

Associations between electronic cigarette use and quitting behaviours among South African adult smokers

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ABSTRACT

Background: The South African Medicines Control Council classifies e-cigarettes as Schedule 3 substances and requires them to be dispensed only within pharmacies. e-Cigarettes are however ubiquitous and are marketed as cessation aids. We investigated the relationship between e-cigarette use and smoking cessation among South African adult smokers.

Methods: Data came from a 2018 web survey of South African adults aged ≥ 18 years ($n=18\ 208$). Cessation-related attitudes and behaviours were assessed. Using multivariable logistic regression, we measured the association between e-cigarette use and cessation behaviours among ever-established combustible tobacco smokers who tried to quit.

Findings: Among current combustible smokers, more e-cigarette ever versus never users believed e-cigarettes could assist smokers to completely quit (35.5% vs 20.4%) or cut down (51.7% vs 26.5%) (all $p<0.05$). Among ever-established smokers, the odds of sustained quitting at the 12-month mark were lower among those who used e-cigarettes once off/rarely (adjusted OR (AOR)=0.20, 95% CI=0.16–0.24), former e-cigarette users (AOR=0.30, 95% CI=0.24–0.38) and current e-cigarette users (AOR=0.23, 95% CI=0.18–0.29), compared with never e-cigarette users. Among ever-established smokers who had ever tried to quit, 53.6% relapsed into smoking after quitting for any length of time. The odds of relapsing among ever-established smokers who had made a quit attempt and had a quit intention were higher among those who used e-cigarettes once off/rarely (AOR=2.66; 95% CI=2.31–3.08), former e-cigarette users (AOR=1.41; 95% CI=1.18–1.69) and current e-cigarette users (AOR=1.85; 95% CI=1.55–2.22) than never e-cigarette users.

Conclusion: e-Cigarette use depressed long-term cessation. These findings can inform restrictions on unsubstantiated claims of e-cigarettes as cessation aids within South Africa.

INTRODUCTION

Like several other countries, South Africa is witnessing a rapid increase in popularity and use of newer products that are often marketed as ‘reduced harm’, including electronic cigarettes (e-cigarettes) and heated tobacco products.^{1–5} South Africa is a major gateway to Africa for marketing new products by multinational tobacco companies; the first IQOS flagship store in Africa was in South Africa.⁶ Furthermore, few other African countries have seen as remarkable growth in e-cigarette uptake as South Africa has.⁶ Since their debut in 2008, e-cigarette sales have increased dramatically in South Africa, and even more growth is projected in the coming years.⁶ During 2011–2016, volume sales for ‘smokeless tobacco and vapour products’ increased by 12.6%, from 3.7 to 4.2 tons, whereas volume sales for cigarettes declined by 12.3%, from 22.41 billion sticks to 19.66 billion sticks.⁶ A contributing factor to this increase in e-cigarette consumption may be the aggressive marketing of e-cigarettes as smoking cessation aids in South Africa, which may increase their appeal to smokers who have tried to quit unsuccessfully in the past, or those unable to use evidence-based interventions such as pharmacotherapy or cessation counselling because of challenges with affordability, accessibility or acceptability.⁷

Unlike in most other countries, e-cigarettes are legally designated as medicines in South Africa, rather than as tobacco products.⁸ The South African Medicines Control Council classifies e-cigarettes as Schedule 3 substances and requires them to be dispensed within a pharmacy.⁸ Retail outlets in South Africa typically sell e-cigarettes as ‘Stop smoking’ products and these devices are often displayed together with over-the-counter nicotine replacement therapy in pharmacies, implying they are also proven medication for cessation (supplemental figure 1). South Africa’s recently proposed tobacco control and prevention legislation (*Control of Tobacco Products and Electronic Delivery Systems Bill*) would however require e-cigarettes to be regulated same as other tobacco products if passed as law,⁹ a move that has been strongly opposed by e-cigarette manufacturers and retailers.¹⁰

A review of the evidence to date from other countries on the associations between e-cigarette use and quitting is mixed^{11–17}; direct comparisons of some of these studies may be challenging because of differences in how the primary outcome of ‘successful quitting’ is defined. The US Preventive Services Task Force concluded that there is insufficient evidence to evaluate the effectiveness of e-cigarettes in helping smokers quit.¹⁸ The US National Academies of Science, Engineering, and Medicine has likewise called for more research on the long-term impact of e-cigarettes on smoking cessation.¹⁹ Within the South African context, the evolving regulatory environment for e-cigarettes underscores the need for epidemiological evidence to evaluate the effectiveness of e-cigarettes as smoking cessation aids. A 2016 cross-sectional survey that examined intentions to quit cigarette smoking among 161 e-cigarette users in the Gauteng Province of South Africa found that e-cigarette use was unrelated to quit intentions.²⁰ No previous study has however empirically evaluated the effectiveness of e-cigarettes in helping South African smokers achieve sustained smoking cessation. The objective of this study therefore was to determine whether the likelihood of quitting smoking among ever-established smokers who had attempted to quit was different among those who used e-cigarettes compared with those who did not. The current state of policy and clinical equipoise in relation to e-cigarettes in South Africa makes this study highly timely and relevant in the policy and clinical practice realm. South Africa is a leader in tobacco control in the region and tobacco control approaches in the country have potential to set an example for other countries in the region. The strong presence of multinational tobacco companies in South Africa also makes e-cigarette regulatory issues in South Africa matters of regional concern for comprehensive tobacco

control in sub-Saharan Africa, and by implication in low-income and middle-income countries (LMICs) in general.

METHODS

Data sources

This was a cross-sectional survey of South African adults who participated in the 2018 Health 24 survey (n=18 208). Participants were recruited online and from the national consumer database for News24—South Africa’s largest digital publisher. Volunteers who consented to participate were eligible for a raffle draw prize of R5000 for completing the survey. This study, conducted with secondary data, was approved by the University of Pretoria’s Faculty of Health Sciences’ Ethics Review (no. 39/2019).

Measures

Tobacco use behaviour

Combustible tobacco products assessed were cigarettes, cigars, pipes or roll-your-own tobacco (RYO). For each of these specified combustible tobacco product types, current users were defined as individuals who self-identified as being a ‘regular’ user of at any ‘smoke or smokeless’ product (including vape products) in general and who also reported current use of the specified product type at any frequency at the time of the survey. Similar definitions were applied for defining current use of e-cigarettes. Ever-established combustible tobacco product users were individuals who had smoked a combustible tobacco product beyond experimentation, including former smokers, current ‘social’ smokers and current ‘regular’ smokers (n=9422). Current any combustible tobacco smokers were individuals who reported current use of at least one combustible tobacco product at the time of the survey (n=5657). Henceforth, the term ‘smoker’ is used in this paper to describe combustible tobacco smokers (ie, not just cigarettes). Attitudes towards e-cigarettes were also assessed in relation to smoking cessation and other markers of social acceptability and harm perception among all participants.

The survey further asked for current age (measured as a continuous variable, range 18–100) and age at tobacco initiation (measured as a categorical variable in years; ‘<6’; ‘6–13’; ‘14–18’; ‘19–24’; ‘25–29’; ‘30–39’ and ‘40 years or older’). We conservatively recoded this latter variable, using discrete values of ‘6’ and ‘40’ for the extreme cut-offs, and the interval midpoints for the remaining categories (eg, ‘9.5’ as the midpoint for the interval ‘6–13’). The difference between current age and the transformed indicator for age at initiation yielded a rough measure for duration of tobacco use.

Cessation AIDs

Respondents were asked of their lifetime usage of nicotine replacement therapy (NRT; nicotine gum or spray), prescription medication (bupropion or varenicline) and cessation counselling programmes. Any pharmacotherapy was defined as either NRT or prescription medication. Together with data on lifetime e-cigarette use, we created 10 mutually exclusive intervention groups for the purpose of descriptive analyses: (1) e-cigarettes only (regardless of whether used for cessation); (2) cessation counselling only; (3) NRT only; (4) prescription medication only; (5) NRT+prescription medication only; (6) cessation counseling+any pharmacotherapy only;

(7) cessation counseling+e-cigarettes only; (8) any pharmacotherapy+e-cigarettes only; (9) any pharmacotherapy+cessation counseling+e-cigarettes; (10) no intervention.

For multivariable analyses, the non-exposed group (e-cigarette nonusers) was defined as ever-established smokers who had tried to quit and reported never using e-cigarettes. The exposed individuals (e-cigarette users) were defined as persons meeting all of the following criteria: (1) ever-established smokers who had tried to quit, (2) reported any frequency of e-cigarette use and (3) perceived that e-cigarettes ‘Can assist people to stop smoking cigarettes completely’, or ‘Can help people cut down on their cigarette smoking’. Hence, e-cigarette use was only deemed a relevant exposure if accompanied with endorsement of its role in smoking cessation. Of ever-established smokers who had made a quit attempt and ever used e-cigarettes, we excluded from our multivariable analysis 1739 who did not perceive e-cigarettes could help with smoking cessation.

Smoking cessation

Participants who answered, ‘Not anymore, I have successfully quit’ when asked their smoking status were asked this follow-up question, ‘How long ago did you quit smoking?’ Response options were ‘Less than a month’; ‘1–6 months’; ‘6–12 months’; ‘1–3 years’ or ‘3+ years’. We assumed a time-varying effect of e-cigarette use on smoking cessation and analysed the following slightly overlapping time periods separately: <1 month, 1–6 months and 6–12 months. For brevity, we subsequently refer to these 3 time points as the 1-month, 6-month, and 12-month marks respectively, aligned with the corresponding upper limits of the intervals. The time periods beyond 1 year were not assessed separately within multivariable analyses because of the potential for recall bias from the long recall window, as well as the possibility that smoking cessation may have occurred before e-cigarette use uptake. For purpose of descriptive analysis, we further created aggregate indicators for quitting lasting ≥ 6 months (ie, sustained quitting, ‘6–12 months’, ‘1–3 years’ or ‘3+ years’), as well as ≥ 1 day (ie, any quit attempt, ‘Less than a month’; ‘1–6 months’; ‘6–12 months’; ‘1–3 years’ or ‘3+ years’). Never smokers, never established smokers who only experimented one or few times, and ever-established smokers who had never made a quit attempt were all excluded from the analyses.

The question of whether e-cigarettes help with smoking cessation implicitly assumes that cigarette smoking preceded e-cigarettes use, and that subsequent e-cigarette initiation was driven by a desire to quit or reduce smoking. To address the issue of temporality in our study, we conducted additional sensitivity analyses among ever-established smokers whose duration of smoking was >10 years, a period that preceded the presence of e-cigarettes on the South African market.

Among all current combustible smokers, quit intention was defined as interest in quitting in the future, regardless of past quit attempts or how far in the future they planned to quit; those who answered ‘I’ve never tried to quit and don’t want to’ or ‘I’ve tried before and failed, so why try again?’ were classified as having no intention to quit.

Smoking relapse

The secondary outcome was smoking relapse among ever-established smokers who had ever made a quit attempt (n=9422). Respondents were classified as having relapsed if they resumed smoking after having stopped for any length of time (≥ 1 day); operationally, this was defined as any one of the following two responses among ever-established smokers who had tried to

quit ‘I have successfully quit before but started smoking again’ or ‘I have tried to quit before and failed’.

Sociodemographic and other tobacco use characteristics

Other variables assessed included age, gender, race/ethnicity, monthly personal income and self-reported health status. Three separate sets of questions were asked to assess reasons for different aspects of smoking behaviour with the aim of comparing these indicators between e-cigarette ever versus never users: reasons for current smoking (among current combustible smokers); reasons for having never attempted to quit smoking (among current combustible smokers who never tried to quit); and reasons for relapsing (among current combustible smokers who ever tried to quit). Skip patterns were used in the survey; only individuals eligible for a given question answered it.

Analyses

Calibration weights were developed using raking (iterative proportional fitting) with the South African census estimate serving as the reference population. Descriptive analyses were performed using weighted percentages and bootstrapped 95% CIs; prevalence ratios (PRs) were calculated using Poisson regression models to compare prevalence estimates. Logistic regression analyses were used to measure dose–response in the relationship between e-cigarette use and cessation-related endpoints, controlling for age, race/ethnicity, gender, income, self-rated health status, use of NRT, prescription medication, or cessation counselling, and age at tobacco initiation as a marker for extent of nicotine dependence. We considered several threats to internal validity during multivariable analyses to mitigate bias. We restricted the study population to ever-established smokers who had ever tried to quit in the past (for the outcome successful quit attempt), or those who tried to quit in the past and also reported an intention to quit at the time of the survey (for the outcome relapse). Statistical significance was assessed at $p < 0.05$ and all tests were two-sided. All statistical analyses were performed with R V. 3.5.1.

RESULTS

e-Cigarette use behaviours and attitudes

Among ever-established smokers, the majority were blacks (58.5%) and men (58.8%). Overall, 37.0% of ever-established smokers had ever used an e-cigarette, while 36.1% of current combustible smokers currently used an e-cigarette. Subgroup differences in use are shown in table 1. Regarding lifetime usage of the various interventions assessed regardless of the intention behind use (e-cigarettes, NRT, prescription medication and cessation counselling), the composition (row percentages, adding up to 100%) of ever-established smokers who had ever tried to quit was as follows: used no intervention at all (44.4%); e-cigarettes only (20.0%); cessation counselling only (2.0%); NRT only (7.7%); prescription medication only (3.1%); NRT+prescription medication only (3.7%); any pharmacotherapy (ie, prescription medication or NRT)+e-cigarettes only (12.2%); cessation counseling+any pharmacotherapy only (2.2%); cessation counseling+e-cigarettes only (1.2%); any pharmacotherapy+cessation counseling+e-cigarettes (3.5%). Among current combustible smokers, a significantly greater proportion of ever e-cigarette users versus never e-cigarette users endorsed positive beliefs about e-cigarettes’ role in cessation, including that e-cigarettes can assist people to completely quit (35.5% vs 20.4%) or cut down on cigarettes smoked (51.7% vs 26.5%; figure 1). The percentage of current combustible smokers who held the perception that e-cigarettes are too

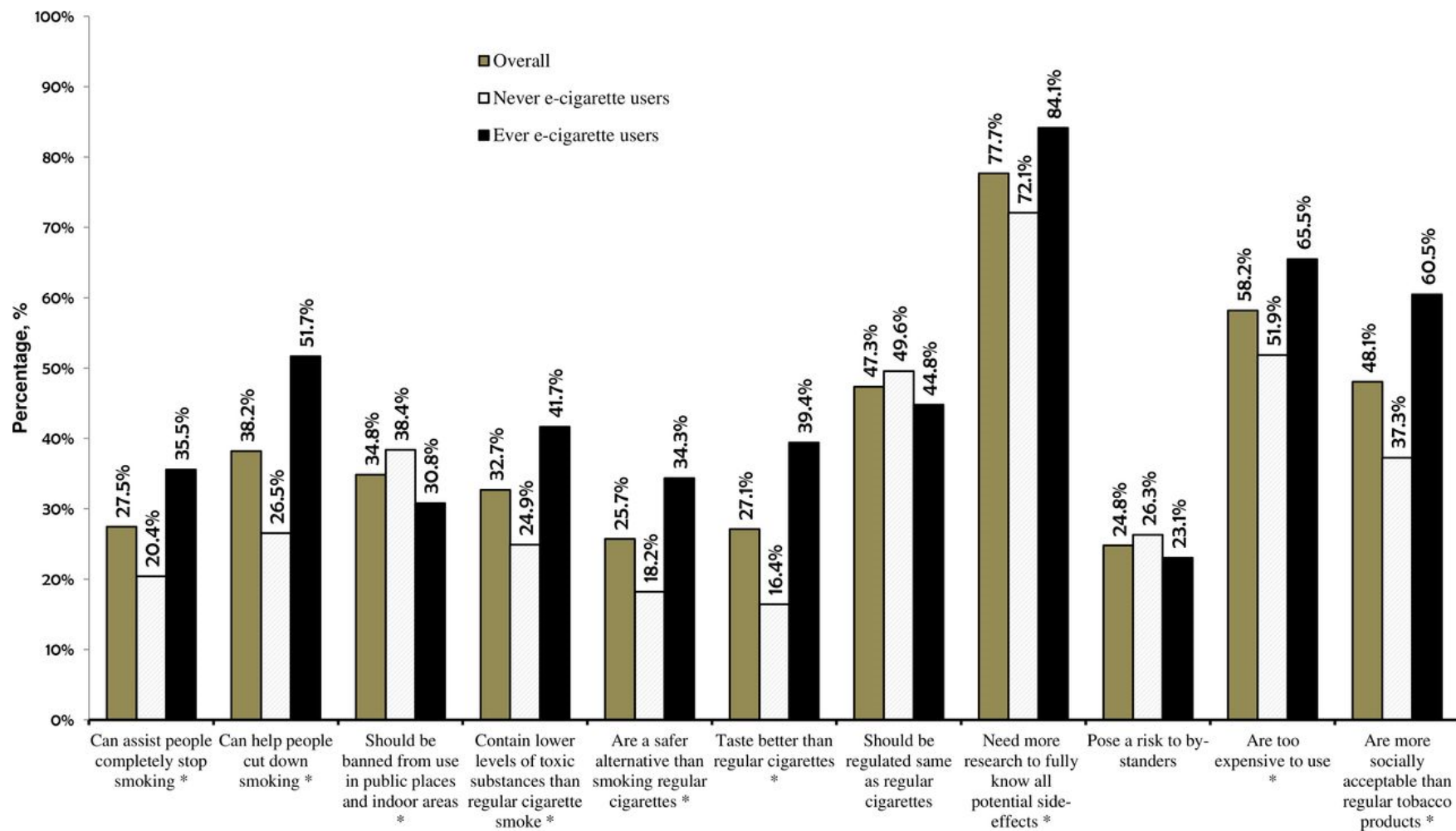


Figure 1. e-Cigarette-related perceptions among current combustible tobacco smokers, overall and by e-cigarette use status, South Africa, 2018 (n=5657). Asterisk (*) indicates statistically significant differences between e-cigarette ever versus never users. All percentages were weighted.

Table 1. e-Cigarette use and quitting behaviours among South African adult combustible tobacco smokers*, by demographic characteristics, 2018

Characteristics	e-Cigarette use behaviours among combustible tobacco smokers		Cessation behaviours among combustible tobacco smokers		
	% of ever-established combustible smokers* that have ever used an e-cigarette†	% of current combustible smokers‡ that reported current use of an e-cigarette§	Sustained quitting¶ among ever-established smokers who ever tried to quit	Recent quitting** among ever-established smokers who ever tried to quit	Relapse among ever established smokers who ever tried to quit ††
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Overall	37.0 (35.1–39.0)	36.1 (33.6–38.7)	34.3 (31.7–38.1)	16.7 (14.9–18.4)	53.6 (51.0–55.7)
Race/ethnicity					
Black African	29.8 (26.5–32.9)	28.0 (24.3–31.8)	29.3 (25.6–34.2)	17.4 (14.4–20.5)	57.4 (53.6–61.4)
Coloured	42.9 (39.0–46.4)	39.1 (35.1–43.4)	31.3 (27.6–35.0)	14.1 (10.8–17.5)	58.5 (53.5–61.9)
Indian/Asian	52.8 (47.8–58.4)	47.9 (42.2–52.1)	33.2 (26.4–40.9)	17.0 (13.7–20.4)	54.5 (49.1–60.5)
White	47.8 (46.3–49.4)	49.0 (47.5–50.6)	47.7 (39.7–55.0)	15.9 (14.8–17.0)	40.0 (34.3–47.8)
Other	47.6 (40.7–54.3)	51.4 (42.4–58.1)	44.0 (42.4–45.7)	17.8 (13.0–22.6)	45.7 (44.3–47.3)
Gender					
Women	40.5 (37.6–42.8)	36.2 (33.1–39.6)	27.1 (24.3–30.0)	19.8 (17.0–22.5)	58.8 (55.2–61.5)
Men	34.4 (32.3–36.6)	36.1 (33.4–39.1)	39.1 (36.2–43.0)	14.6 (12.4–16.8)	50.1 (45.9–53.3)
Age, years					
18–25	51.5 (46.1–58.8)	46.1 (38.8–54.1)	14.1 (7.6–20.8)	21.8 (15.6–28.1)	68.7 (62.8–75.4)
26–35	44.9 (42.8–46.7)	39.1 (36.8–41.8)	22.0 (20.5–23.9)	20.6 (18.8–22.4)	62.8 (60.8–64.8)
36–45	35.2 (32.8–37.6)	33.1 (29.0–36.3)	31.8 (28.9–35.9)	16.4 (13.9–18.8)	55.9 (53.0–59.4)
46–55	27.7 (24.3–31.1)	30.4 (24.9–37.0)	36.7 (32.0–41.4)	14.4 (10.3–18.5)	52.5 (47.2–58.1)
56–65	21.0 (15.6–27.5)	19.2 (13.1–28.6)	55.4 (45.6–64.9)	12.7 (4.9–20.4)	39.5 (30.0–48.7)
66+	14.7 (7.0–25.6)	23.6 (10.8–41.7)	82.6 (69.7–91.8)	4.6 (1.8–7.3)	10.1 (5.7–15.3)
Income, ZAR††					
None	35.2 (27.2–42.8)	34.3 (22.5–46.5)	33.2 (21.4–45.9)	26.7 (15.0–38.4)	53.4 (41.8–67.3)

≤10-000	39.1 (31.4–45.7)	31.2 (26.3–37.6)	27.9 (20.0–35.7)	13.6 (9.6–17.6)	60.0 (51.5–68.8)
≤20-000	36.3 (32.7–40.5)	37.3 (32.6–41.5)	30.0 (26.3–35.7)	14.7 (12.2–17.2)	56.2 (52.1–61.1)
≤30-000	37.1 (32.8–41.4)	36.8 (32.6–42.3)	38.1 (33.4–41.9)	16.2 (13.2–19.3)	50.7 (47.0–55.3)
≤50-000	37.3 (33.8–40.7)	40.8 (35.8–46.2)	39.4 (35.7–45.1)	17.2 (13.6–20.7)	48.8 (45.1–53.2)
>50-000	35.9 (32.0–40.1)	33.7 (30.4–37.7)	34.1 (29.7–37.8)	14.9 (12.4–17.3)	55.8 (52.0–59.4)
Undisclosed	40.7 (33.5–47.8)	47.1 (36.8–55.6)	46.1 (37.7–53.9)	19.7 (14.7–24.8)	40.4 (34.9–45.6)
Self-rated health status					
Very good	24.4 (20.7–29.2)	32.5 (26.2–37.6)	67.8 (60.2–74.4)	18.1 (13.9–22.3)	21.1 (17.5–24.9)
Good	38.7 (36.3–41.1)	42.6 (39.2–46.5)	40.4 (36.7–44.0)	21.1 (18.4–23.9)	45.7 (42.5–48.9)
Moderate	39.3 (36.2–42.7)	34.8 (31.3–39.3)	20.3 (17.0–23.2)	14.7 (11.4–18.1)	68.2 (64.7–71.8)
Bad	39.0 (30.9–46.0)	29.5 (22.5–36.8)	9.3 (6.6–14.1)	4.6 (1.2–7.9)	84.2 (78.6–89.9)
Very bad	39.5 (23.9–58.1)	20.1 (13.2–34.7)	35.9 (11.7–58.2)	4.8 (1.2–8.4)	60.6 (43.0–83.2)

Combustible products were cigarettes, pipes, cigars and RYO. All percentages were weighted.

*Ever-established smokers (n=11 381) were defined as individuals who reported having used at least one combustible tobacco product (cigarettes, pipes, cigars and roll-your-own tobacco) beyond experimentation. This included both former and any current smokers (ie, current 'social' smokers or current regular smokers).

†Ever e-cigarette use was defined as having used an e-cigarette at least once in lifetime.

‡Current combustible tobacco product smokers (n=5657) were defined as individuals who self-identified as being a regular user of any 'smoke or smokeless' product in general *and* reported using at least one combustible tobacco product at the time of the survey at any frequency (cigarettes, pipes, cigars and roll-your-own tobacco).

§Current e-cigarette use was defined as those who self-identified as being a regular user of any 'smoke or smokeless' product (including vape products) in general *and* reported using e-cigarettes at the time of the survey at any frequency.

¶Sustained quitting was assessed among ever-established smokers who had tried to quit at least once in lifetime and was defined as having stopped smoking for ≥6 months. Never smokers, never-established smokers who only experimented one or few times and ever-established smokers who had never made a quit attempt were all excluded from the analyses.

**Recent quitting was defined as having stopped smoking in the past year. Operationally, this was defined by responses of 'Less than a month'; '1–6 months'; '6–12 months' to the question 'How long ago did you quit smoking?'

††Each income category not inclusive of previous grouping (ie, mutually exclusive).

‡‡Smoking relapse was assessed among ever-established smokers who had tried to quit at least once in lifetime and was defined as having resumed smoking after having quit for any length of time (ie, ≥1 day).

RYO, roll-your-own tobacco; ZAR, South African Rand;

expensive to use was however higher among e-cigarette ever users (65.5%) compared with e-cigarette never users (51.9%; $p < 0.05$).

Associations between e-cigarette use and quitting behaviours

Of ever-established combustible smokers who had tried to quit, 34.3% reported sustained quitting lasting ≥ 6 months (table 1), and 16.7% reported recent quitting within the past year. Analyses of length of self-reported cessation at the 1-month, 6-month and 12-month periods indicated that e-cigarettes were associated with higher likelihood of stopping smoking at the 1-month and 6-month marks, but with lower likelihood of smoking cessation at the 12-month mark. Compared with those ever-established smokers who had never used an e-cigarette, the odds of smoking cessation at the 1-month mark were higher among former e-cigarette users (AOR=1.74, 95% CI 1.35 to 2.24) and current users (AOR=1.50, 95% CI 1.15 to 1.95). There was, however, no significant difference between never e-cigarette users and those reporting e-cigarette use ‘once off/rarely’ at the 1-month mark. At the 6-month mark, higher odds were also seen among all groups of e-cigarette users compared to never users: ‘use once off/rarely’ (AOR=1.44, 95% CI 1.10–1.89), former users (AOR=2.12, 95% CI=1.56–2.88) and current users (AOR=1.74, 95% CI=1.26–2.41). At the 12-month mark, in contrast, an inverse relation was seen with cessation for all groups of e-cigarette users compared to never users: ‘use once off/rarely’ (AOR=0.20, 95% CI 0.16–0.24), former users (AOR=0.30, 95% CI=0.24–0.38) and current users (AOR=0.23, 95% CI=0.18–0.29). Consistent results were seen when restricting analyses to those who started smoking > 10 years ago (table 2).

Among ever-established combustible smokers who had ever tried to quit, 53.6% relapsed into smoking after having quit for any length of time. Across mutually-exclusive groups of ever-established combustible smokers who tried to quit, categorized by lifetime usage of different interventions (figure 2), e-cigarette-only users reported rates of relapse (65.1%) that were higher than those seen for counseling-only users (38.6%; PR=0.59; 95% CI=0.38–0.81); NRT-only users (54.8%; PR=0.84; 95% CI=0.72–0.94); NRT+prescription medication-only users (45.3%; PR=0.69; 95% CI=0.50–0.89), or those not using any intervention at all (43.8%; PR=0.66; 95% CI=0.59–0.75). The odds of relapsing among ever-established combustible smokers who had made a quit attempt and had a quit intention were higher among those who used e-cigarettes once off/rarely (AOR=2.66; 95% CI=2.31–3.08); former e-cigarette users (AOR=1.41; 95% CI=1.18–1.69); and current e-cigarette users (AOR=1.85; 95% CI=1.55–2.22) than never e-cigarette users.

Reasons for smoking aligned with reasons for relapse among current combustible smokers who had ever tried to quit but relapsed (table 3; supplemental figure 2). Of current combustible smokers who ever tried to quit but relapsed ($n=4309$), the following reported reasons for currently smoking were significantly higher among e-cigarette ever versus never users: smoking for enjoyment (59.8% vs 44.0%), for stress relief (66.7% vs 60.1%) and because the respondent’s partner smoked (11.9% vs 7.8%; e-cigarette ever vs never users, respectively) (all $p < 0.05$). Among those who had relapsed, e-cigarette ever users were also more likely than e-cigarette never users to report the following reasons for relapsing: enjoyment of smoking (41.8% vs 27.3%, PR=1.53; 95% CI=1.30–1.80), having friends that smoked (48.3% vs 42.4%; PR=1.14; 95% CI=1.01–1.30) or perceiving smoking to be safe (1.7% vs 0.8%; PR=2.49; 95% CI=1.02–5.51). Similarly, e-cigarette ever users were more likely than e-cigarette never users to never have attempted to quit because of perceiving smoking as safe (table 3).

Table 2. Adjusted ORs* for the associations between e-cigarette use status† and quitting‡ as well as relapse§ among ever-established smokers who tried to quit¶, South Africa, 2018

Outcome	All eligible participants (ever-established combustible tobacco smokers who ever tried to quit) (n=7682)			Eligible participants with smoking duration >10 years (n=6420)		
	e-Cigarette exposure status	Adjusted odds ratios [‡]	P value	e-Cigarette exposure status	Adjusted odds ratios	P value
Stopped smoking <1 month ago	Never e-cigarette use (n=4856)	1.00 (Referent)		Never e-cigarette use (n=4199)	1.00 (Referent)	
	Use once off/rarely (n=1377)	0.97 (0.77–1.23)	0.798	Use once off/rarely (n=1078)	1.08 (0.83–1.39)	0.582
	Former user (n=729)	1.74 (1.35–2.24)	<0.001	Former user (n=579)	1.71 (1.29–2.28)	<0.001
	Current user (n=720)	1.50 (1.15–1.95)	0.003	Current user (n=564)	1.57 (1.17–2.11)	0.003
Stopped smoking between 1-6 months ago	Never e-cigarette use (n=4856)	1.00 (Referent)		Never e-cigarette use (n=4,199)	1.00 (Referent)	
	Use once off/rarely (n=1377)	1.44 (1.10–1.89)	0.008	Use once off/rarely (n=1078)	1.68 (1.23–2.29)	0.001
	Former user (n=729)	2.12 (1.56–2.88)	<0.001	Former user (n=579)	2.25 (1.58–3.21)	<0.001
	Current user (n=720)	1.74 (1.26–2.41)	0.001	Current user (n=564)	1.76 (1.20–2.59)	0.004
Stopped smoking between 6-12 months ago	Never e-cigarette use (n=4856)	1.00 (Referent)		Never e-cigarette use (n=4199)	1.00 (Referent)	
	Use once off/rarely (n=1377)	0.20 (0.16–0.24)	<0.001	Use once off/rarely (n=1078)	0.19 (0.16–0.24)	<0.001
	Former user (n=729)	0.30 (0.24–0.38)	<0.001	Former user (n=579)	0.27 (0.21–0.35)	<0.001
	Current user (n=720)	0.23 (0.18–0.29)	<0.001	Current user (n=564)	0.22 (0.17–0.29)	<0.001
Relapsed into smoking after stopping for any length of time	Never e-cigarette use (n=4856)	1.00 (Referent)		Never e-cigarette use (n=4199)	1.00 (Referent)	
	Use once off/rarely (n=1377)	2.66 (2.31–3.08)	<0.001	Use once off/rarely (n=1078)	2.91 (2.48–3.42)	<0.001
	Former user (n=729)	1.41 (1.18–1.69)	<0.001	Former user (n=579)	1.65 (1.35–2.01)	<0.001
	Current user (n=720)	1.85 (1.55–2.22)	<0.001	Current user (n=564)	2.02 (1.66–2.48)	<0.001

'Smoker(s)' is used as an abbreviated form of 'any combustible tobacco product smoker(s)', that is, cigarettes, pipes, cigars or roll-your-own tobacco.

*Adjusted for age, race/ethnicity, gender, income, self-rated health status, use of NRT, prescription medication, or cessation counselling and age at tobacco initiation. The first three outcomes related to quitting were assessed among ever established combustible tobacco smokers who ever tried to quit. The last outcome (relapse) was assessed among ever-established combustible tobacco smokers who ever tried to quit *and* who reported a quit intention at the time of the survey. Logistic regression analyses were unweighted.

†The exposed individuals (e-cigarette users) were defined as ever-established smokers who had tried to quit, *and* reported e-cigarette use at the specified threshold, *and* perceived e-cigarettes could help with either quitting smoking completely or cutting down. The non-exposed group (e-cigarette non-users) was defined as ever-established smokers who had tried to quit and reported never using e-cigarettes.

‡We assumed a time-varying effect of e-cigarette use on smoking cessation and analysed the following slightly overlapping time periods separately: <1 month, 1–6 months and 6–12 months.

§Smoking relapse was assessed among ever-established smokers who had tried to quit at least once in lifetime and was defined as having resumed smoking after having quit for any length of time (ie, ≥ 1 day). Analyses were restricted to those with a quit intention.

¶Ever-established tobacco smoking was defined as having used at least one combustible tobacco product (cigarettes, pipes, cigars, and roll-your-own tobacco) beyond experimentation. This included both former and any current smokers (ie, either current 'social' smokers or current regular smokers).

NRT, nicotine replacement therapy.

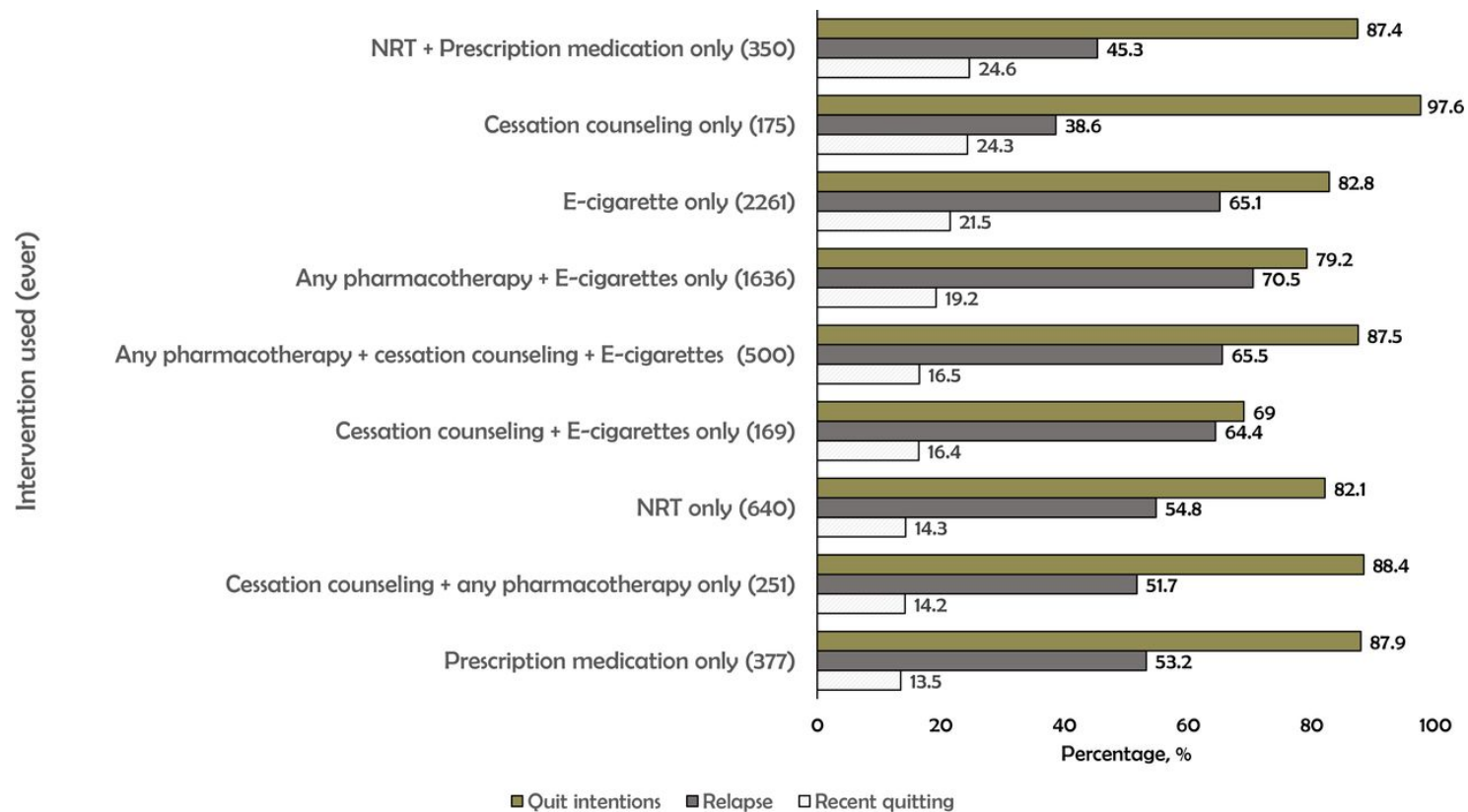


Figure 2. Percentage of ever-established combustible tobacco smokers^a who tried to quit smoking that reported sustained quitting^b, recent quitting^c, and relapse^d, by type of intervention ever used regardless of intentions behind use^e, South Africa, 2018 (n=9422). NRT, nicotine replacement therapy. Combustible tobacco products included cigarettes, pipes, cigars or roll-your-own tobacco. All percentages were weighted. ^a Ever-established tobacco smoking was defined as having used at least one combustible tobacco product (cigarettes, pipes, cigars, and roll-your-own tobacco) beyond experimentation. This included both former and any current smokers (ie, either current ‘social’ smokers or current regular smokers). ^b Sustained quitting was assessed among ever-established smokers who had tried to quit at least once in lifetime and was defined as having stopped smoking for ≥ 6 months. Never smokers; never established smokers who only experimented one or few times, and ever-established smokers who had never made a quit attempt were all excluded from the analyses. ^c Recent quitting was defined as having stopped smoking in the past year. Operationally, this was defined by responses of ‘Less than a month’; ‘1–6 months’; ‘6–12 months’ to the question ‘How long ago did you quit smoking?’ ^d Smoking relapse was assessed among ever-established smokers who had tried to quit at least once in lifetime and was defined as having resumed smoking after having quit for any length of time (ie, ≥ 1 day). ^e Unlike within the multivariable analysis, all e-cigarette users were analysed within this figure, regardless of whether they were using (or had used) e-cigarettes for smoking cessation.

Table 3. Smoking cessation behaviours and attitudes among South African current combustible tobacco smokers, by e-cigarette use status, 2018

Indicator	Reported reason	All current smokers who ever tried to quit smoking (n=4309)	Current smokers who never used e-cigarettes and have ever tried to quit smoking* (n=1732)	Current smokers who ever used e-cigarettes and have ever tried to quit smoking† (n=2577)	Current smokers who currently use e-cigarettes and have ever tried to quit smoking‡ (n=1928)	Prevalence ratio (Ever/Never e-cigarette users)	Prevalence ratio (Current/Never e-cigarette users)
		% (95% CI)	% (95% CI)	% (95%CI)	% (95% CI)	PR (95% CI)	PR (95% CI)
Reasons for relapsing (among current combustible tobacco smokers who have ever tried to quit; n=4309)	Enjoy smoking	34.1 (32.1 to 36.2)	27.3 (23.9 to 31.2)	41.8 (39.3 to 44.7)	41.7 (37.9 to 44.7)	1.53 (1.30 to 1.80)*	1.53 (1.29 to 1.78)*
	Quitting smoking is hard	56.9 (54.4 to 59.7)	60.2 (55.1 to 64.4)	53.1 (49.6 to 56.3)	51.2 (48.2 to 54.8)	0.88 (0.79 to 0.98)*	0.85 (0.77 to 0.94)*
	Smoking is safe	1.2 (0.8 to 1.6)	0.8 (0.4 to 1.3)	1.7 (1.0 to 2.5)	1.8 (0.9 to 2.7)	2.49 (1.02 to 5.51)*	2.62 (0.99 to 5.70)
	Low self-efficacy to quit	13.8 (11.9 to 15.8)	12.7 (10.0 to 15.4)	15.0 (11.9 to 18.7)	13.7 (10.1 to 17.5)	1.19 (0.87 to 1.59)	1.09 (0.75 to 1.53)
	Peer influence	45.2 (42.7 to 48.8)	42.4 (37.9 to 47.6)	48.3 (45.2 to 51.8)	49.5 (45.7 to 52.4)	1.14 (1.01 to 1.30)*	1.17 (1.03 to 1.34)*
Reasons for never attempting quitting (among current combustible tobacco smokers who have never tried to quit; n=1348)	Enjoy smoking	49.2 (44.0 to 55.5)	44.0 (37.4 to 51)	55.4 (48.3 to 64.9)	56.4 (50.5 to 64.9)	1.27 (0.99 to 1.59)	1.29 (1.01 to 1.59)*
	Quitting smoking is hard	57.1 (52.4 to 62.5)	63.2 (54.8 to 68.9)	49.6 (42.5 to 58.9)	46.7 (39.7 to 55.2)	0.79 (0.63 to 0.95)*	0.74 (0.58 to 0.93)*
	Smoking is safe	4.4 (2.8 to 6.8)	2.5 (1.4 to 3.7)	6.6 (2.9 to 11.2)	7.6 (3.7 to 12.3)	2.73 (1.11 to 5.36)*	3.14 (1.30 to 6.26)*

Asterisks (*) Indicate statistically significant results at p<0.05. All percentages were weighted.

*e-Cigarette never users defined as smokers who have never used e-cigarettes in their lifetime, not even once or twice.

†e-Cigarette ever users defined as smokers who have used e-cigarettes at least once in their lifetime.

‡e-Cigarette current users defined as persons who indicated that they used at least one 'smoke or smokeless' tobacco product (including vape products) regularly and also indicated using e-cigarettes at any frequency at the time of the survey.

PR, prevalence ratio.

DISCUSSION

We found that while e-cigarettes were associated with higher likelihood of smoking cessation short term, they lowered the likelihood of long-term quitting compared with never using e-cigarettes. e-Cigarette users were more likely to cite smoking-related perceptions of safety, enjoyment and conviviality as reasons for continuing to smoke, relapsing back into smoking or having never made a quit attempt. By providing a mechanism for continued self-administration of nicotine which perpetuates physical or psychological dependence,^{21, 22} the likelihood of smoking relapse may be elevated when e-cigarette users can no longer sustain the vaping habit because of higher costs of vaping or other perceived limitations of vaping. Indeed, our results showed that the only negative opinion expressed by a greater proportion of ever e-cigarette users relative to never users (65.5% vs 51.9%, respectively) was that e-cigarettes were too expensive to use, suggesting that the cumulative costs (devices, vaping liquids and other inputs) associated with vaping may be much higher, contrary to industry claims,²³ possibly contributing to switching back to cheaper-priced cigarettes to access nicotine. e-Cigarettes may also be associated with a greater operational burden (eg, constant charging of devices, especially in LMICs with interrupted power supply, or transporting a paraphernalia of gadgets) which may become perceived as a nuisance that limits long-term use. This has implications for worsening inequity in cessation outcomes as it means those individuals or nations/regions that can afford e-cigarette habit might have better success at sustaining cigarette smoking abstinence than those who cannot afford them or have no constant power supply to charge. The higher relapse rates among e-cigarette users could also arise from dual use behaviour, especially if e-cigarettes positively enhance or reinforces certain aspects of the cigarette smoking sensory experience physically, physiologically or psychologically in a manner that increases dependence for both products. Perceptions and behaviors towards e-cigarettes and cessation have been shown to be wide ranging.^{24, 25} e-Cigarettes could also mediate smoking relapse through attitudinal changes (eg, altered harm perception and social norms) and intensified social cues (increased exposure to smoking friends or environments that may trigger relapse).²⁶⁻²⁹ Previous research has documented that e-cigarette-related social norms and perceptions could have a cross-over effect to regular tobacco products, including cigarettes.^{26, 27}

Several factors may explain the disparate findings in our study versus those reported elsewhere regarding the effectiveness of e-cigarettes as smoking cessation aids.^{12-17, 30} Some of these studies assessed cessation aids used in the most recent quit attempt only,³⁰ without considering previous lifetime usage; this assumes a complete washout of the effect of previously used interventions. Past users of NRT, for example, may be systematically more health conscious and more likely to make a quit attempt,³¹ confounding becomes an issue if the distribution of ever users of NRT varies between e-cigarettes users and non-users. It is also possible that differences in socioeconomic factors, smoking topography, coupled with political and historical differences among the various smoker populations may be contributory as well. While randomised controlled trials are the gold standard in terms of internal validity, their external validity (generalisability) to other populations, especially for behavioural outcomes (as opposed to biologic relationships), is limited because randomised trials are often simple, small, specific and short term.³² Cross-country differences in tobacco use behaviours and differences in the stages of the smoking epidemic necessitates real-world evidence within different settings.³³ This is a fundamental principle in the scientific validation process that is alluded to in two of Hills criteria for causality: coherence (findings have been replicated using different study designs and endpoints) and consistency (findings have been replicated from different settings or populations).³⁴ It will be important for meta-analyses of the effect of e-

cigarettes on smoking cessation to be inclusive of data from the African region as well, especially as this region is experiencing one of the fastest rates of increase in tobacco consumption across the globe.^{35,36}

Consistent with previous research,³⁷ use of counselling only was associated with reduced relapse; utilisation of counselling was however low. The higher effectiveness of cessation counselling among the South African smoker population could be attributable to the relatively low smoking intensity among the South African smoker population (9.33 cigarettes per day), which falls below the threshold for heavy smokers (>10 cigarettes per day) among whom pharmacotherapy is mostly indicated.³⁸ Only 40.4% of the smoker population in our study reported 'very good' or 'good' health status with close to one in five reporting 'bad' or 'very bad' health. Smokers who are possibly experiencing polypharmacy from treatment of existing comorbidities may be less adherent with concomitant medication for smoking cessation, especially if perceived as relatively less important than other ongoing treatments. Irregular, incomplete or discontinued administration of cessation medication may be compounded by the high cost of over-the-counter NRT, which are not included in the list of essential medicines for South Africa.^{39, 40} It is also possible that attempting to quit cold turkey or with cessation counselling only may involve greater belief in 'willpower' than might be seen with pharmacotherapy where smokers may almost expect a 'medical cure' for their smoking behaviour.⁴¹

Demographic differences noted in sustained quitting mirror previously documented variations in quit attempts among South African smokers.⁴² While tobacco-related morbidity and mortality disproportionately affects vulnerable populations and those of low socioeconomic status in South Africa, including black Africans, and those of low income,⁴³ we found higher rates of sustained quitting among whites, men and those with high income. Reducing the inequalities in smoking is therefore a public health priority. Behavioural interventions, including motivational interviewing, can help smokers, including those living with chronic conditions.⁴⁴ Our study also underscores the need for health professionals to ensure follow-up even with patients who initially quit; we observed relapse among over half of those who had tried to quit for any length of time in our study.

Some limitations exist to this study. First, with the cross-sectional design, only associations can be drawn. We captured only a single snapshot in time; some of our underlying assumptions may therefore be inaccurate. For example, we assumed that the sentiments endorsed by the respondents at the time of the survey (eg, regarding whether e-cigarettes could help with smoking cessation) are the same as when they made their past quit attempt. The self-reported nature of the observations may also render the study findings subject to misreporting. Furthermore, we do not have evidence that the e-cigarette users in our study were all using it to aid quitting. Finally, despite weighting to reduce non-coverage and non-response biases, these data may still not be fully representative of the South African adult population because adjustments were only made for a few variables for which information was available in the dataset. Despite these limitations, this study has the potential to inform ongoing policy efforts towards comprehensive regulation of e-cigarettes within South Africa.

CONCLUSION

e-Cigarette use, while associated with higher likelihood of quitting short term, was associated with lowered likelihood of long-term quitting and higher likelihood of smoking relapse among ever-established smokers who had tried to quit. These findings can inform restrictions on

unsubstantiated claims of e-cigarettes as cessation aids within South Africa. Regulating e-cigarettes as tobacco products may benefit public health in South Africa and regionally by minimising population-level harms such as smoking relapse and the perpetuation of smoking behaviour.

What this paper adds

- This study, which is the largest in South Africa to date, empirically examined the relationship between e-cigarette use and self-reported smoking cessation.
- Within multivariable analyses, the odds of sustained quitting at the 12-month mark were lower among those who used e-cigarettes once off/rarely (adjusted OR (AOR)=0.20, 95% CI 0.16–0.24), former users (AOR=0.30, 95% CI=0.24–0.38) and current users (AOR=0.23, 95% CI=0.18–0.29), compared with never e-cigarette users.
- Among ever-established smokers who had ever tried to quit, 53.6% relapsed into smoking after having quit for any length of time.
- e-Cigarette-only users reported rates of relapse (65.1%) that were higher than those seen for counseling-only users (38.6%); nicotine replacement therapy (NRT)-only users (54.8%); NRT+prescription medication-only users (45.3%); or those not using any intervention at all (43.8%).
- These findings can help inform comprehensive tobacco prevention and control efforts, including restricting unsubstantiated marketing claims of e-cigarettes as effective smoking cessation aids within South Africa.

Data availability statement

Requests should be directed to the corresponding and will be considered on a case-by-case basis.

Ethics statements

Patient consent for publication

Not required.

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