cigarette use, the 2022 HBSC data also provided insights into the use of electronic cigarettes among Czech adolescents. The findings underscored the relevance of e-cigarettes in adolescent nicotine exposure. In 2022, more than one-third of Czech 15-year-olds reported lifetime experience with e-cigarettes (35.1% among boys and 36.6% among girls), and about one in five reported use in the last 30 days (19.6% among boys and 23.0% among girls). When examined together with conventional cigarettes, the results indicate that by mid-adolescence (age 15), more than two in five Czech adolescents had already experimented with at least one of these cigarette products (40.8% of boys and 43.1% of girls), and one in four had used it in the last 30 days (22.5% of boys and 26.7% of girls). Although not directly comparable, these figures appear to exceed those observed for conventional cigarettes in 2018, suggesting no overall decline in adolescent nicotine exposure between 2018 and 2022.

Similar findings for Czechia were also reported in the ESPAD survey, which provides data on e-cigarette use for the two most recent rounds, 2019 and 2024. The decline in use of conventional cigarettes over this period was outweighed by a notable increase in e-cigarettes. Specifically, the prevalence of e-cigarette use in the last 30 days rose from 19.8% in 2019 to 31.2% in 2024 (21), while the combined indicator of using either conventional or electronic cigarettes in the last 30 days increased from 33.2% to 37.1% (8). Thus, these findings in fact indicate a temporal increase in adolescents' overall exposure to nicotine products in the most recent period.

When discussing temporal changes in smoking prevalence, Lopez et al. (24) proposed a descriptive model of the cigarette epidemic in developed countries, outlining a series of consecutive stages in its progression. The later stages of this model are characterised by declining cigarette use among both male and female populations as smoking-related awareness and policy interventions take effect. However, when considering the continuous declines observed among younger age groups, such as adolescents, additional hypotheses have been proposed – particularly in relation to the increasing relevance of new nicotine delivery systems (NDS), such as electronic cigarettes.

The 'displacement hypothesis' suggests that the use of NDS or e-cigarettes leads to a decrease in traditional cigarette smoking – a view often inferred from scenarios showing declining prevalence of cigarette use alongside increasing e-cigarettes in repeated cross-sectional monitoring surveys. In contrast, the 'gateway hypothesis' posits that the use of NDS or e-cigarettes by non-smokers, particularly during adolescence (25), increases the risk of subsequent initiation of smoking conventional cigarettes, thus in a longitudinal perspective. A third hypothesis could posit that the prevalence of cigarette use and NDS use are independent phenomena, representing two unrelated temporal trends. Given the cross-sectional design and limited number of time periods in our data, we caution against drawing conclusions in favour of any of these competing hypotheses, even though some readers might be inclined to interpret the findings as supporting displacement effects. In fact, as elegantly demonstrated in the recent study by Egger et al. (26), any of the three hypotheses can be equally consistent with scenarios showing decreasing prevalence in smoking conventional cigarettes alongside increasing use of e-cigarettes, as well as with other possible trajectories, including rising prevalence rates of either product. Moreover, another recent study (27), employing interrupted time-series analysis, reported that the increasing prevalence of e-cigarette use significantly slowed the previously observed long-term decline in conventional cigarettes among adolescents – that is, while the downward trend persisted, its rate of decline decreased markedly as e-cigarette use became more widespread. Therefore, in explaining the observed decline in conventional cigarettes, we rather point to some other explanatory factors.

The international literature attributes the declining trends in adolescent smoking to a range of processes operating at multiple levels and often synergistically. These include the effects of comprehensive tobacco control policies, the denormalisation of smoking behaviour, increased health awareness and changing social norms associated with smoking, as well as broader shifts in adolescent lifestyle and socialisation, including competing behaviours such as digitalisation and screen-based leisure. From these factors, we highlight those we consider most plausible in the Czech context.

The ESPAD survey provides evidence of growing risk perceptions related to smoking conventional cigarettes. For example, the proportion of 15–16-year-old Czechs who perceived occasional cigarette smoking as posing a moderate or great risk to their health increased from 32.5% in 2015 to 41.5% in 2024 (8). Unfortunately, the HBSC does not provide comparable data on adolescent risk perceptions. At the same time, more complex shifts may be occurring in how adolescents perceive the relative risks of conventional cigarettes versus e-cigarettes and other NDS products, underscoring the need for more in-depth analyses in this area.

Changes in parental control and monitoring practices regarding adolescents' out-of-school time may also play a certain role. The increasing availability and use of digital applications that allow parents to track their children's location or communicate instantly (28, 29) could contribute to greater parental oversight and reduce opportunities for unsupervised socialisation. Furthermore, the increasing shift from face-to-face interactions to virtual spaces and social media use may also be significant. Together, these factors can cumulatively reduce unsupervised and unstructured peer socialisation during adolescence. Indeed, the Czech study by Chomynová and Kážmér (30) largely attributed the decline in adolescent alcohol use observed in the mid-2010s to decreases in unstructured leisure-time socialising with peers – risk factors traditionally associated with smoking as well.

Policy Implications

From a policy perspective, the findings suggest that recent public health measures and regulatory efforts in Czechia – including Act No. 65/2017 Coll., school-based prevention programmes, and strengthened enforcement of age-of-sale restrictions – may also have contributed to the decline in conventional cigarette smoking among adolescents. Nonetheless, the notable prevalence of electronic cigarette use observed in 2022 indicates that traditional strategies focused solely on combustible cigarettes may no longer be sufficient. Expanding regulatory frameworks to explicitly cover all nicotine-containing products could strengthen prevention efforts. These should include consistent enforcement, restrictions on marketing and flavourings that appeal to youth, and clear, targeted risk communication. Continued monitoring through population-based surveys, such as those provided by HBSC and ESPAD, will be essential to ensure that policy interventions remain responsive to newly emerging smoking-related products and evolving adolescent risk behaviours.

Strengths and Limitations

With respect to the limitations of the study, several issues should be kept in mind. Although the results are based on data from a series of large, representative samples of Czech adolescents collected using a rigorous and standardised methodology, smoking prevalence was obtained through self-reported questionnaires, which may be subject to recall and/or social desirability bias. However, unless such biases changed substantially across survey periods, they are unlikely to explain the consistent downward trends in cigarette smoking observed in our findings.

Another limitation is that the present analyses focused only on conventional cigarettes and e-cigarettes. Other alternative nicotine products, such as heated and/or smokeless tobacco, were not included. This omission may lead to an underestimation of overall nicotine exposure. It should be noted, however, that the Czech 2022 HBSC data included information on the lifetime use of a selected set of these products (IQOS, nicotine pouches, chewing tobacco, and snus), but only among 15-year-old respondents. When combined with data on the use of either conventional or e-cigarettes, the estimated lifetime prevalence presented in Table 5 increased by 3.5 percentage points for 15-year-old boys and by 1.5 percentage points for girls.

In a similar vein, it should be acknowledged that the HBSC questions on e-cigarette use did not assess the presence of nicotine in the devices. Nevertheless, it is likely that the majority of these products contained nicotine, thus significantly increasing the overall nicotine exposure among the surveyed adolescents.

CONCLUSIONS

The study provides evidence for continuing decline in adolescent cigarette smoking that has been documented in previous research conducted in Czechia. Nonetheless, while this downward trend persisted following the 2014 HBSC round, the findings also highlight the relevance of electronic cigarettes among Czech adolescents. Given that e-cigarette use during adolescence has been associated in multiple prospective cohort studies with an increased risk of subsequent tobacco use, this emerging pattern undermines ongoing efforts to reduce overall nicotine exposure and, in the long term, may counteract the declining trends in conventional cigarettes among youth.

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Conflicts of Interest

None declared

Authors’ Contributions

LK performed statistical analyses, literature review, drafted the manuscript and was responsible for its final revision; OŠ contributed to drafting and revising the manuscript; MK and LC oversaw survey data collection and ensured compliance with HBSC methodology in Czechia in 2014, 2018 and 2022. All authors had full access to the survey data, contributed to the interpretation of the findings, and approved the final version of the manuscript.

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