pISSN: 1906 - 6406 The Scholar: Human Sciences
eISSN: 2586 - 9388 The Scholar: Human Sciences
https://assumptionjournal.au.edu/index.php/Scholar

The Effectiveness of Electronic Cigarette on Smoking Cessation in Adult Smokers: A Systematic review and Meta-analysis

Supa Pudkasam, Nucharapon Liangruenrom, Siriporn Poonruksa*

Received: October 03, 2025 Revised: November 25, 2025 Accepted: December 02, 2025.

Abstract

Purpose: The study aims to examine the effect size of e-cigarettes on smoking cessation in adult smokers with subgroups analysis based on their intention to quit. **Research design, data and methodology:** Quantitative studies that assessed the effect size of e-cigarettes on smoking cessation in adult smokers were searched from four databases. The included articles were imported into EndNote X8 and screened based on eligibility criteria. The data extraction was completed using Microsoft Excel. Pooled effect size (odds ratio) was used to analyze the fixed effect model or random effect model depending on the similarity of recruited studies. **Results:** The overall odds ratio of six recruited randomized controlled trials (RCTs), eight longitudinal and two cross-sectional studies showed that there was no significant effect of e-cigarette on smoking cessation. In the subgroup analysis of smokers who initially intended to quit, the odds ratio for smoking cessation associated with e-cigarette use also showed no significant effect. **Conclusions and implication:** The study asserted that e-cigarettes could not show significant effect on smoking cessation in adult smokers. The intention to quit at the beginning does not significantly facilitate smoking cessation by e-cigarette application. Future studies should place greater emphasis on participants' intentions to quit at both baseline and follow-up.
Systematic review registration: PROSPERO Registration number CRD42022360634

Keywords: Electronic Cigarette, Smoking Cessation, Adult, Intention

JEL Classification Code: I10, I12, I31

1. Introduction

An electronic cigarette, otherwise known as an e-cigarette, is a powered battery device for the inhalation of vaporized liquid containing nicotine, other chemicals, and flavorings (Margham et al., 2016). The use of e-cigarettes, commonly referred to as vaping, has become popular among smokers with the belief that they are less harmful than combustible cigarettes. (Dutra et al., 2017) and there is no tar in e-cigarettes (Jenssen & Boykan, 2019). Nevertheless, some research warns that e-cigarette consumers are exposed to other toxic substances, such as carbonyl compounds, heavy metals, and formaldehyde, that can be harmful to smokers' health (Allen et al., 2016).

Remarkably, there is some evidence supporting the safety and potential effectiveness of e-cigarettes on smoking cessation (Lisko et al., 2015). Over recent years, e-cigarettes have gained attention from tobacco smokers due to marketing towards a reduction in hazard and social acceptability (Dutra et al., 2017). Nevertheless, the Food and Drug Administration (FDA) in the United States, has not approved e-cigarettes as a smoking cessation aid (Centers for Disease Control and Prevention, 2023).

Inconsistent results among previous studies were evident, a longitudinal study on 949 cigarette users showed that e-cigarette use did not yield significant levels of smoking cessation after a one-year follow-up (Grana et al., 2014). However, a previous RCT reported that the application of e-cigarette could significantly facilitate cigarette abstinence in smokers who wanted to quit (Bullen et al., 2013). Therefore, the benefit of e-cigarettes on smoking cessation is in ambivalent opinions and remains inconclusive which is likely to depend on the heterogeneity of study designs and

1 Supa Pudkasam, Lecturer, Nursing Science Faculty, Assumption University, Thailand. Email: supapdk@au.edu
2 Nucharapon Liangruenrom, Lecturer, Institute for Population and Social Research, Mahidol University, Thailand, Email: nucharapon.lia@mahidol.ac.th
3*Siriporn Poonruksa, Lecturer, Nursing Science Faculty, Assumption University, Thailand. Email: siripornPnr@au.edu

some confounding factors such as intention to quit. A previous systematic review commented that smokers' intention to quit for a year may affect their smoking cessation rate (Kalkhoran & Glantz, 2016).

Intention to perform some behaviors of interest can be explained by the Theory of Planned Behavior (Ajzen & Schmidt, 2020). An individual's intention possibly depends on their attitude, perceived social pressure and perceived behavioral control (Ajzen & Schmidt, 2020). Hence, future studies should evaluate more about the significance of e-cigarette usage and intention or motivation to quit smoking (Kalkhoran & Glantz, 2016). The current systematic review utilizes various peer-reviewed studies to examine whether e-cigarettes can be an effective tool for smoking cessation. Additionally, subgroup analysis will explore the influence of quit intention of smokers on smoking cessation after using e-cigarette.

1.1 Objectives

The main objective of this systematic review and meta-analysis was to investigate the effectiveness of e-cigarettes on traditional cigarette cessation in adult smokers with and without intention to quit.

2. Methods

2.1 Protocol and registration

The protocol used in the review followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) in 2015 (Shamseer, 2016). The protocol of this systematic review has been registered with the International Prospective Register of Systematic Reviews (PROSPERO) (Registration number CRD42022360634).

2.2 Study selection

The systematic review selected quantitative studies consisting of randomized controlled trials (RCTs), observational cohort studies, and cross-sectional surveys. There is no limitation to the publication period of the articles included. We selected the studies that recruited male and female adults aged between 18 and 65 who were conventional cigarette smokers who consumed at least 100 cigarettes in their lifetime and had a history of everyday smoking or some days over the last 30 days before participating in the research studies (Zhuang et al., 2016). The review recruited studies focusing on the application of e-cigarettes in smokers who either had the intention to quit conventional cigarettes or without intention including the studies had not mention the quit intention of participants. The study compared cigarette cessation rates between smokers who consumed only conventional cigarettes (control group) and smokers who consumed both conventional and e-cigarettes (intervention group). The outcome of this systematic review was the cigarette cessation rate which was reported as dichotomous data, risk ratio or odd ratio. The study recruited articles that passed the peer-reviewed process and had their full text available. The study excluded reviews, thesis or dissertation, book chapters, editorial comments or opinions, and conference abstracts.

2.3 Information sources

The study applied Medical Subject Heading (MeSH) for the definition and related terms of smoker, adult, addiction, e-cigarette, cigarette, and cessation.

The systematic review searched target studies through four databases related to health science and human behavior: PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), PsycINFO, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL).

2.4 Search Strategy

The systematic review used the following search terms based on PICO (Participant, Intervention, Comparison, and Outcome) to search for potential studies:

Smoker OR Vaper OR Tobacco smoker

Adult OR Middle-aged OR Young adult

Cigarette OR Cigar OR Tobacco product OR Regular cigarette OR Traditional Cigarette OR Pipe OR Bidis OR Bidi

Addiction OR Tobacco abuse OR Craves

Electronic cigarette OR Electronic nicotine delivery system OR Vaping OR E-cigarette vapor

Cigarette cessation OR Termination OR Stopping OR Ending OR Suspension OR Quitting

All search-yielded references were imported into the Endnote version X8 program to screen and remove duplicated articles.

2.5 Study collection and extraction

After EndNote removed duplicates, two reviewers independently screened all article titles and abstracts based on the inclusion and exclusion criteria. The full texts of all remaining articles were uploaded and read by two reviewers separately to select the articles based on eligible criteria. The third reviewer resolved the discrepancies between the first two reviewers.

Data items consisting of bibliographical data (i.e., publication year and author names), study design,

characteristics of the study population (i.e., gender and age), intention to quit smoking of participants, measurement (i.e., study duration, follow-up period), and outcomes of the study (i.e., smoking cessation) were extracted in Microsoft Excel spreadsheet.

2.6 Risk of bias

Risk of bias was assessed using Cochrane's assessment for six recruited RTCs (Higgins & Altman, 2008) and the Newcastle-Ottawa Scale (NOS) for non-RCT studies (twenty-one longitudinal cohort studies and ten cross-sectional surveys).

2.7 Synthesis of the results

The studies were separately analyzed according to the study design (i.e., RCTs, observational cohort studies, and cross-sectional surveys). The study's primary outcome was the cigarette smoking cessation rate, which we expected to obtain dichotomous data or the number of participants who could quit cigarette smoking during the follow-up period in both intervention and control groups. Meta-analysis was applied to estimate the pooled odds ratio of smoking cessation by e-cigarette. The study analyzed the odds ratio and 95% confidence interval (CI) of individual studies and calculated pooled intervention effect estimates by analyzing a weighted average of intervention effects in individual studies using inverse-variance method. The present review considered heterogeneity intervention effects among the recruited studies by Forest plot and statistical value of chi-square (Q value) at p value < 0.1 and I square at the value > 50% which may represent substantial and considerable heterogeneity. Inverse-variance random-effect meta-analysis was selected when heterogeneity of intervention effects was detected, whereas we used an inverse-variance fixed-effect model when the consistency of the effect size among recruited studies was found. All statistical analyses were conducted by using the free online Meta-Mar v3.5.1.

Subgroup analysis regarding to participants' intention to quit was performed to compare whether intention to quit affected smoking cessation after e-cigarette application.

3. Results

3.1 Study selection

The literature search was conducted between the database inception and February 2025 through four databases: PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), PsycINFO, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). The total number of collected articles after removing duplicate articles was 1,445. There were 255 articles eligible for full-text screening. A final inclusion of 37 studies following eligible criteria was included in this review. Among the 37 articles, six were RCT, 21 were longitudinal cohort studies, and 10 were cross-sectional surveys. The flow of systematic review was illustrated in Figure 1. The variation of the follow-up period among recruited studies ranges from one month to six years.

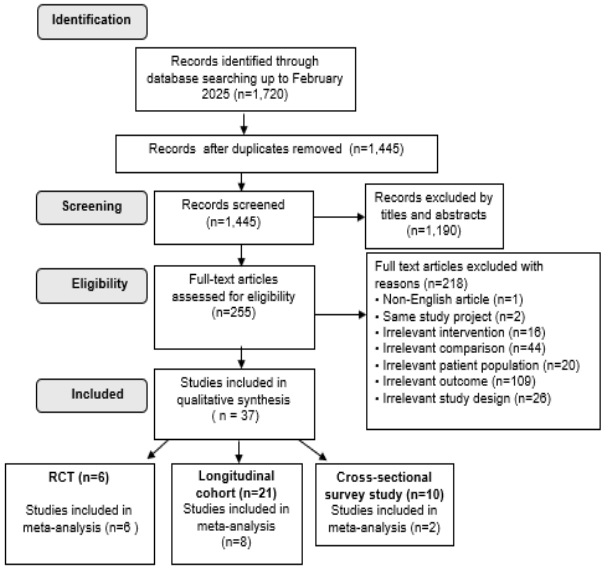


Figure 1: Flow of information through the different phases of a systematic review

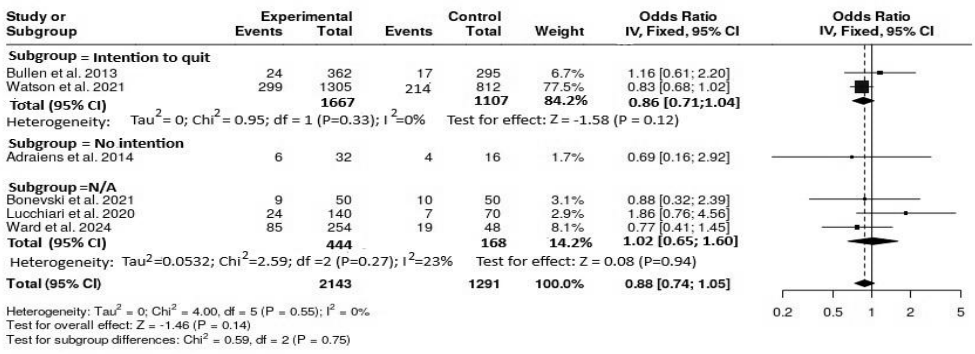
3.2 Study characteristics

3.2.1 The meta-analysis on six RCT studies' effect size (odds ratio) and subgroup analysis regarding participants' intention to quit cigarette smoking

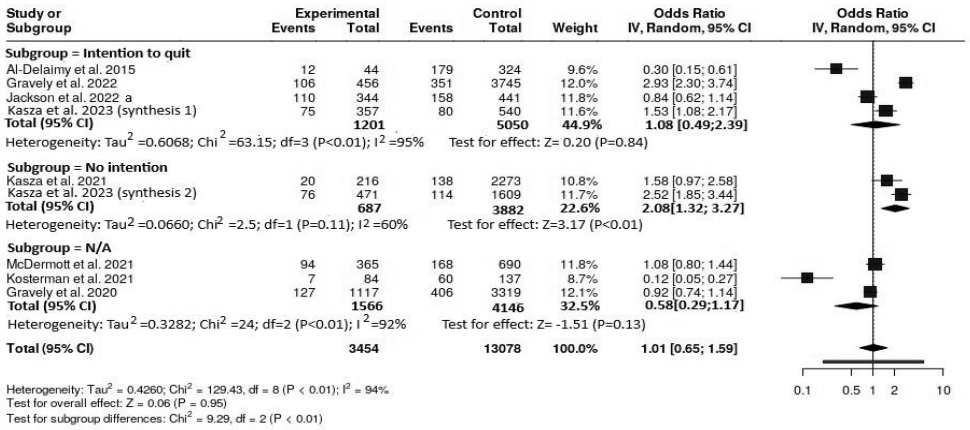
The heterogeneity among six RCT studies was not detected (Chi-square = 4.0, p = 0.55, and I^2 = 0). When an overall meta-analysis using a fixed-effect model with inverse-variance (IV) method was applied, the e-cigarette group had lower odds of cigarette smoking cessation than the control group (OR = 0.88, 95% CI: 0.74-1.05); Z test for overall effect: Z=-1.46, P=0.14. Hence, the review could not find a significant effect of e-cigarettes on smoking cessation from overall RCT studies.

Subgroup analysis regarding intention to quit of participants showed a consistent result among participants who had intention to quit; OR = 0.86, 95% CI: 0.71-1.04 (Bullen et al., 2013; Watson et al., 2021). Meanwhile, the subgroup containing only one study that recruited participants without the intention to quit (Adriaens et al., 2014) showed lower odds ratio of cigarette smoking cessation. However, the range of 95% CI: is broad and crosses 1 (OR = 0.69, 95% CI: 0.16-2.92), meaning there is no significant effect of e-cigarette on smoking cessation. Subgroups in which the intention to quit has not been involved in their effect size analysis showed mixed results; the overall OR = 1.02, 95% CI: 0.65-1.60 (Bonevski et al., 2021; Lucchiari et al., 2020; Ward et al., 2024). The pooled-effect estimation and heterogeneity test among six studies with subgroup analysis regarding the intention to quit cigarette smoking and its forest plot was shown in Figure 2 .

RCTs



Longitudinal cohort studies



Cross-sectional studies

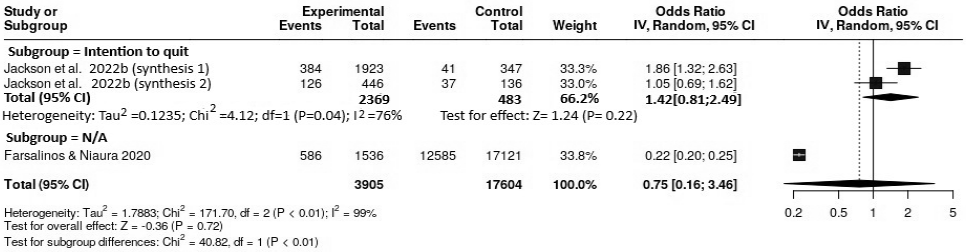


Figure 2: Overall Odds ratio of RCTs, longitudinal cohort and cross-sectional studies with subgroup analysis regarding to participants' intention to quit cigarette smoking and forest plot

Note: Three subgroups analysis classified by the intention of participants to quit smoking, where N/A (not applicable) = no assessment of their intention to quit or the intention to quit of participants is not involved in effect size (Odds ratio) analysis

3.2.2 The meta-analysis on six longitudinal cohort study's effect size (odds ratio) and subgroup analysis regarding participants' intention to quit cigarette smoking

Figure 2 showed the meta-analysis estimating pooled odds ratio and 95% CI of cigarette cessation by the effect of e-cigarettes from eight longitudinal cohort studies that reported dichotomous data in cigarette cessation outcomes. One study reported two data sets regarding the intention to quit smoking of participants (Kasza et al., 2023). The overall odds ratio by the random effect model with IV method was 1.01, and 95% CI crossed 1 (between 0.65 and 1.59; Z=0.06, P=0.95). Substantial heterogeneity was detected, and the I-squared value was 94%. Like the RCT studies, the results of the meta-analysis of longitudinal cohort studies suggest that e-cigarettes had no significant effect on cigarette cessation. Subgroup analysis for participants with intention to quit also showed no significant effect of e-cigarettes on tobacco cessation with a broad range of 95% CI (OR = 1.08, 95% CI: 0.49-2.39). The subgroup in which participants' intention was not applicable in effect size analysis showed lower odds of cigarette cessation (OR = 0.58, 95% CI: 0.29-1.17). Meanwhile, the subgroup that recruited participants who had no intention to quit at the beginning showed significantly higher odds ratio of cigarette smoking cessation by e-cigarette (OR = 2.08, 95% CI: 1.32-3.27); Z=3.17, P <0.01.

There were 13 longitudinal studies that were excluded from meta-analysis reported individual odds or risk ratio scattering across 1 as indicated in Figure 3 The inconsistency of odds or risk ratio across 1 indicated that there was no significant evidence of benefit of e-cigarette smoking cessation.

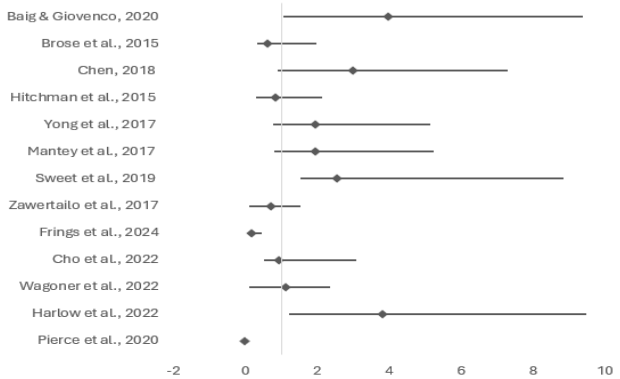


Figure 3: Forest Plot of Odds Ratio or Risk Ratio, 95% Confidence Interval (CI) of Cigarette Cessation by E-Cigarette in Longitudinal Cohort Studies Which were Excluded in Meta-Analysis

Note: Nine longitudinal cohort studies reported Odds ratio (Baig & Giovenco, 2020; Brose et al., 2015; Chen, 2018; Frings et al., 2024; Hitchman et al., 2015; Yong et al., 2017; Mantey et al., 2017; Sweet et al., 2019; Zawertailo et al., 2017). Three studies reported Risk Ratio (Cho et al., 2022; Harlow et al., 2022; Wagoner et al., 2022). One study reported Risk difference (Pierce et al., 2020)

3.2.3 The meta-analysis on two cross-sectional survey studies' effect size (odds ratio) and subgroup analysis regarding participants' intention to quit cigarette smoking

Figure 2 illustrated the meta-analysis of pooled effect size (odds ratio) and 95% CI of cigarette cessation by the effect of e-cigarettes from two survey studies with three data sets on cigarette cessation outcomes. The overall odds ratio by the random effect model was 0.75, and 95% CI was between 0.16 and 3.46; Z=-0.36, P= 0.72. Substantial heterogeneity was detected with an I-squared value of 99%. The meta-analysis of cross-sectional studies also suggested no significant effect of e-cigarettes on tobacco cessation. Subgroup analysis regarding the intention to quit of participants showed higher odds of smoking cessation by an e-cigarette with wide range of 95% CI in the participants intending to quit (OR = 1.42, 95% CI: 0.81-2.49; Z=1.24, P=0.22). On the other hand, the subgroup in which participants' intention was not applicable in effect size analysis (only one study) showed a lower odds ratio of cigarette cessation (OR = 0.22, 95% CI: 0.20-0.25).

Eight cross-sectional surveys that were excluded from meta-analysis reported individual odds ratio or risk ratio across 1 as indicated in Figure 4. Therefore, the benefit of e-cigarette on smoking cessation could not be detected.

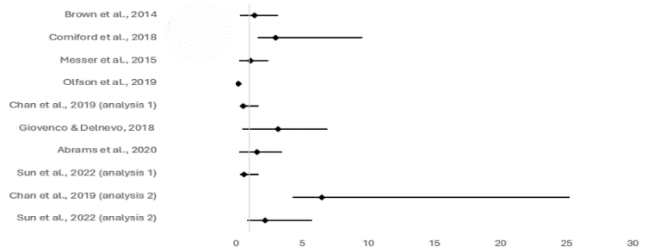


Figure 4: Forest Plot of Odds Ratio or Risk Ratio, 95% Confidence Interval (CI) of Cigarette Cessation by E-Cigarette in Cross sectional survey Studies Which were Excluded in Meta-Analysis

Note: Four cross sectional survey studies reported Odds ratio (Brown et al., 2014; Comiford et al., 2018; Messer et al., 2015; Olfson et al., 2019). Four studies reported Risk Ratio (Abrams et al., 2020; Chan et al., 2019; Giovenco & Delnevo, 2018; Sun et al., 2022).

The studies with analysis 1 presented the effect of occasional use of e-cigarette. The studies with analysis 2 presented the effect of daily use of e-cigarette.

3.3 Risk of bias within the studies

3.3.1 Risk of bias within recruited RCTs

All RCTs included in the meta-analysis were found to have a 'low risk of bias' in random sequence generation and selective reporting. In terms of allocation concealment, one study (16.7%) reported the allocation concealment of participants as the randomization was prepared by an independent person (Lucchiari et al., 2020). For blinding of

participants, only one RCT had participants blinded in using an e-cigarette kit and placebo (Lucchiari et al., 2020). Nearly all studies did not declare the blindness of personnel and outcome assessors, except one study (Bullen et al., 2013). Three studies presented methods for missing data (Bonevski et al., 2021; Bullen et al., 2013; Watson et al., 2021). Other sources of bias were found to be high for all recruited studies, as they applied the selective recruitment of participants who were willing to use e-cigarettes or had an intention to quit smoking (Adriaens et al., 2014; Bullen et al., 2013; Lucchiari et al., 2020). Risk of Bias using the Cochrane Risk of Bias Tool for randomized controlled trials was shown in Figure 5.

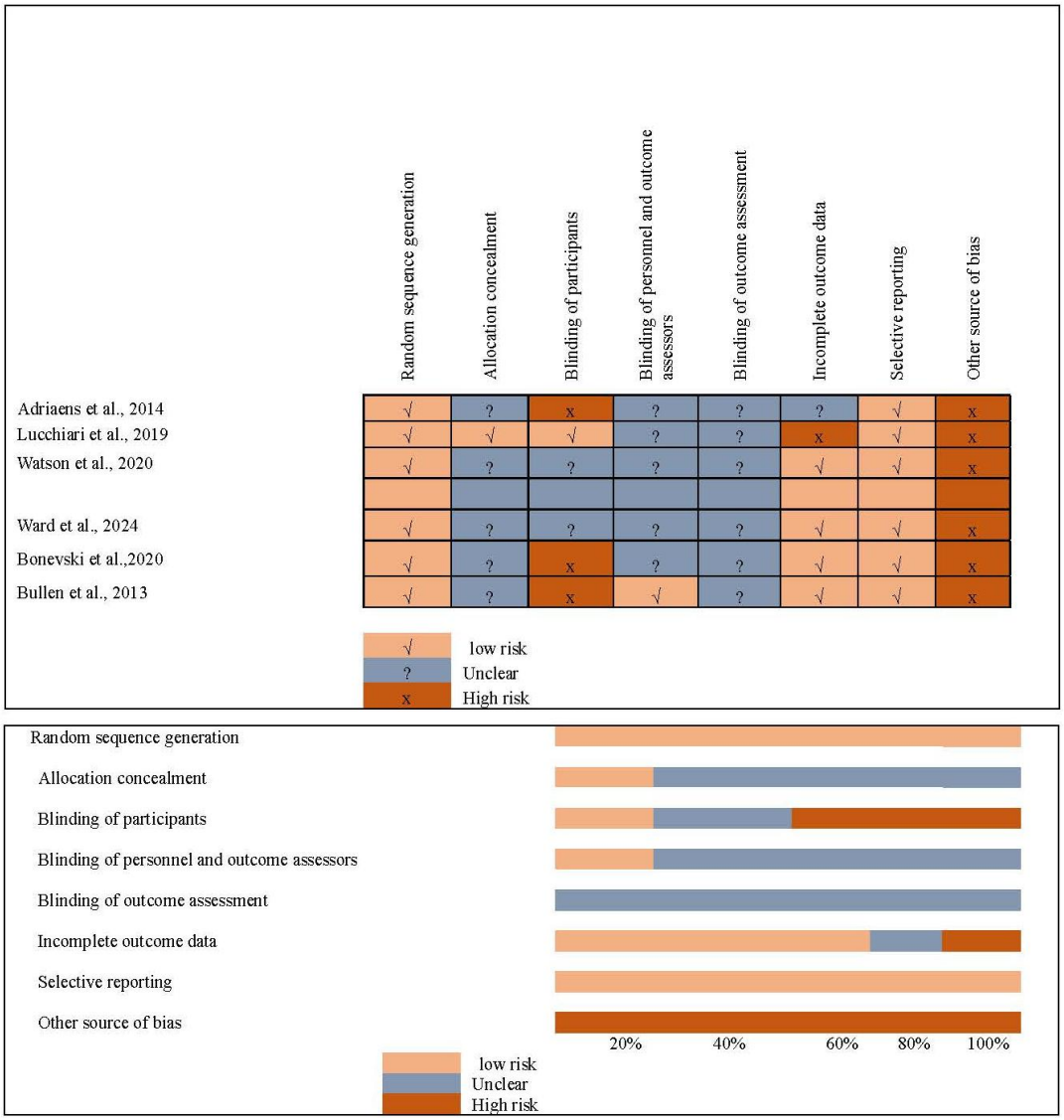


Figure 5: Results of the Cochrane Risk of Bias Tool for randomized controlled trials

3.3.2 Risk of bias within recruited non-RCTs

All cohort studies (n = 21) were categorized as 'low risk of bias.' Nineteen studies earned a maximum of nine stars, while two studies earned eight stars. Similar results of methodological assessment were found for cross-sectional studies. The overall scores of the included cross-sectional studies ranged from seven to ten stars, with a median of 8.5 (classified as 'low risk of bias'). Based on the overall scores, two studies were categorized as 'moderate risk of bias' (Brown et al., 2014; Farsalinos & Niaura, 2020), while all other studies were classified as 'low risk of bias'. Risk of bias within recruited non-RCTs was shown in Table 1 and Table 2.

Table 1: Results of the Newcastle-Ottawa Scale (NOS) for evaluating the risk of bias in cohort studies

No.	Study	Representativeness of the expose	Selection of non-exposure	Ascertainment of exposure	Demonstration of outcome	Comparability of cohort	Assessment of outcome	Follow-up is long enough for outcome	Adequate follow up of cohort	Overall Score (9)
1	Al-Delaimy et al. (2015)	*	*	*	*	**	*	*	*	9
2	McDermott et al. (2021)	*	*	*	*	**	*	*	*	9
3	Gravely et al. (2022)	*	*	*	*	**	*	*	*	9
4	Kasza et al. (2021)	*	*	*	*	**	*	*	*	9
5	Kosterman et al. (2021)	*	*	*	*	**	*	*	*	9
6	Gravely et al. (2022)	*	*	*	*	**	*	*	*	9
7	Kasza et al. (2023)	*	*	*	*	**	*	*	*	9
8	Jackson et al. (2022)	*	*	*	*	**	*	*	*	9
9	Baig and Giovenco (2020)	*	*	*	*	**	*	*	*	9
10	Brose et al. (2015)	*	*	-	*	**	*	*	*	8
11	Chen (2018)	*	*	*	*	**	*	*	*	9
12	Hitchman et al. (2015)	*	*	*	*	**	*	*	*	9
13	Yong et al. (2017)	*	*	*	*	**	*	*	*	9
14	Mantey et al. (2017)	*	*	*	*	**	*	*	*	9
15	Sweet et al. (2019)	*	*	*	*	**	*	*	-	8
16	Pierce et al. (2020)	*	*	*	*	**	*	*	*	9
17	Zawertailo et al. (2017)	*	*	*	*	**	*	*	*	9
18	Cho et al. (2022)	*	*	*	*	**	*	*	*	9
19	Wagoner et al. (2022)	*	*	*	*	**	*	*	*	9
20	Harlow et al. (2022)	*	*	*	*	**	*	*	*	9
21	Frings et al. (2024)	*	*	*	*	**	*	*	*	9

Table 2: Results of the Newcastle-Ottawa Scale (NOS) for evaluating the risk of bias in cross-sectional survey

No.	Study	Sample representative	Sample size	Non-respondents	Assessment of exposure	Comparability	Assessment of outcome	Statistical test	Overall score (10)
1	Farsalinos and Niaura (2020)	*	-	*	*	**	*	*	7
2	Jackson et al. (2022)	*	*	*	*	**	*	*	8
3	Brown et al. (2014)	*	-	*	**	**	*	*	8
4	Comiford et al. (2018)	*	*	*	**	**	**	*	10
5	Messer et al. (2015)	*	*	*	**	**	*	*	9
6	Olfson et al. (2019)	*	*	*	*	**	*	*	8
7	Chan et al. (2019)	*	*	*	**	**	*	*	9
8	Giovenco and Delnevo (2018)	*	*	*	**	**	*	*	9
9	Abrams et al. (2020)	*	-	*	*	**	*	*	7
10	Sun et al. (2022)	*	*	*	**	**	*	*	9

4. Discussion

The current study found substantial statistical heterogeneity among recruited longitudinal cohort and cross-sectional studies, except for recruited randomized controlled trials (RCTs). The heterogeneity detected in the cohort and cross-sectional studies alerts that there may be a spreading of factors influencing the intervention effect size among various studies (Higgins, 2008). The homogeneity among recruited RCTs could represent the likelihood of their clearly defined inclusion criteria, study design, and outcome measures (Gavaghan et al., 2000). The inconsistency of odds ratio across 1 after the application of e-cigarettes reported among studies was possibly due to some common errors of non-controlled trial studies, such as underutilized accessible data, an underestimated variability, and type II statistical error (Caruana et al., 2015).

In our study, we conducted a separate meta-analysis according to the study designs: RCTs, longitudinal cohort, and cross-sectional study. However, we found a similar results trend among the three study designs, denoting no significantly overall effect of e-cigarettes on smoking cessation. Our result was similar to the result of a previous systemic review and meta-analysis among smokers regardless of their willingness to quit (Kalkhoran & Glantz, 2016). Our study could detect some factors from individual study that potentially affected the success or failure of smoking cessation after e-cigarette usage during the trials, including cessation motivation and intention of participants to quit cigarette smoking (Bullen et al., 2013; Kasza et al., 2023; Watson et al., 2021) and length of the follow-up periods (Adriaens et al., 2014). However, our studies could only collect enough studies for subgroups analysis regarding the intention or willingness to quit.

In subgroup analysis regarding the participants' intention to quit cigarette smoking, we discovered that two RCT studies recruiting participants who had intentions to quit smoking at the beginning of the trials could not have a significant effect on cigarette cessation after six- and twelve-month trials of e-cigarettes (Bullen et al., 2013; Watson et al., 2021). Likewise, the other RCT study specifically recruited participants who had no intentions to quit (Adriaens et al., 2014), thus producing a lower effect size but a wide range of 95% CI. The unbiased RCT studies concerning intentions to quit illustrated mixed results, possibly because of a random chance (Bonevski et al., 2021; Lucchiari et al., 2020; Ward et al., 2024). Indeed, intention to quit is a crucial predictor of successful smoking cessation, which can be explained by the theory of planned behavior (TPB) (Rise et al., 2008). The TPB proposes that behavioral intention will likely direct behavioral change as human belief could form their intention in engaging behavior (Ajzen & Schmidt, 2020). A person intends to perform a behavior when they realize its value, social expectation and believe that they can accomplish that behavior (Ajzen & Schmidt, 2020). Furthermore, the possible mechanism which could explain motivation for smoking cessation was the enhancement of self-efficacy after e-cigarette vaping among smokers who had no plan to quit at the beginning (Kasza et al., 2023). Our study could not detect the effect of intention to quit tobacco on smoking cessation by e-cigarette method probably due to few studies involved in the subset analysis. However, most recruited studies did not assess the participants' intention to quit smoking at the follow-up time. Therefore, we posited that future studies should assess the intention to quit tobacco of a smoker at baseline and follow-up. Additionally, behavioral change theory should be applied into the interventions for cigarette cessation.

5. Conclusion and implications

The overall result of the study urges that e-cigarettes are probably not an effective tool for smoking cessation for smokers, and we could not detect the significant effect of intention to quit cigarettes by e-cigarette vaping from subgroups analysis. Therefore, we suggest that future studies on cigarette cessation programs should evaluate participants' intentions to quit and follow-up period of smoking cessation. We would also suggest that more research on smoking cessation strategies based on behavioral change theory is necessary to provide meaningful context that can help in the success rate of smoking cessation.

Conflict of interest

The authors confirm that there are no competing interests exist.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Reference

Abrams, L. R., Kalousova, L., & Fleischer, N. L. (2020). Gender differences in relationships between sociodemographic factors and e-cigarette use with smoking cessation: 2014-15 current population survey tobacco use supplement. *Journal of Public Health*, *42*(1), e42-e50. https://doi.org/10.1093/pub med/fdz017

Adriaens, K., Van Gucht, D., Declerck, P., & Baeyens, F. (2014). Effectiveness of the electronic cigarette: an eight-week Flemish study with six-month follow-up on smoking reduction, craving and experienced benefits and complaints. *Int J Environ Res Public Health*, *11*(11), 11220-11248. https://doi:10.3390/ ijerph111111220.

Ajzen, I., & Schmidt, P. (2020). Changing behavior using the theory of planned behavior. In M. S. Hagger, L. D. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *The handbook of behavior change* (pp. 17-31). Cambridge University Press. https://doi.org/10.1017/9781108677318.002

Al-Delaimy, W. K., Myers, M. G., Leas, E. C., Strong, D. R., & Hofstetter, C. R. (2015). E-Cigarette Use in the Past and Quitting Behavior in the Future: A Population-Based Study. *Am J Public Health*, *105*(6), 1213-1219. https://doi.org/10.2105/AJPH. 2014.302482

Allen, J. G., Flanigan, S. S., LeBlanc, M., Vallarino, J., MacNaughton, P., Stewart, J. H., & Christiani, D. C. (2016). Flavoring chemicals in e-cigarettes: diacetyl, 2, 3-pentanedione, and acetoin in a sample of 51 products, including fruit-, candy-, and cocktail-flavored e-cigarettes. *Environ Health Perspect*, *124*(6), 733-739. https://doi:10.1289/ehp. 1510185

Baig, S. A., & Giovenco, D. P. (2020). Behavioral heterogeneity among cigarette and e-cigarette dual-users and associations with future tobacco use: Findings from the Population Assessment of Tobacco and Health Study. *Addict Behav*, *104*, 106263. https://doi.org/10.1016/j.addbeh.2019. 106263

Bonevski, B., Manning, V., Wynne, O., Gartner, C., Borland, R., Baker, A. L., Segan, C. J., Skelton, E., Moore, L., Bathish, R., Chiu, S., Guillaumier, A., & Lubman, D. I. (2021). QuitNic: A Pilot Randomized Controlled Trial Comparing Nicotine Vaping Products With Nicotine Replacement Therapy for Smoking Cessation Following Residential Detoxification. *Nicotine & Tobacco Research*, *23*(3), 462-470. https://doi.0rg/10.1093/ ntr/ntaa143

Brose, L. S., Hitchman, S. C., Brown, J., West, R., & McNeill, A. (2015). Is the use of electronic cigarettes while smoking associated with smoking cessation attempts, cessation and reduced cigarette consumption? A survey with a 1-year follow-up. *Addiction*, *110*(7), 1160-1168. https://doi.org/10. 1111 /add.12917

Brown, J., Beard, E., Kotz, D., Michie, S., & West, R. (2014). Real-world effectiveness of e-cigarettes when used to aid smoking cessation: a cross-sectional population study. *Addiction*, *109*(9), 1531-1540. https://doi.org/10.1111/add.12623

Bullen, C., Howe, C., Laugesen, M., McRobbie, H., Parag, V., Williman, J., & Walker, N. (2013). Electronic cigarettes for smoking cessation: A randomised controlled trial. *The Lancet*, *382*(9905), 1629-1637. https://doi.org/10.1016/S0140-6736(13)61842-5

Caruana, E. J., Roman, M., Hernández-Sánchez, J., & Solli, P. (2015). Longitudinal studies. *Journal of thoracic disease*, *7*(11), 537-540. https://doi:10.3978/j.issn. 2072-1439.2015.10.63

Centers for Disease Control and Prevention. (2023). *Adult Smoking Cessation—The Use of E-Cigarettes*. https://www.cdc.gov/tobacco/sgr/2020-smokingcessation/fact-sheets/adult-smoking-cessation-e-cigarettes-use/index.html

Chan, G., Leung, J., Gartner, C., Yong, H. H., Borland, R., & Hall, W. (2019). Correlates of electronic cigarette use in the general population and among smokers in Australia - Findings from a nationally representative survey. *Addict Behav*, *95*, 6-10. https://doi.org/10.1016/j.addbeh.2019.02.012

Chen, J. C. (2018). Flavored e-cigarette use and cigarette smoking reduction and cessation—A large national study among young adult smokers. *Subst Use Misuse*, *53*(12), 2017-2031. https://doi.org/10.1080 /10826084.2018.1455704

Cho, Y. J., Thrasher, J. F., Gravely, S., Alberg, A., Borland, R., Yong, H. H., Cummings, K. M., Hitchman, S. C., & Fong, G. T. (2022). *Adult smokers' discussions about vaping with health professionals and subsequent behavior change: a cohort study.* Addiction. https://doi.org/10.1111/add.15994

Comiford, A. L., Rhoades, D. A., Spicer, P., Kai, D., Dvorak, J. D., Leslie, D., Wagener, T. L., & Doescher, M. P. (2018). E-cigarettes and Tobacco Exposure Biomarkers among American Indian Smokers. *Am J Health Behav*, *42*(6), 101-109. https://doi.org/10.5993/AJHB.42.6.10

Dutra, L. M., Grana, R., & Glantz, S. A. (2017). Philip Morris research on precursors to the modern e-cigarette since 1990. *Tob Control*, *26*(2), 97-105. https://doi.org/10.1136/tobaccocontrol-2016-053406

Farsalinos, K. E., & Niaura, R. (2020). E-cigarettes and smoking cessation in the United States according to frequency of e-cigarette use and quitting duration: analysis of the 2016 and 2017 National Health Interview Surveys. *Nicotine and Tobacco Research*,*b22*(5), 655-662. https://doi.org/10.10. 1093/ntr/ntz025

Frings, D., Albery, I. P., Kimber, C., Naughton, F., Sideropoulos, V., & Dawkins, L. (2024). Change in vaping, smoking and dual-use identities predicts quit success and cigarette usage: A prospective study of people quitting smoking with electronic cigarette support. *Br J Health Psychol*, *29*(4), 877-888. https://doi.org/10.1111/bjhp.12735

Gavaghan, D. J., Moore, R. A., & McQuay, H. J. (2000). An evaluation of homogeneity tests in meta-analyses in pain using simulations of individual patient data. *Pain*, *85*(3), 415-424. https:doi.org/10.1016/S0304- 3959(99)00302-4

Giovenco, D. P., & Delnevo, C. D. (2018). Prevalence of population smoking cessation by electronic cigarette use status in a national sample of recent smokers. *Addict Behav*, *76*, 129-134. https://doi.org/10.1016/j.addbeh.2017.08.002

Grana, R. A., Popova, L., & Ling, P. M. (2014). A longitudinal analysis of electronic cigarette use and smoking cessation. *JAMA Intern Med*, *174*(5), 812-813. https://doi:10.1001/jamainternmed.2014.187

Gravely, S., Meng, G., Hammond, D., Hyland, A., Michael Cummings, K., Borland, R., Kasza, K. A., Yong, H. H., Thompson, M. E., Quah, A. C. K., Ouimet, J., Martin, N., O'Connor, R. J., East, K. A., McNeill, A., Boudreau, C., Levy, D. T., Sweanor, D. T., & Fong, G. T. (2022). Differences in cigarette smoking quit attempts and cessation between adults who did and did not take up nicotine vaping: Findings from the ITC four country smoking and vaping surveys. *Addict Behav*, *132*, 107339. https://doi.org/10.1016/j.addbeh.2022.107339

Harlow, A. F., Stokes, A. C., Brooks, D. R., Benjamin, E. J., Leventhal, A. M., McConnell, R. S., Barrington-Trimis, J. L., & Ross, C. S. (2022). *Prospective association between e-cigarette use frequency patterns and cigarette smoking abstinence among adult cigarette smokers in the United States.* Addiction. https://doi.org/10.1111/add.16009

Higgins, J. P., & Altman, D. G. (2008). Assessing risk of bias in included studies. *Cochrane handbook for systematic reviews of interventions: Cochrane book series*, 187-241. https://doi.org/10.1002/ 9780470712184.ch8

Higgins, J. P. T. (2008). Commentary: Heterogeneity in meta-analysis should be expected and appropriately quantified. *International journal of epidemiology*, *37*(5), 1158-1160. https://doi.org/10.1093/ije/dyn 204

Hitchman, S. C., Brose, L. S., Brown, J., Robson, D., & McNeill, A. (2015). Associations between E-cigarette type, frequency of use, and quitting smoking: Findings from a longitudinal online panel survey in Great Britain. *Nicotine & Tobacco Research*, *17*(10), 1187-1194. https://doi.org/10. 1093/ntr/ntv078

Jackson, S. E., Cox, S., Shahab, L., & Brown, J. (2022). Prevalence of use and real-world effectiveness of smoking cessation aids during the COVID-19 pandemic: a representative study of smokers in England. *Addiction*, *117*(9), 2504-2514. https://doi.org/10.1111/add.15903

Jackson, S. E., Kock, L., Kotz, D., & Brown, J. (2022). Real-world effectiveness of smoking cessation aids: A population survey in England with 12-month follow-up, 2015-2020. *Addict Behav*, *135*, 107442. https://doi.org/10.1016/j.addbeh.2022.107442

Jenssen, B. P., & Boykan, R. (2019). Electronic cigarettes and youth in the United States: A call to action (at the local, national and global levels). *Children*, *6*(2), 30. https://doi.org/10.3390/children6020030

Kalkhoran, S., & Glantz, S. A. (2016). E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med*, *4*(2), 116-128. https://doi.org/10.1016/s2213-2600(15)00521-4

Kasza, K. A., Edwards, K. C., Kimmel, H. L., Anesetti-Rothermel, A., Cummings, K. M., Niaura, R. S., Sharma, A., Ellis, E. M., Jackson, R., Blanco, C., Silveira, M. L., Hatsukami, D. K., & Hyland, A. (2021). Association of e-Cigarette Use With Discontinuation of Cigarette Smoking Among Adult Smokers Who Were Initially Never Planning to Quit. *JAMA Netw Open*, *4*(12), e2140880. https://doi.org/10.1001/jamanetworkopen.2021.40880

Kasza, K. A., Hammond, D., Gravely, S., O'Connor, R. J., Meng, G., East, K., Borland, R., Cummings, K. M., Fong, G. T., & Hyland, A. (2023). Associations between nicotine vaping uptake and cigarette smoking cessation vary by smokers' plans to quit: longitudinal findings from the International Tobacco Control Four Country Smoking and Vaping Surveys. *Addiction*, *118*(2), 340-352. https://doi.org/10.1111/add.16050

Kosterman, R., Epstein, M., Bailey, J. A., Furlong, M., & Hawkins, J. D. (2021). The role of electronic cigarette use for quitting or reducing combustible cigarette use in the 30s: Longitudinal changes and moderated relationships. *Drug Alcohol Depend*, *227*, 108940. https://doi.org/10.1016/j.drugalcdep. 2021.108940

Lisko, J. G., Tran, H., Stanfill, S. B., Blount, B. C., & Watson, C. H. (2015). Chemical composition and evaluation of nicotine, tobacco alkaloids, pH, and selected flavors in e-cigarette cartridges and refill solutions. *Nicotine & Tobacco Research*, *17*(10), 1270-1278. https://doi.org/10.1093/ntr/ntu279

Lucchiari, C., Masiero, M., Mazzocco, K., Veronesi, G., Maisonneuve, P., Jemos, C., Omodeo Salè, E., Spina, S., Bertolotti, R., & Pravettoni, G. (2020). Benefits of e-cigarettes in smoking reduction and in pulmonary health among chronic smokers undergoing a lung cancer screening program at 6 months. *Addict Behav*, *103*, 106222. https://doi.org/10.1016/j.addbeh.2019.106222

Mantey, D. S., Cooper, M. R., Loukas, A., & Perry, C. L. (2017). E-cigarette Use and Cigarette Smoking Cessation among Texas College Students. *Am J Health Behav*, *41*(6), 750-759. https://doi.org/10. 5993/AJHB.41.6.9

Margham, J., McAdam, K., Forster, M., Liu, C., Wright, C., Mariner, D., & Proctor, C. (2016). Chemical composition of aerosol from an e-cigarette: a quantitative comparison with cigarette smoke. *Chemical research in toxicology*, *29*(10), 1662-1678. https://doi 10.1021/acs.chemrestox.6b00188.

McDermott, M. S., East, K. A., Brose, L. S., McNeill, A., Hitchman, S. C., & Partos, T. R. (2021). *The effectiveness of using e-cigarettes for quitting smoking compared to other cessation methods among adults in the united kingdom.* Addiction. https://doi.org/10.1111/add.15474

Messer, K., Vijayaraghavan, M., White, M. M., Shi, Y., Chang, C., Conway, K. P., Hartman, A., Schroeder, M. J., Compton, W. M., & Pierce, J. P. (2015). Cigarette smoking cessation attempts among current US smokers who also use smokeless tobacco. *Addict Behav*, *51*, 113-119. https://doi.org/10.1016/j.addbeh.2015.06.045

Olfson, M., Wall, M. M., Liu, S. M., Sultan, R. S., & Blanco, C. (2019). E-cigarette Use Among Young Adults in the U.S. *Am J Prev Med*, *56*(5), 655-663. https://doi.org/10.1016/j.amepre.2018.12.004

Pierce, J. P., Benmarhnia, T., Chen, R., White, M., Abrams, D. B., Ambrose, B. K., Blanco, C., Borek, N., Choi, K., Coleman, B., Compton, W. M., Cummings, K. M., Delnevo, C. D., Elton-Marshall, T., Goniewicz, M. L., Gravely, S., Fong, G. T., Hatsukami, D., Henrie, J., . . . Messer, K. (2020). Role of e-cigarettes and pharmacotherapy during attempts to quit cigarette smoking: The PATH Study 2013-16. *PLoS One*, *15*(9). https://doi.org/10.1371/journal.pone.0237938

Rise, J., Kovac, V., Kraft, P., & Moan, I. S. (2008). Predicting the intention to quit smoking and quitting behaviour: Extending the theory of planned behaviour. *Br J Health Psychol*, *13*(2), 291-310. https://doi.org/10.1348/135910707X187245

Shamseer, L. (2016). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation (vol 350, g7647, 2015). *Bmj-British Medical Journal*, *354*. https://doi.org/10.1136/bmj.g7647

Sun, T., Lim, C. C. W., Rutherford, B. N., Johnson, B., Leung, J., Gartner, C., Hall, W. D., Connor, J. P., & Chan, G. C. K. (2022). Is smoking reduction and cessation associated with increased e-cigarette use? Findings from a nationally representative sample of adult smokers in Australia. *Addict Behav*, *127*, 107217. https://doi.org/10.1016/j.addbeh.2021.

Sweet, L., Brasky, T. M., Cooper, S., Doogan, N., Hinton, A., Klein, E. G., Nagaraja, H., Quisenberry, A., Xi, W., & Wewers, M. E. (2019). Quitting Behaviors Among Dual Cigarette and E-Cigarette Users and Cigarette Smokers Enrolled in the Tobacco User Adult Cohort. *Nicotine Tob Res*, *21*(3), 278-284. https://doi.org/10.1093/ntr/nty222

Wagoner, K. G., Reboussin, B. A., Ross, J. C., Denlinger-Apte, R., Spangler, J., & Sutfin, E. L. (2022). Exposure to e-cigarette health claims and association with e-cigarette use and risk perceptions : A cohort study of young adults. *Addict behav*, *132*,107359. https://doi.org/10.1016/ j.addbeh.2022. 107359

Ward, E., Belderson, P., Clark, A., Stirling, S., Clark, L., Pope, I., & Notley, C. (2024). How do people quit smoking using e-cigarettes? A mixed-methods exploration of participant smoking pathways following receiving an opportunistic e-cigarette-based smoking cessation intervention. *Addiction*, *119*(12), 2185-2196. https://doi.org/10.1111/add. 16633

Watson, N. L., Mull, K. E., & Bricker, J. B. (2021). The association between frequency of e-cigarette use and long-term smoking cessation outcomes among treatment-seeking smokers receiving a behavioral intervention. *Drug Alcohol Depend*, *218*, 108394. https://doi.org/10.1016/j.drugalcdep.2020.108394

Yong, H. H., Hitchman, S. C., Cummings, K. M., Borland, R., Gravely, S. M. L., McNeill, A., & Fong, G. T. (2017). Does the Regulatory Environment for E-Cigarettes Influence the Effectiveness of E-Cigarettes for Smoking Cessation?: Longitudinal Findings From the ITC Four Country Survey. *Nicotine Tob Res*, *19*(11), 1268-1276. https://doi.org/10.1093/ntr/ntx056

Zawertailo, L., Pavlov, D., Ivanova, A., Ng, G., Baliunas, D., & Selby, P. (2017). Concurrent E-Cigarette Use During Tobacco Dependence Treatment in Primary Care Settings: Association With Smoking Cessation at Three and Six Months. *Nicotine & Tobacco Research*, *19*(2), 183-189. https://doi.org/ 10.1093/ntr/ntw218

Zhuang, Y.-L., Cummins, S. E., Sun, J. Y., & Zhu, S.-H. (2016). Long-term e-cigarette use and smoking cessation: a longitudinal study with US population. *Tob Control*, *25* (l1), 90. https:// doi.org/10. 1136/tobaccocontrol-2016-053096