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Effects of providing tailored information about e-cigarettes in a digital smoking cessation intervention: randomized controlled trial

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Abstract

The effectiveness of e-cigarettes in smoking cessation is under debate. Informing smokers who are motivated to quit smoking about e-cigarettes may help them to make an informed decision about their use for smoking cessation, which, however, may also lead to unintended effects such as less quitting. This experimental study assessed the influence of providing tailored information about e-cigarettes in a web-based tailored smoking cessation intervention on participants' decision-making and smoking behavior. Adult smokers ($N = 331$) were randomized into a personalized eHealth intervention on (i) smoking cessation (control condition) or (ii) smoking cessation and information about e-cigarettes (intervention condition). Directly postintervention, participants in the intervention condition had more knowledge about e-cigarettes than participants in the control condition. Attitudes toward e-cigarettes were more positive among intervention participants than control participants, but the differences in attitude were less pronounced than the differences in knowledge and not consistent across items. At a 6-month follow-up, no between-condition differences were observed in the use of e-cigarettes as a smoking cessation method, the number of tobacco cigarettes smoked in the past 7 days, or other smoking outcomes.

Introduction

Tobacco smoking is the leading cause of preventable morbidity and mortality [1]. Yet, despite widespread awareness of the harms of smoking, 20% of Dutch adults still smoke [2]. More than one in three Dutch smokers undertake at least one serious quit attempt per year [3]; however, most of these attempts fail. Smokers take an average of 30 attempts to successfully quit smoking [4], partly due to the highly addictive nature of nicotine [5]. Nicotine is the main addictive substance in tobacco, but most smoking-related health problems are caused by components of tobacco and tobacco smoke other than nicotine [6].

Nicotine can also be delivered through electronic cigarettes (e-cigarettes), which produce an aerosol by heating a liquid that usually contains nicotine. E-cigarettes are used regularly by 1.1% of adults in the Netherlands, most of whom are smokers or former smokers; only 0.1% of adults who have never smoked use e-cigarettes regularly [3]. The use of e-cigarettes can lead to irritation and damage of the respiratory tract, palpitation, and increased risk of developing several kinds of cancers [7, 8]. The long-term health effects of using e-cigarettes cannot yet be investigated, but there is compelling evidence that when comparing the harmfulness of using e-cigarettes with smoking tobacco, the exclusive use of e-cigarettes is less harmful than smoking tobacco [9]. The intervention in this study targeted

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only adult smokers; therefore, only the effects of e-cigarettes on adult smokers are discussed in this article. When assessing the overall impact of e-cigarettes on public health, it is important to consider the impact on all groups, particularly on tobacco-naïve individuals and youth.

Concurrent use of e-cigarettes alongside cigarettes (referred to as dual use) exposes dual users to toxicants and nicotine from both e-cigarette vapor and tobacco smoke. Studies indicate that dual use may result in additive or synergistic effects of additional pathology [10, 11]. More research is needed to examine the effects of dual use; however, the health promotion potential of e-cigarette use likely depends on the impact of e-cigarette use on actual smoking cessation. In the context of this study, smoking cessation is defined as the cessation of cigarette smoking, regardless of the use of e-cigarettes.

There is an ongoing controversy regarding the use of e-cigarettes for smoking cessation. Some scholars stress that e-cigarettes are less harmful than combustible smoking, whereas others argue that there is a lack of evidence of safety and efficacy in terms of smoking cessation [9]. A Cochrane review concluded that moderate evidence suggests that smokers have a higher chance of successfully quitting if they use nicotine e-cigarettes compared with nicotine replacement therapy (NRT) [odds ratio (OR): 1.53, 95% confidence interval (CI): 1.21–1.93] [9]. Unfortunately, there are too few studies to compare e-cigarettes with behavioral support or no support with sufficient precision to draw conclusions [9].

We conducted a randomized controlled trial with a 6-month follow-up period during which adult smokers who were motivated to quit smoking were randomly assigned to either the intervention condition or the control condition. Participants in both conditions received the same web-based smoking cessation intervention. The two conditions differed in the provision of information on e-cigarettes. Participants in the intervention condition received detailed tailored information about e-cigarettes (e.g. about the harmfulness of e-cigarettes compared with smoking and the use of e-cigarettes for smoking cessation), whereas participants in the control condition received a short statement that e-cigarettes are not recommended for smoking cessation.

The aim of the study was to investigate the effects of including tailored information about e-cigarettes in a digital smoking cessation intervention on decision-making and smoking behavior. Regarding decision-making, it was hypothesized that participants in the intervention condition would possess more knowledge about e-cigarettes than participants in the control condition immediately after the intervention (H1). No hypothesis was formulated for the attitude toward e-cigarette use, because neither more positive nor more negative attitudes can be directly associated with improved decision-making. Regarding smoking behavior, it was hypothesized that intervention participants would have smoked fewer cigarettes in the past 7 days at their 6-month follow-up than control participants, while adjusting for the number of cigarettes smoked in the past 7 days at baseline (H2). This hypothesis was formulated to capture a possible effect on smoking behavior, as a potential increase in e-cigarette use among participants in the intervention condition as a result of the information provided may lead to a decrease in the number of cigarettes smoked by intervention participants.

Materials and methods

Design and participants

A detailed description of the protocol for the randomized controlled trial is provided elsewhere [12]. Participants were recruited for participation at baseline between March 2020 and July 2020 through a Dutch research agency (Flycatcher Internet Research B.V., Maastricht, NL). Participants needed to satisfy the following inclusion criteria to be eligible for participation: at least 18 years old, have sufficient command of the Dutch language, had smoked tobacco in the past 7 days, and were motivated to quit tobacco smoking within 5 years. After completing a web-based eligibility

screening and providing informed consent, eligible participants completed the baseline survey and were randomized into either the intervention condition or the control condition. Study incentives were conditional on answering all questionnaires (baseline, postintervention and 6-month follow-up). Participants received credits in the research agency system, which could be redeemed for vouchers or donations after crediting various participations in research.

Sample size

Based on sample size estimation for Cohen's *d* with prespecified CI widths for accuracy of estimates, the aim was to recruit 687 study participants. The ufs package [13] in R was used to estimate the sample size, accounting for a small effect size of Cohen's *d* of 0.2, a margin of error (half-width) of 0.15 and a confidence level of 95%. The effect size could not be inferred from prior research because the study team was unable to identify prior research based on a similar research question. A small effect size was assumed because it is common in research on web-based smoking cessation interventions [14].

Ethical approval

Ethical approval was granted by the Ethics Review Committee Health, Medicine and Life Sciences (FHML-REC) at Maastricht University (FHML-REC/2019/072), and the research study was prospectively registered with the Netherlands Trial Register (NL8330).

Intervention

The intervention was a web-based computer-tailored smoking cessation intervention that consisted of a single session. The I-Change model, which integrates several social cognitive theories, served as the theoretical framework for the development of the intervention [15, 16] (see Fig. 1). Tailored advice was provided regarding the pros

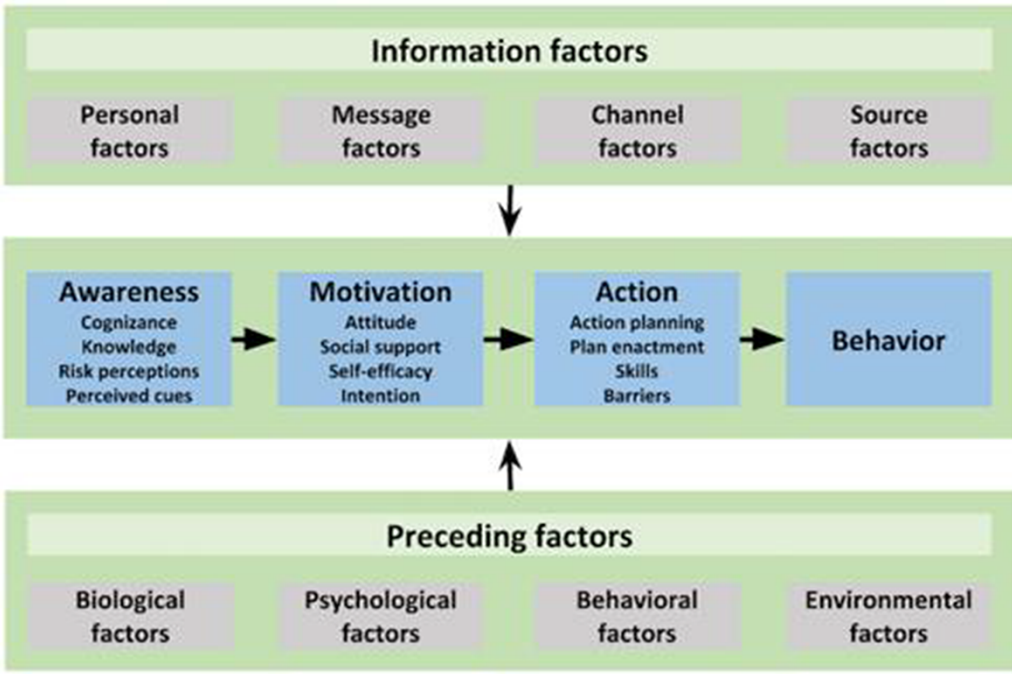

Fig. 1. I-Change model [16]; figure adapted from [31].

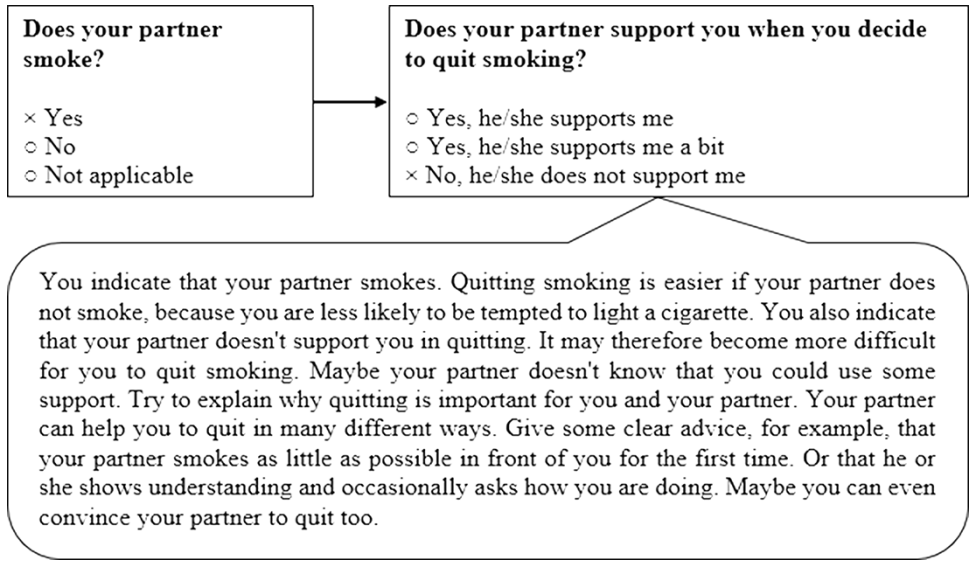

Fig. 2. Example of the tailoring process for the advice about the social influence of the participant's partner.

and cons of quitting smoking (i.e. attitude), social influence, preparatory plans, self-efficacy and coping plans concerning smoking cessation. An example of the tailoring process for social influence is presented in Fig. 2. Participants decided which of the determinants they wanted to receive advice about based on their own interests and needs. The intervention is characterized by the use of narrated animations instead of text for most tailored advice [17]. A screenshot of a typical webpage of the intervention is presented in Fig. 3.

The two conditions (intervention condition versus control condition) differed in the extent to which information on e-cigarettes was provided. Participants in the control condition received a short statement that e-cigarettes are not actively recommended for smoking cessation. Participants in the intervention condition received detailed tailored information on e-cigarettes. The information was tailored to each individual participant based on their responses to five items (i.e. 'do you know what an e-cigarette is?' 'How harmful do you think e-cigarettes are compared with tobacco cigarettes?' 'Do you think e-cigarettes are helpful in quitting smoking?' 'Do you think using e-cigarettes is difficult or easy?' and 'Have you seen reports in the media about illnesses and deaths in the United States related to the use of e-cigarettes?'). The information about e-cigarettes conveyed the message that, for smokers, the use of e-cigarettes is less harmful than continuing to smoke cigarettes; however, the use of e-cigarettes is not without risk. Since e-cigarette use also carries risks, it should eventually be stopped. It was explained that the use of e-cigarettes may hold interest as a smoking cessation method for smokers who have tried to quit several times but have not succeeded.

Measures

All self-reported items of the three questionnaires (baseline, postintervention and 6-month follow-up) can be found in Supplementary Appendix A.

Baseline measures

The demographics assessed included gender (0 = male, 1 = female, 2= not on the list), age and education level (1 = low, 2 = intermediate,

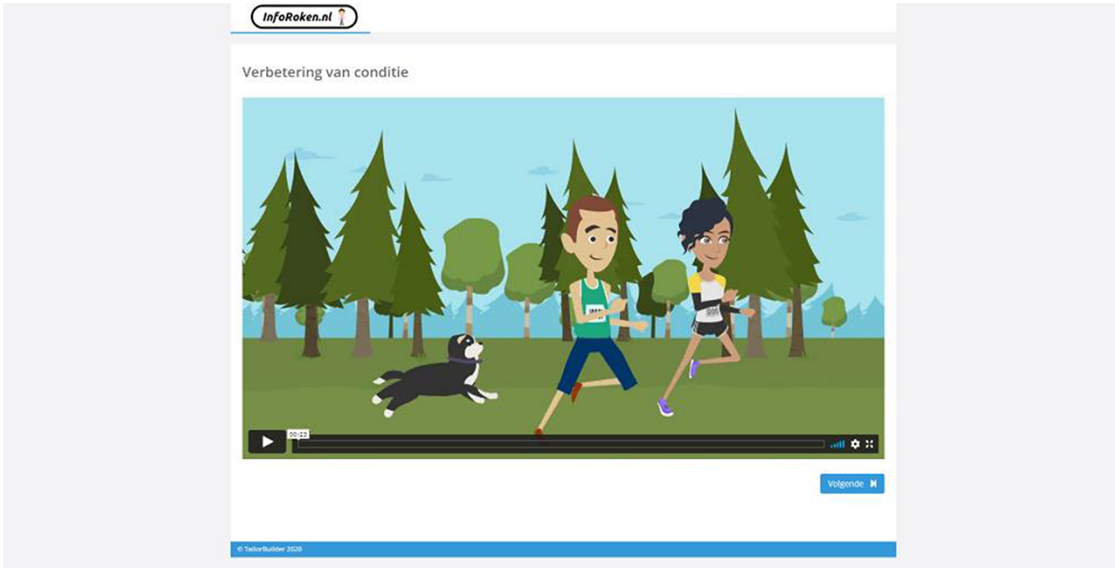

Fig. 3. Screenshot of a typical webpage of the intervention presenting an animated video.

3 = high). Addiction level was assessed using the Fagerström Test for Nicotine Dependence. The six scale items were summed to identify an overall score that ranged from 0–10. Dependence level was classified as 0–2 = low, 3–4 = moderate, 5–6 = strong and 7–10 = very strong. Intention to quit smoking was assessed by two items that asked participants: (i) when they plan to quit smoking (1 = within 1 month, 2 = within 6 months, 3 = within 1 year, 4 = within 5 years) [18] and (ii) whether they plan to quit smoking within 1 year (measured on a 5-point Likert scale ranging from 1 = definitely do not to 5 = definitely do).

Postintervention measures

Directly postintervention, participants were asked to answer a questionnaire. Participants' knowledge about e-cigarettes and attitude toward e-cigarettes were assessed as determinants of decision-making. Knowledge was measured using seven items (e.g. 'there are less harmful substances in e-cigarettes compared with tobacco cigarettes') with the response options 1 = true, 2 = false and 3 = I do not know. Correct answers were coded as 1, and incorrect answers and the answer option 'I do not know' as 0. The sum of the correct answers was calculated as an overall score for the construct knowledge. Attitude toward e-cigarettes was measured using 10 items (e.g. 'I think that using e-cigarettes is better for my health than smoking cigarettes') on a 5-point Likert scale that ranged from 1 = I totally disagree to 5 = I totally agree.

A process evaluation included an overall grade (i.e. 'what is the overall grade you would give to the online program?') on a scale ranging from 1 = very bad to 10 = very good. The time spent on the intervention website was measured using TailorBuilder software (OverNite Software Europe BV). The time could not be recorded for nine participants (9/331, 2.7%) because of technical issues; those participants were excluded in the analysis of the time spent on the website. Participants were also asked to respond to open-ended questions to describe positive and negative aspects of the intervention.

Six-month follow-up measures

The number of tobacco cigarettes smoked in the past 7 days was the primary smoking outcome measure. Secondary smoking outcome measures included the average number of tobacco cigarettes smoked per day, 7-day point prevalence tobacco abstinence and number of days to relapse. Participants were asked whether they had used each of a list of smoking cessation methods (i.e. face-to-face counseling, eHealth interventions, telephone counseling, group-based programs, NRT, prescription medication and e-cigarettes) on a dichotomous scale (i.e. yes or no).

Analyses

Statistical analyses were conducted using SPSS version 27 and R version 4. The focus of all analyses was on the effect size accompanied by the CI. Primary analyses were performed among complete observations. Secondary analyses were performed in multiply imputed data and in penalized imputed data. In multiple imputation, missing values at a 6-month follow-up were imputed using the R package 'mice' by 16 imputations [19]. The number of imputations was similar to the percentage of cases that were incomplete [20]. In penalized imputation, all participants lost to follow-up after 6 months were classified as smokers.

Descriptive statistics were used to describe the study population. Between-condition differences in knowledge items were assessed by chi-square tests, and between-condition differences in the sum score of correct answers were assessed by analysis of variance. Between-condition differences in attitude were assessed by multivariate analysis of variance followed by testing individual dependent variables separately. Between-condition differences in the use of smoking cessation methods during the study period were assessed by chi-square tests. Between-condition differences in the number of tobacco cigarettes smoked in the past 7 days and the average number of tobacco cigarettes smoked per day were assessed by analysis of covariance, including the baseline value of the same variables as a covariate. The same analysis was performed in the multiply imputed data as a secondary analysis using the R package 'miceadds' [21]. Between-condition differences in point prevalence tobacco abstinence were analyzed by chi-square tests. Secondary analyses were performed in the multiply imputed data and the penalized imputed data. The chi-square values from the analyses in the multiply imputed data were pooled using the R package 'miceadds' [21]. Between-condition differences in the number of days to relapse were assessed by a survival analysis using the R package 'survival' [22]. A Kaplan–Meier plot was drawn using the R package 'survminer' [23]. Relapse in the survival analysis was defined as having smoked on seven consecutive days after the participant seriously tried to quit smoking for the first time. Participants who did not make a quit attempt were excluded in the analysis. Participants who remained quit at a 6-month follow-up were censored. Responses to the open-ended questions were qualitatively analyzed by the first author by identifying recurring themes. The analysis was created inductively through an iterative process of repeatedly reading the responses and organizing them into themes.

Results

Participants

Table I presents participants' baseline characteristics by condition. On average, participants were 49.0 years old (SD: 13.2). The majority of participants were women (59.8%) and had a medium level of education (43.2%). The flow of participants through the study is presented in Fig. 4. We explored alternative recruitment methods [12], but since these did not result in noticeable success, we were not able to include additional participants.

Between-condition differences in determinants of decision-making directly postintervention

Table II reports participants' postintervention knowledge about e-cigarettes by condition. Participants in the intervention condition were

Table I. *Baseline characteristics of participants by condition*

	Overall sample ($N = 331$)	Intervention condition ($n = 157$)	Control condition ($n = 174$)
Age (SD)	49.0 (13.2)	48.2 (13.0)	49.7 (13.2)
Female (%)	198 (59.8)	96 (61.1)	102 (58.6)
Education level (%)			
Low	71 (21.5)	28 (17.8)	43 (24.7)
Medium	143 (43.2)	72 (45.9)	71 (40.8)
High	117 (35.3)	57 (36.3)	60 (34.5)
Cigarettes per week (SD)	88.3 (68.5)	91.3 (59.9)	85.6 (75.4)
Fagerström	3.8 (2.6)	4.1 (2.6)	3.5 (2.5)
Use of e-cigarette in the past 7 days (%)	33 (10)	17 (10.8)	16 (9.2)
Nicotine content of e-cigarette liquid (%)			
Mainly with nicotine	22 (66.7)	9 (52.9)	13 (81.3)
Mainly without nicotine	10 (30.3)	7 (41.2)	3 (18.8)
I do not know	1 (3.0)	1 (5.9)	0 (0.0)
Intention to quit smoking (%)			
Within 1 month	61 (18.4)	30 (19.1)	31 (17.8)
Within 6 months	121 (36.6)	64 (40.8)	57 (32.8)
Within 1 year	89 (26.9)	36 (22.9)	53 (30.5)
Within 5 years	60 (18.1)	27 (17.2)	33 (19.0)
Planning to quit within 1 year[a] (SD)	4.0 (1.0)	4.0 (1.0)	4.1 (0.9)
Made a quit attempt in the past year (%)	143 (43.2)	69 (43.9)	74 (42.5)

[a]Measured on a 5-point Likert scale ranging from 1 = 'definitely do not' to 5 = 'definitely do.'

more knowledgeable than participants in the control condition. The sum score of correct answers differed ($F_{1,329} = 35.36$, $P < 0.001$, $\eta_p{}^2 = 0.097$) between participants in the intervention condition (mean: 4.82, SD: 1.67) and participants in the control condition (mean: 3.69, SD: 1.76). Table III reports participants' postintervention attitudes toward e-cigarettes by condition. The multivariate analysis indicated that participants in the intervention condition held more positive attitudes toward e-cigarettes than participants in the control group (Pillai's Trace = 0.08, $F_{10,320} = 2.86$, $P < 0.01$, $\eta_p{}^2 = 0.082$).

Smoking cessation outcome measures after 6 months

No differences were found between participants in the intervention condition ($N = 16$, 11.5%) and the control condition ($N = 10$, 7.2%) regarding the use of e-cigarettes as a smoking cessation method during the 6-month study period (OR: 1.67, 95% CI: 0.73–3.81). Table IV reports between-condition differences in the use of smoking cessation methods during the 6-month study period. No differences were found between participants in the intervention condition ($N = 5$, 3.6%) and the control condition ($N = 11$, 8.0%) regarding dual use of cigarettes and e-cigarettes at 6-month follow-up (OR: 0.43, 95% CI: 0.15–1.27).

No differences were found between participants in the intervention condition (estimated marginal mean [EMM]: 60.88, standard error [SE]: 4.42) and the control condition (EMM: 53.46, SE: 4.44) regarding the number of tobacco cigarettes smoked in the past 7 days at a 6-month follow-up ($F_{1,274} = 1.40$, $P = 0.24$, $\eta_p{}^2 = 0.005$). Similar results were found for the multiply imputed data ($F = 3.10$, $P = 0.08$, $\eta_p{}^2 = 0.010$). Also, no differences were found between participants in the intervention condition (EMM: 9.34, SE: 0.54) and the control condition (EMM: 8.65, SE: 0.54) regarding the average number of tobacco cigarettes smoked per day ($F_{1,274} = 0.82$, $P = 0.37$, $\eta_p{}^2 = 0.003$). Similar results were found for the multiply imputed data ($F = 2.17$, $P = 0.14$, $\eta_p{}^2 = 0.007$).

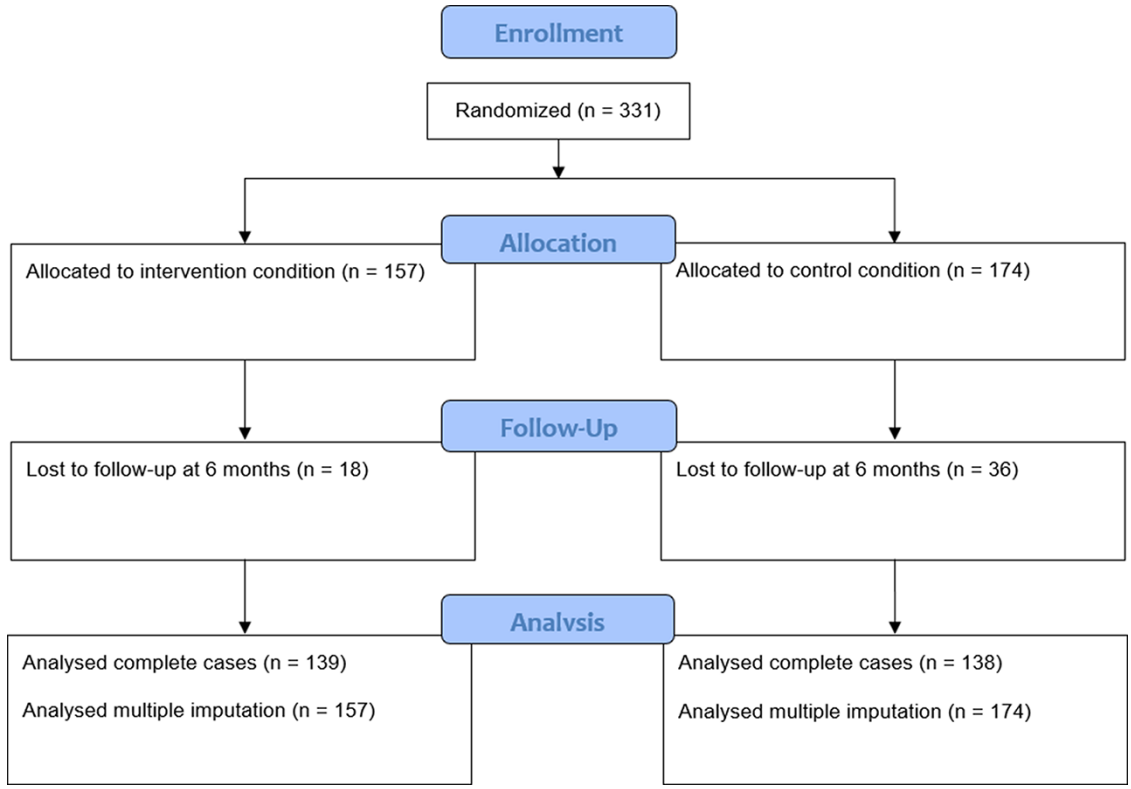

Fig. 4. Flow of participants through the study.

Seven-day tobacco point prevalence abstinence did not differ ($X^2_1 = 0.80$, $P = 0.37$; OR: 0.77, 95% CI: 0.44–1.36) between the intervention condition (28/139, 20.1%) and the control condition (34/138, 24.6%). Secondary analyses in the multiply imputed data set ($F = 2.42$, $P = 0.12$) and the penalized imputed data set ($X^2_1 = 0.16$, $P = 0.69$; OR: 0.89, 95% CI: 0.51–1.56) yielded similar results. In the overall sample, 22.4% (62/277) of participants reached 7-day tobacco point prevalence abstinence. There were also no differences between the intervention condition (35/139, 25.2%) and the control condition (41/138, 29.7%) regarding 24-hour tobacco point prevalence abstinence ($X^2_1 = 0.71$, $P = 0.40$; OR: 0.80, 95% CI: 0.47–1.35). These results were confirmed by secondary analyses in the multiply imputed data set ($F = 1.49$, $P = 0.22$) and the penalized imputed data set ($X^2_1 = 0.08$, $P = 0.78$; OR: 0.93, 95% CI: 0.56–1.56).

The survival probability regarding the number of days to relapse did not differ between conditions ($P = 0.55$). The median number of days to relapse (i.e. time corresponding to a probability of not relapsing of 0.5) was 7.5 days in both conditions. The Kaplan–Meier survival curves for the intervention condition and the control condition are reported in Fig. 5.

Process evaluation

On average, participants graded the intervention with 7.44 (SD: 1.24) and spent 23:31 (mm:ss, SD: 43:19) on the intervention website. No differences were observed between participants in the intervention condition (mean: 7.39, SD: 1.29) and

Table II. *Number (%) of smokers who correctly assessed the proposition per condition*

	Intervention condition ($n = 157$)	Control condition ($n = 174$)	X^2	P	OR (95% CI)
E-cigarettes contain tobacco	116 (73.9)	102 (58.6)	8.55	<0.01	2.00 (1.25–3.18)
E-cigarettes contain less harmful substances than regular cigarettes	93 (59.2)	51 (29.3)	30.07	<0.001	3.50 (2.22–5.53)
E-cigarettes with nicotine are addictive	127 (80.9)	116 (66.7)	8.56	<0.01	2.12 (1.27–3.52)
The vapor of e-cigarettes consists only of water	75 (47.8)	69 (39.7)	2.21	0.14	1.39 (0.90–2.15)
The use of e-cigarettes can cause irritation and damage to the respiratory tract	120 (76.4)	112 (64.4)	5.73	0.02	1.80 (1.11–2.91)
For smokers, the use of e-cigarettes is less harmful than continuing to smoke	102 (65.0)	68 (39.1)	22.14	<0.001	2.89 (1.85–4.52)
The long-term effects of the use of e-cigarettes have not been sufficiently researched	123 (78.3)	124 (71.3)	2.18	0.14	1.46 (0.88–2.41)

Table III. *Attitude about e-cigarettes by condition*

	Intervention condition mean (SD) ($n = 157$)	Control condition mean (SD) ($n = 174$)	F	P	η_p^2
I think that it is wise to use e-cigarettes instead of smoking regular cigarettes	2.80 (1.13)	2.66 (1.12)	1.31	0.25	0.004
I think that the use of e-cigarettes is better for my health than smoking regular cigarettes	3.22 (1.12)	2.84 (1.18)	9.16	<0.01	0.027
I think that the use of e-cigarettes is better for the health of the people around me than smoking regular cigarettes	3.52 (1.10)	3.16 (1.18)	7.98	<0.01	0.024
I think that e-cigarettes can help me to smoke less	2.81 (1.21)	2.79 (1.19)	0.03	0.87	0.000
I think that e-cigarettes can help me to quit smoking	2.64 (1.14)	2.70 (1.17)	0.21	0.65	0.001
I think that the use of e-cigarettes increases my chances of successfully quitting smoking	2.76 (1.23)	2.71 (1.18)	0.15	0.70	0.000
I think that e-cigarettes can help me to quench my cravings for regular cigarettes	2.94 (1.21)	2.87 (1.16)	0.28	0.60	0.001
I think that e-cigarettes taste good	2.81 (1.10)	2.68 (1.04)	1.13	0.29	0.003
I think that e-cigarettes are easy to use	3.61 (1.07)	3.37 (1.05)	4.15	0.04	0.012
I think that I smell less like smoke when I use e-cigarettes instead of regular cigarettes	3.81 (1.12)	3.77 (1.03)	0.11	0.74	0.000

All constructs were measured on a 5-point Likert scale that ranged from 1 ('I totally disagree') to 5 ('I totally agree').

the control condition (mean: 7.49, SD: 1.19) in the evaluation of the overall grade ($F_{1,329} = 0.64$, $P = 0.43$, $\eta_p^2 = 0.002$). Intervention participants (mean: 22:39, SD: 31:08) and control participants (mean: 24:19, SD: 52:20) did not differ in the time spent on the intervention website ($F_{1,320} = 0.12$, $P = 0.73$, $\eta_p^2 = 0.000$). The themes derived from the qualitative analysis of the answers to the open-ended questions are reported in Table V.

Discussion

This study examined the effects of providing detailed tailored information about e-cigarettes in a web-based smoking cessation intervention on decision-making and smoking behavior. Directly postintervention, the results showed that providing information on e-cigarettes increased participants' knowledge about e-cigarettes (H1) and influenced

Table IV. *Between-condition differences in the use of smoking cessation methods during the study period*

	Total ($n = 277$)	Intervention condition ($n = 139$)	Control condition ($n = 138$)	X^2	P	OR (95% CI)
No method	166 (59.9%)	77 (55.4%)	89 (64.5%)	2.39	0.12	0.68 (0.42–1.11)
NRT	53 (19.1%)	35 (25.2%)	18 (13.0%)	6.59	0.01	2.24 (1.20–4.20)
E-cigarette	26 (9.4%)	16 (11.5%)	10 (7.2%)	1.48	0.22	1.67 (0.73–3.81)
Other methods	24 (8.7%)	12 (8.6%)	12 (8.7%)	0.00	0.99	0.99 (0.43–2.29)
Prescription medication	17 (6.1%)	9 (6.5%)	8 (5.8%)	0.06	0.81	1.13 (0.42–3.01)
eHealth interventions	14 (5.1%)	8 (5.8%)	6 (4.3%)	0.29	0.59	1.34 (0.45–3.98)
Face-to-face counseling	13 (4.7%)	3 (2.2%)	10 (7.2%)	4.01	0.045	0.28 (0.08–1.05)
Group-based programs	10 (3.6%)	2 (1.4%)	8 (5.8%)	3.78	0.05	0.24 (0.05–1.14)
Telephone counseling	7 (2.5%)	3 (2.2%)	4 (2.9%)	0.15	0.69	0.74 (0.16–3.36)

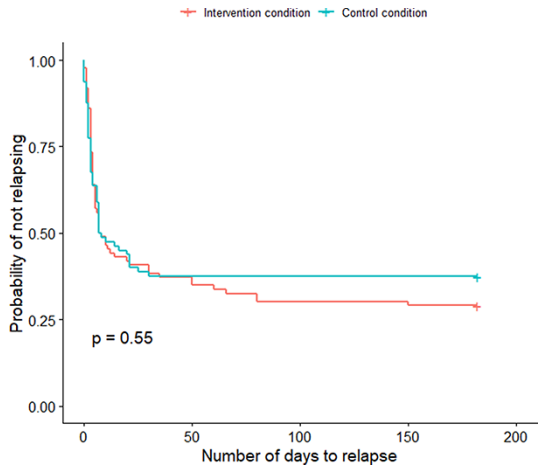

Fig. 5. Between-condition differences in the number of days to relapse.

their attitude toward e-cigarettes. After 6 months, no between-condition differences in the use of e-cigarettes as a smoking cessation method were observed nor any other effects on behavior (H2).

Determinants of decision-making on the use of e-cigarettes for smoking cessation

The results confirmed the first hypothesis concerning knowledge as participants in the intervention condition assessed more propositions correctly than participants in the control condition. An important finding was that knowledge among participants in the control condition was low. Three knowledge items were assessed incorrectly by more than half of the participants in the control condition. For example, three out of five participants in the control condition did not know that, for smokers, the use of e-cigarettes is less harmful than continuing to smoke. This is alarming as these participants represent the general population of smokers in the Netherlands. Our results are consistent with previous research that found an increasing misperception of the relative harmfulness of e-cigarettes compared with cigarettes among the general population [24–27] and adult smokers [28]. The results of our study add to these findings that Dutch smokers who were motivated to quit smoking similarly misperceived the relative harm of e-cigarettes.

The results regarding attitude showed a similar picture as far as beliefs about the relative harmfulness of e-cigarettes versus cigarettes are concerned. The results showed that intervention participants were more likely than control participants to believe that e-cigarettes compared with cigarettes were better for their own health and for the health of those around them. Yet, it is interesting to note that the intervention had no effect on beliefs about the effectiveness of e-cigarettes for smoking cessation. No between-condition differences were found for the beliefs that e-cigarettes can help to smoke less, quit smoking or quench the craving for smoking cigarettes. This indicates that the intervention corrected misperceptions about the relative harm of e-cigarettes compared with cigarettes, but did not influence beliefs on the effectiveness of e-cigarettes for smoking cessation.

Table V. *Positive and negative aspects of the intervention reported by the participants*

What did you like about the online program?	*n*	What did you dislike about the online program?	*n*
Clarity (e.g. 'clear information')	89	Superficial (e.g. 'I expected more depth')	16
Advice (e.g. 'all the good advice')	70	More help expected (e.g. 'need more tips, personal guidance')	15
Animations (e.g. 'the clear videos appealed to me')	31	Information was missing (e.g. 'too few options. I want to try to stop by hypnosis.')	12
Raises awareness (e.g. 'that you start thinking more consciously about quitting')	21	Animations (e.g. 'I hate cartoons.')	11
Computer tailoring (e.g. 'it responds directly to my answers')	14	Information on e-cigarettes (e.g. 'I think there were too many questions about quitting with an e-cigarette. I do not want to quit with an e-cigarette.')	10
Comprehensiveness (e.g. 'all aspects of quitting smoking were covered')	8	Patronizing and childish (e.g. 'the voice in the movies sounds rather patronizing and prissy')	10
Information on e-cigarettes (e.g. 'I found the information about the e-cigarette useful because there are different opinions about it')	5	Too long (e.g. 'it's pretty long')	9
Language (e.g. 'clear language')	4	Little new information (e.g. 'I already knew a lot')	7
		Difficulties using the program (e.g. 'took a long time to load')	6
		Not motivating (e.g. 'lack of motivation')	4

Smoking behavior

Our second hypothesis was that intervention participants would have smoked fewer tobacco cigarettes in the past 7 days at their 6-month follow-up than control participants. First of all, the intervention did not lead to more participants in the intervention condition trying e-cigarettes as a cessation method compared with participants in the control condition. Since the intervention had no influence on the use of e-cigarettes to support smoking cessation, other differences in smoking outcomes are not to be expected as only the information about e-cigarettes was manipulated in the study. Thus, second, no between-condition differences were found in the number of tobacco cigarettes smoked in the past 7 days, 7-day point prevalence tobacco abstinence and 24-hour point prevalence tobacco abstinence. The second hypothesis can therefore be clearly rejected.

An unanticipated finding was that intervention participants used NRT more often than control participants. This might suggest that informing smokers about e-cigarettes and the role of nicotine in e-cigarette use could lead smokers to consider using nicotine replacement in general. However, with a small number of participants using NRT, caution must be applied, as this finding may also be by chance and warrants further exploration in future research.

Limitations

The study was subject to several limitations. First, the analyzed sample was smaller than targeted because we were unable to retain enough participants who were recruited outside of the research agency for the 6-month follow-up. The small sample led to less precise CIs around some associations of interest. Additional strategies to improve retention are recommended in future studies of this nature (e.g. increase contact between research team and participants). Second, smoking abstinence was self-reported and not biochemically validated, which could introduce social desirability bias. Yet, self-reports in smoking cessation research are generally accurate [29, 30]. Third, the forced exposure of the intervention lacks ecological validity and results may differ outside of the

experimental context. Fourth, we did not explicitly assess intervention participants' thoughts about the information on e-cigarettes in a qualitative manner, which might have been valuable information in order to explain the lack of behavioral effects. Major strengths of the study were the experimental design with the control group, the 6-month follow-up of behavioral outcome measures and an intervention that was developed based on social cognitive theory [16].

Conclusion

An informed decision about e-cigarette use for smoking cessation can only be made if smokers have sufficient knowledge about the relative risks of e-cigarette use and tobacco smoking. The results of our study show that knowledge was limited among participants in the control condition, who are representative of the general public of smokers in the Netherlands. Providing detailed tailored information about e-cigarettes in the intervention condition increased knowledge and had no unintended consequences on smoking behavior. Important information for smokers includes that the long-term health consequences of e-cigarette use are not yet known, but that e-cigarettes are in all likelihood less harmful to smokers than continuing to smoke cigarettes. The information should also include that dual use of both products has probably detrimental effects and should only be done temporarily to quit smoking. This information can be communicated to smokers in a variety of ways. While further research is needed, the digital intervention in this study appears to be an appropriate means of increasing knowledge to facilitate informed decision-making about e-cigarette use for smoking cessation in adult smokers.

Supplementary data

Supplementary data are available at *HEAL* online.

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Conflict of interest statement

None declared.

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