Addictive Behaviors 138 (2023) 107570

Contents lists available at ScienceDirect

Addictive Behaviors

journal homepage: www.elsevier.com/locate/addictbeh

Association of psychological distress with smoking cessation, duration of abstinence from smoking, and use of non-combustible nicotine-containing products: A cross-sectional population survey in Great Britain

Loren Kock [a,b,*], Jamie Brown [a,b], Sharon Cox [a,b], Ann McNeill [b,c], Debbie Robson [b,c], Lion Shahab [a,b], Harry Tattan-Birch [a,b], Leonie S. Brose [b,c]

[a] Department of Behavioural Science and Health, University College London, UK
[b] SPECTRUM Consortium, UK
[c] Addictions Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, UK

A B S T R A C T

Background: Tobacco smoking cessation is associated with improvements in mental health. This study assessed psychological distress, using the K6 non-specific screening tool ((items cover feelings of nervousness, hopelessness, restlessness, depression, 'everything an effort' and worthlessness), by smoking status, time since quit, and use of a non-combustible nicotine product.

Methods: Monthly repeat cross-sectional household survey of adults (18 +) from October 2020–February 2022 in Great Britain (N = 32,727). Using unadjusted and adjusted logistic regression (adjusted models included socio-demographic characteristics and ever diagnosis with a mental health condition), we assessed: associations between any/serious past-month psychological distress and smoking status and time since quit, whether these relationships were moderated by ever diagnosis with a mental health condition, and associations between distress and use of a nicotine product by people who formerly smoked.

Results: In the unadjusted model, those who had not smoked for > 1y and who had never smoked had lower odds of any distress (OR = 0·42, 95 % CI 0·39-0·45; OR = 0·44, 0·41-0·47) compared with those who currently smoked. Moreover, the association of lower distress in those who had not smoked for > 1y and never smoked compared with those who currently smoked was more pronounced among those who had ever been diagnosed with a mental health condition (AOR = 0·58, 0·51-0·66; AOR = 0·60, 0·53-0·67) than among those who had not (AOR = 0·86, 0·76-0·98; AOR = 0·72, 0·65-0·81). In adjusted models of people who formerly smoked, current use of any nicotine product was associated with higher odds of distress compared with not using any nicotine product (AOR 1·23, 1·06-1·42).

Conclusion: People who had never smoked, or had not smoked for > 1y had lower levels of distress than those who currently smoked. The lower odds of distress among people who had not smoked for > 1y was more pronounced among those with an ever (vs never) diagnosis of a mental health condition. Nicotine product use among those who formerly smoked was associated with greater distress. Due to potential residual confounding and selection bias more research is needed to determine causality.

1. Introduction

In England, recent patient surveys estimate the prevalence of smoking to be 26 % among those with anxiety or depression, and 41 % among those with serious mental illness (including psychosis, bipolar disorder, eating disorders and severe depression) - compared with 12.1 % in the general population.(Office for Health Improvement and Disparities. Public health profiles - Smoking [Internet]., 2021) Aside from the potential for common causes of smoking and poor mental health (including factors such as age and gender, and stressors related to the experience of socio-economic disadvantage, and difficult/challenging life circumstances), there is evidence that this relationship may be bi-directional.(Wootton et al., 2020; Fluharty et al., 2017; Leung et al., 2012; Treur et al., 2021) Individuals experiencing stress, anxiety or depression may 'self-medicate' with cigarettes in an attempt to alleviate their symptoms, or smoke as a maladaptive passive coping strategy. (Spring et al., 2003 Feb) In addition, people often mistakenly believe smoking generally reduces stress because it alleviates withdrawal symptoms from cigarette abstinence.(Le Moal and Koob, 2007) Conversely, long-term tobacco smoking causes changes in nicotine-mediated reward pathways in the brain that are associated with the experience of withdrawal symptoms such as depressed mood, agitation, and anxiety.(Benowitz, 2010) These symptoms are alleviated by smoking but return soon after, when the constituents of smoke are metabolised.(Benowitz, 2009 Feb; Mansvelder and McGehee, 2002) Through functional changes in dopaminergic and serotoninergic pathways in the

* Corresponding author at: 1-19 Torrington Place, London WC1E 7HB, United Kingdom.
E-mail address: l.kock@ucl.ac.uk (L. Kock).

https://doi.org/10.1016/j.addbeh.2022.107570
Received 22 June 2022; Received in revised form 16 November 2022; Accepted 28 November 2022
Available online 2 December 2022

brain, it is also possible that long-term smoking may itself contribute to poor mental health.(Wootton et al., 2020).

There is some evidence that smoking cessation is associated with improved mental health outcomes.(Taylor et al., 2020; Taylor GMJ, Lindson N, Farley A, Leinberger-Jabari A, Sawyer K, te Water Naudé R, et al. Smoking cessation for improving mental health. Cochrane Database of Systematic Reviews., 2021; Wootton et al., 2022) It is possible that this reflects real and perceived improvements in physical health, and feelings of achievement and self-efficacy, along with the alleviation of frequent withdrawal symptoms in those who have successfully quit. These improvements have been seen among people with and without pre-existing mental health conditions. A history of mental health conditions is often associated with current symptoms of poor mental health. (Nishi et al., 2020 Mar; Segal et al., 2003 Nov 1) It is likely that both people who currently smoke and formerly smoked who have ever been diagnosed with a mental health condition report higher levels of distress compared with those who have not.

Our study seeks to address two current evidence gaps. First, there is little evidence from randomised controlled trials or observational studies on changes in mental health according to the length of time after cessation. For most of the outcomes included in a recent Cochrane review, there was no clear evidence for differences based on length of follow-up.(Taylor GMJ, Lindson N, Farley A, Leinberger-Jabari A, Sawyer K, te Water Naudé R, et al. Smoking cessation for improving mental health. Cochrane Database of Systematic Reviews., 2021) The experience of success in quitting smoking could lead to temporarily improved mental health in the short-term, but it may be offset by distress from acute nicotine withdrawal. Moreover, if smoking is a cause of poor mental health, improvements may become more pronounced with longer abstinence. From a public health perspective, if data showed that although recent former smokers may not experience improvements in mental health in the shorter term after cessation, but may do so in the longer term, this evidence could highlight further benefits of long-term abstinence beyond physical health improvements. Exploring the shape of the trend in improvements according to time since quitting in years may provide additional insights.

Second, if changes in mental health are seen because stopping smoking prevents the experience of regular nicotine withdrawal, we might expect to see greater improvements in people who formerly smoked who abstain from all nicotine products than those who continue to use nicotine in other forms. Other factors associated with quitting nicotine use entirely, such as feelings of achievement/self-efficacy, might also influence improvements in mental health. Most of the evidence on this topic relates to changes in mental health related to smoking cessation (Taylor GMJ, Lindson N, Farley A, Leinberger-Jabari A, Sawyer K, te Water Naudé R, et al. Smoking cessation for improving mental health. Cochrane Database of Systematic Reviews., 2021) but there is little data on the use of non-combustible nicotine products and mental health in this context. Vaping prevalence among people who formerly smoked is approximately 11 % in Great Britain (McNeill et al., February 2021). As such it is important to assess mental health for those who continue to use nicotine.

This study aimed to compare mental health (assessed by past-month psychological distress) in adults by smoking status (current smoker, stopped in past 6 months, stopped between 6 and 12 months ago, stopped over 1 year ago and never smoker) and whether there are differences according to whether an individual had ever been diagnosed with a mental health condition. Further aims were to compare mental health according to continued use of nicotine-containing products among all adults who have stopped smoking.

2. Methods

2.1. Design

Data came from the Smoking Toolkit Study (STS) which uses a form of random location sampling to select a cross-sectional sample of approximately 2,450 adults aged $\geq$ 18 years in Great Britain each month. Data collection for the STS commenced in 2006 in England among adults aged 16+, and was extended to all of Great Britain in October 2020. Due to the pandemic, data were collected via telephone and among those aged 18 + from April 2020 onwards.

The telephone interviews are conducted by landline and mobile using a standard landline random digit dialling (RDD), mobile RDD, and targeted mobile. Each eligible landline telephone number across GB has a random probability of selection proportionate to population distribution (i.e. stratification of the landline telephone database by and within Government Office Region). Within region, the system is based on postcode sector information. Each postcode sector is matched to the relevant standard telephone dialling code and telephone number stubs are derived from information obtained from a government approved regulator (the Office of Communications). Selection probability of postcode sectors is proportional to the number of households within or across a given area by using the household density information that is attached to each postcode sector. Mobile sampling uses a similar approach to landline sampling; however, the selection is in proportion to the known mobile network share. This mobile network share is continually updated using robust publicly available statistics to ensure that accurate samples of the mobile using population. Mobile, targeted mobile and landline sampling are carried out in equal proportions. To maximise response rates more landline sampling takes places earlier in the day, with more mobile sampling later in the day.

Response rates are not appropriate to record, unlike random probability sampling, where interviewers have no choice as to the properties sampled and so response at each number/address can be recorded. The analysis uses the rim (marginal) weighting technique, an iterative sequence of weighting adjustments whereby separate nationally representative target profiles are set (for gender, working status, prevalence of children in the household, age, social grade and region) and the process repeated until all variables match the specified targets.(Kock et al., 2021 Mar) Comparisons with sales data and other national surveys show that the STS recruits a representative sample of the population in England with regards to key demographic and smoking-related variables.(Fidler et al., 2011 Jun; Jackson et al., 2019).

2.2. Population

We included adults (18 +) from Great Britain who completed the STS between October 2020-February 2022.

2.3. Ethics

Ethical approval for the STS was granted by the UCL Ethics Committee (0498/001; 2808/005).

2.4. Measures

2.4.1. Dependent variable

2.4.1.1. Past-month psychological distress. Psychological distress was measured using the Kessler (K6) measure.(Kessler et al., 2002; Kessler et al., 2010) This six-question measure identifies individuals with a high likelihood of being diagnosed with a mental illness and its associated effects. Respondents were asked "During the past 30 days, about how often, if at all, did you feel…a) Nervous; b) Hopeless; c) Restless or fidgety; d) So depressed that nothing could cheer you up; e) That everything was an effort; f) Worthless". For each of a to f, the respondent indicates one of the following: All of the time (scored 4); Most of the time (3); Some of the time (2); A little of the time (1); None of the time (0). A sum score with a possible range from 0 to 24 was calculated; scores of 5 and over were categorised as any distress, scores between 5 and 12 were

categorised as moderate distress, scores of 13 and higher as serious distress.(Kessler et al., 2002; Kessler et al., 2010; Prochaska et al., 2012) The K6 has demonstrated its utility to screen for clinically relevant levels of distress in the population that warrant intervention, and is a widely use measure in general purpose health surveys.(Prochaska et al., 2012) An analysis of data in nationally or regionally representative WHO world mental health surveys in 14 countries generated estimates of the predicted probability of serious mental illness using the K6, with results indicating substantial concordance (median 0.83).(Prochaska et al., 2012).

2.4.2. Independent variables

2.4.2.1. Smoking status. Smoking status was assessed with the question: "Which of the following best applies to you? Please note we are referring to cigarettes and other kinds of tobacco that you set light to and NOT electronic or 'heat-not-burn' cigarettes. (a) I smoke cigarettes (including hand-rolled) every day; (b) I smoke cigarettes (including hand-rolled), but not every day; (c) I do not smoke cigarettes at all, but I do smoke tobacco of some kind (e.g., pipe, cigar or shisha); (d) I have stopped smoking completely in the last year; (e) I stopped smoking completely more than a year ago; (f) I have never been a smoker (i.e. smoked for a year or more)." Respondents who reported smoking any type of tobacco (i.e. responses a-c) were coded as people who currently smoked (termed "smokers" in parts of the results section for brevity). Respondents who reported that they had stopped smoking (responses d, e) were coded as people who formerly smoked (termed "former smoker" in results for brevity) and respondents reporting response f were coded as people who have never smoked (termed "never smoker" in results for brevity).(Kock et al., 2021 Mar).

2.4.2.2. Time since quit (categorical). Information about time since quitting and smoking status (Supplementary materials) were used to code people who formerly smoked into three groups: stopped smoking within the past 6 months; stopped smoking>6 months and up to 1 year ago; stopped smoking more than a year ago.

2.4.2.3. Years since quit (continuous). A continuous variable for length of abstinence in years (how many years ago a respondent quit smoking, starting at 1 for those who had quit one year ago and rising in yearly increments) was calculated as a respondent's actual age minus the age they reported having stopped smoking. This provided a more granular measure of longer-term cessation than the categorical time since quit variable.

2.4.2.4. Ever diagnosis with a mental health condition. Respondents were asked to indicate if they have had a mental health diagnosis: "Since the age of 16, which of the following, if any, has a doctor or health professional ever told you that you had?; None of these; Don't know; Prefer not to say".(Kock et al., 2021 Mar) Respondents who reported any of the mental health diagnoses specified above were classified as "Ever diagnosis" and those reporting none as "No diagnosis".

Age 16 was chosen as a cut off because outside of COVID restrictions, the STS surveys the population aged 16 and over, so an older cut-off age would have omitted a subgroup of participants. This is in line with the Adult Psychiatric Morbidity Survey (APMS), the largest survey of mental health in England (Digital and Morbidity, 2014).

2.4.3. Current use of nicotine-containing products

Use of other nicotine products in the form of nicotine replacement therapy (NRT), e-cigarettes, heated tobacco products (HTP) or nicotine pouches was derived from a set of questions which differed by smoking status but all used the same list of response options (see supplementary materials). Use of any product (a to j in supplementary materials) was coded as current use of a nicotine-containing product. For some analyses, we separated different types of nicotine-containing products into NRT use, electronic cigarette use, and HTP/nicotine pouch use. Numbers for HTP and nicotine pouches were expected to be very small. (Tattan-Birch et al., 2021).

2.4.4. Covariates

2.4.4.1. Socio-demographic characteristics. Socio-demographic variables included age, identified sex (responses of "Man", "Woman", or "In another way" to the question "Which of the following best describes how you think of yourself?") social grade (based on the National Readership Survey classification system for social grade based on occupation of the chief income earner with categories of ABC1 (managerial, professional and intermediate occupations) and C2DE (small employers and own-account workers, lower supervisory and technical occupations, and semi-routine and routine occupations, never workers and long-term unemployed)) and region (London, Southern England, Central England, Northern England, Wales, Scotland).(NRS, 2017).

2.4.4.2. Sample selection. Overall, 38,202 adults aged 18 + were surveyed between October 2020 and February 2022. Those who did not complete the primary outcome mental health questions (n = 4,702), or selected 'I don't know' or 'prefer not to say' in response to any of them (n = 773) were excluded. This left a final unweighted sample of 32,727 adults. For regression analyses, a complete case analysis was used under the assumption that data are missing at random (data were missing for < 5 % of cases overall and under each variable after removing those who did not respond to the mental health questions).

To explore the impact of excluding the 5,475 cases specified above, using a dummy variable to indicate exclusion we conducted unadjusted logistic regression analyses assessing the associations between excluded (versus included) cases and smoking status (Groenwold et al., 2012). There were no apparent associations between exclusion and smoking status for each question in the K6 (Table S7).

2.5. Analyses

All analyses were carried out in R (v4.1.3) using RStudio and pre-registered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/YVJ6W). Alpha was set at 0.05 and was considered alongside the theory and explanation as to the effect, the effect size and the measures of uncertainty around each coefficient.

First, weighted prevalence with 95 % CIs of moderate, serious and any (moderate/serious) past-month distress were calculated overall and by smoking status (currently smoking, stopped smoking in the past 6 months, stopped smoking 6 months to 1 year ago, stopped smoking > 1 year ago, never smoked). Then, unweighted logistic regressions were conducted regressing past-month distress on smoking status. Models were run unadjusted and adjusted for socio-demographic characteristics and ever diagnosis with a mental health condition. The adjusted model included a two-way interaction term between smoking status and ever diagnosis. A significant interaction was explored by stratifying according to ever diagnosis with a mental health condition.

Then to explore trends according to length of abstinence, multivariable logistic regression models were fitted for the prevalence of any past-month distress as a function of years since quit. The adjusted model included a two-way interaction term between years since quit and ever diagnosis. To allow for non-linear trends, years since quit was modelled using a restricted cubic spline with 3 internal knots, each placed at the 25th, 50th and 75th quantiles of the data, with the boundary knots placed at the 5th and 95th quantiles due to data sparseness among those who had quit for>65 years.

Finally, we report weighted prevalence with 95 % CIs of moderate, serious and any (moderate or serious) past-month distress for people who formerly smoked who were using a non-combustible nicotine-

containing product and people who formerly smoked who were not using other nicotine-containing products overall. Unweighted logistic regressions were conducted regressing past-month distress on use of nicotine containing products among people who formerly smoked. Models were run both unadjusted and adjusted for socio-demographic characteristics and ever diagnosis with a mental health condition. All models were limited to those who reported using only one nicotine product. This is because the measure of frequency of use of a nicotine product is only specific for respondents exclusively using one product. Analyses were then repeated with the variable for other nicotine-containing products replaced by the variable separating the type of product (NRT, e-cigarettes, HTP/nicotine pouches).

2.6. Sensitivity analyses and unregistered changes to analysis

The first set of analyses (examining distress according to smoking status) were rerun with those who quit up to one month ago as a distinct category among those who quit in the past six months. This was to separate respondents experiencing the acute phase of withdrawal from smoking associated with depressed mood and anxiety. The responses to the STS question asking how long ago the most recent quit attempt started do not allow for a < 6 weeks categorisation (as stated in the pre-registered protocol).

Related to the analyses on distress among former smokers using a non-combustible nicotine-containing product, sensitivity analyses were run including only those who had not smoked for > 1y, to explore whether the results among all those who formerly smoked in the primary analysis were driven by recent quitters who may be more dependent on nicotine and have worse mental health.

In addition, 21 % of people who formerly smoked who use e-cigarettes and not any other non-combustible nicotine product (n = 191/894) reported using non-nicotine e-cigarettes. These respondents were excluded in a further sensitivity analysis.

It is possible that an association between nicotine product use and psychological distress was due to confounding by unmeasured variables. E-values, are defined as the minimum strength of association (on the risk ratio scale), that an unmeasured confounder would need to have with both treatment and outcome to explain a specific treatment-outcome association, conditional on the measured covariates. We calculated *E*-values for the observed AORs to estimate the strength of association that an unmeasured variable would need to have with nicotine product use and psychological distress to explain the positive product use-mental health association. (Vanderweele and Ding, 2017).

3. Results

A total of 32,727 adults in Great Britain were included in the analytic sample between October 2020 and February 2022. Table 1 presents weighted sample characteristics. The median score for psychological distress using the Kessler measure was 2 (IQR 5; range 0–24); a positively skewed distribution (Figure S1).

3.1. Association between distress and time since quit

Any past-month psychological distress (Fig. 1) was higher among people who currently smoked (42·4%, 95 % CI 41·1-43·8), past 6-month former-smokers (43·1%, 37·5-48·8) and 6–12 month former-smokers (44·3%, 39·0-49·8) than among people who stopped smoking > 1y ago (24·3%, 23·3-25·3) and never smokers (25·4%, 24·8-26·0). Similar patterns were observed for both moderate and serious distress (Fig. 1).

In unadjusted and adjusted logistic regression models, never smokers and > 1y former smokers had lower odds of any distress compared with smokers (Table 2). This was true for both those who had ever been diagnosed with a mental health condition, and those reporting no diagnosis. However, there was an interaction such that the associations with distress among > 1y former-smokers and never smokers were more pronounced among those with a diagnosis (AOR = 0·58, 95 % CI 0·51-0·66; 0·60, 0·53-0·67) than among those with no diagnosis (0.86, 0·76-0·98; 0·72, 0·65-0·81) (Table S1 and Figure S2). In a sensitivity analysis, recoding the past 6-month former-smoker category so that past-month former smokers were a distinct group did not have any impact on the results (Table S4).

Table 1
Characteristics of sample (weighted data).

	GB
Characteristic %, (n)	N = 32,593
Age	
16–24	10.9 %, (3,557)
25–34	17.1 %, (5,583)
35–44	16.0 %, (5,206)
45–54	17.1 % (5,561)
55–64	15.5 % (5,049)
65+	23.4 % (7,636)
Sex	
Men	48.9 % (15,940)
Women	51.1 % (16,648)
In another way	0.0 % (4)
Social grade	
ABC1	54.2 % (16,959)
C2DE	45.8 % (14,350)
Unknown	1,294
Region	
London	13.2 % (4,318)
Northern England	24.0 % (7,827)
Central England	26.2 % (8,534)
Southern England	23.0 % (7,484)
Wales	4.8 % (1,571)
Scotland	8.8 % (2860)
Smoking status	
Smoker	16.5 % (5,311)
Past 6 m former-smoker	1.0 % (317)
6–12 m former -smoker	1.0 % (341)
>1y former -smoker	23.5 % (7,576)
Never smoker	58.0 % (18,718)
Unknown	331
Ever mental health diagnosis	
None	69.5 % (22,667)
Ever diagnosis	30.5 % (9,925)
Use of nicotine product (former-smokers only)	
No nicotine	85.1 % (7,090)
Nicotine	14.9 % (1,242)
E-cigarette*	11.3 % (937)
HTP/Pouch	0.3 % (26)
NRT	3.4 % (279)

Data from October 2020 - February 2022.
Those with missing data (labelled "unknown" were excluded from the analytic sample.
[1]Unweighted N = 32,727.
* Including some non-nicotine e-cigarette use.

The median number of years participants had quit smoking was 17 (IQR 38·5; range 1–78 (Figure S3). The fitted non-linear trend indicated a potential decline in distress with years since quitting among all adults (from 43·3% (95 % CI 34·7-52·3) in year 1 to 35·6% (26·9-45·5) in year 40 (Figure S4). A potential decline was also apparent among those who had ever been diagnosed with a mental health condition (from 66·5% (57·1-74·8) in year 1 to 60·5% (49·7-70·3) in year 40). While this may signal a decline, the confidence intervals for estimates included the possibility of no association and should be viewed with caution. There was little change in distress among those without a diagnosis according to years since quit. People reporting a diagnosis had higher distress than those with none and this was persistent across years quit. The non-linear models were a better fit of the data than null and linear models ($\chi2(3) = 990$, $p < 0·001$; $\chi2(3) = 135·8$, $p < 0·001$).

3.2. Association between distress and nicotine use among former-smokers

The prevalence of any past-month psychological distress (Fig. 2) was

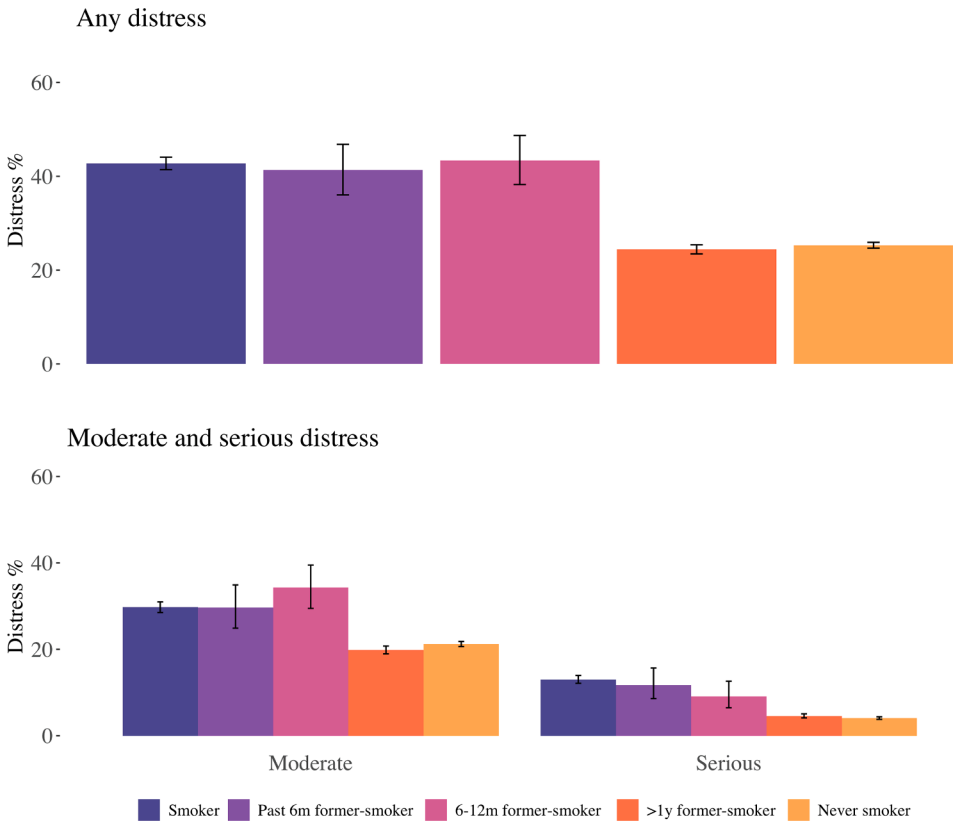

Fig. 1. Prevalence of psychological distress in Great Britain (weighted). [1]Unweighted N = 32,727. Data from October 2020 - February 2022.

Table 2
Association between past-month distress and smoking status in Great Britain.

	Model 1 (unadjusted) N = 32,405				Model 2 (adjusted) N = 30,619			
Variable	Distress % (Total N)	OR[1]	95 % CI[1]	P	Distress % (Total N)	OR[1]	95 % CI[1]	P
Smoking status								
Smoker	41.8 % (4,984)	1	—		41.7 % (4,679)	1	—	
Past 6 m former -smoker	40.8 % (292)	0.96	0.75, 1.21	0.72	40.4 % (270)	0.81	0.52, 1.22	0.16
6–12 m former -smoker	41.3 % (320)	0.98	0.77, 1.23	0.84	41.2 % (306)	0.99	0.68, 1.42	0.54
>1y former -smoker	23.3 % (7,938)	0.42	0.39, 0.45	<0.001	23.2 % (7,581)	0.86	0.76, 0.98	0.022
Never smoker	24.1 % (18,871)	0.44	0.41, 0.47	<0.001	24.1 % (17,783)	0.72	0.65, 0.81	<0.001
Ever mental health diagnosis								
None					16.2 % (21,360)	1	—	
Ever diagnosis					51.6 % (9,259)	5.76	5.04, 6.58	<0.001
Smoking status * Ever mental health diagnosis								
Past 6 m former smoker * Ever diagnosis						0.82	0.47, 1.47	0.5
6–12 m former smoker * Ever diagnosis						0.89	0.53, 1.52	0.66
>1y former smoker * Ever diagnosis						0.67	0.56, 0.80	<0.001
Never smoker * Ever diagnosis						0.83	0.71, 0.96	0.015

[1]OR = Odds Ratio, CI = Confidence Interval

Model 2 adjusted for sex, age, social grade, region and ever diagnosis with a mental health condition.

higher among former-smokers who used any nicotine product (37·2%, 95 % CI 34·6-39·9) than among those who did not use nicotine (24·1%, 23·1-25·1). We observed similar patterns according to nicotine use for both moderate and serious distress (Fig. 2). In unadjusted and adjusted logistic regression models, former-smokers who used nicotine had higher odds of any distress compared with former-smokers who did not use nicotine (Table 3). The *E*-value for the fully adjusted model was 1·42 (lower 95 % CI, 1·20).

In the unadjusted model assessing distress according to type of nicotine product used, those who used an e-cigarette, HTP/pouch or NRT, respectively, had higher odds of distress compared with those who did not use nicotine (Table 3). After adjustment, only NRT use was associated with distress. The *E*-value for the fully adjusted model was 1·85 (lower 95 % CI, 1·43). These results were mirrored by the sensitivity analyses including only > 1y former-smokers (Table S5). Further sensitivity analyses excluding non-nicotine e-cigarette users had little impact on the model (Table S6).

4. Discussion

Between October 2020 and February 2022 in Great Britain, past month psychological distress was higher among people who currently smoked smokers and people who had quit smoking for under one year than among those who had been quit for over one year and who never smoked. However, the lower odds of distress among those who had not smoked in the longer-term (>1 year) and never smoked compared with

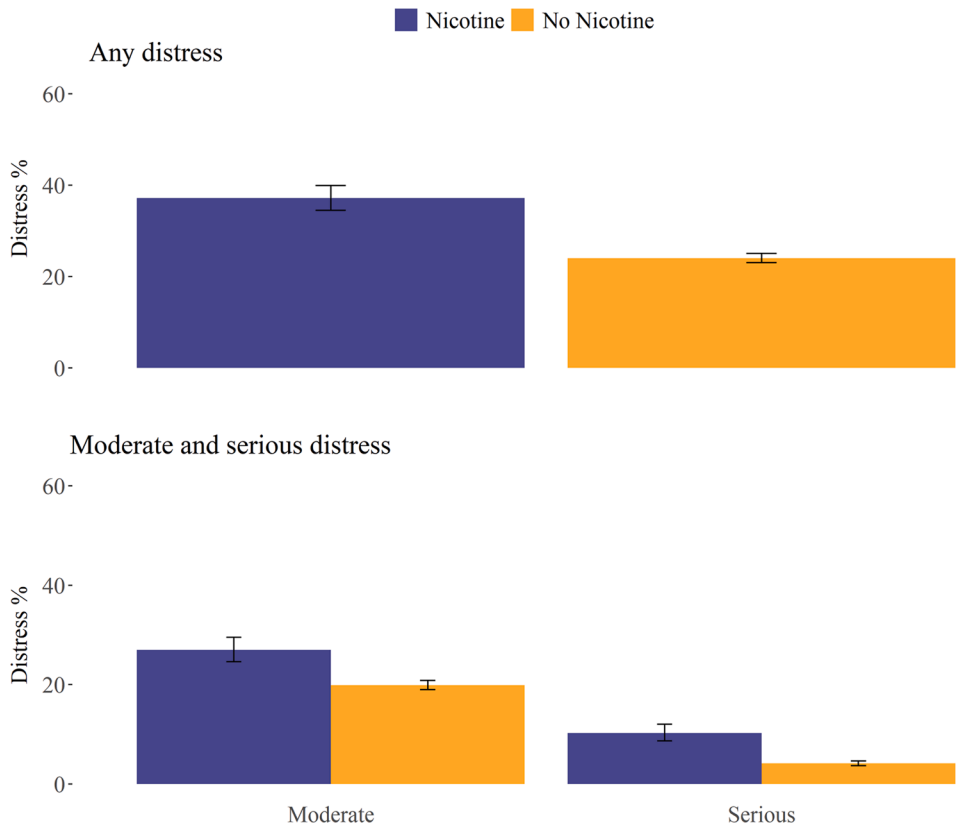

Fig. 2. Prevalence of psychological distress among former-smokers in Great Britain according to use of any nicotine product (weighted). Unweighted N = 8,651; Nicotine includes non-nicotine e-cigarette use (see sensitivity analyses).

Table 3
Association between past-month distress and use of non-combustible nicotine product among former smokers.

	Model 1 (unadjusted) N = 8,651				Model 2 (adjusted) N = 8,247			
Variable	Distress % (Total N)	OR[1]	95 % CI[1]	P	Distress % (Total N)	OR[1]	95 % CI[1]	P
Nicotine product use								
No nicotine	22.9 % (7,455)	1	—		22.9 % (7,111)	1	—	
Nicotine	35.9 % (1,196)	1.88	1.65, 2.14	<0.001	36.0 % (1,136)	1.23	1.06, 1.42	0.007
Nicotine product use								
No nicotine	22.9 % (7,455)	1	—		22.9 % (7,111)	1	—	
E-cigarette	35.0 % (894)	1.81	1.56, 2.10	<0.001	34.8 % (856)	1.12	0.94, 1.33	0.18
HTP/pouch	42.9 % (28)	2.52	1.16, 5.32	0.016	42.9 % (28)	1.61	0.70, 3.64	0.25
NRT	38.0 % (274)	2.06	1.60, 2.64	<0.001	39.3 % (252)	1.61	1.21, 2.13	<0.001

Model 2 adjusted for sex, age, social grade, region and ever diagnosis with a mental health condition.
Nicotine includes non-nicotine e-cigarette use (see sensitivity analyses).
[1] OR = Odds Ratio, CI = Confidence Interval.

those who currently smoked was more pronounced among those who had ever been diagnosed with a mental health condition. Distress was higher among people who formerly smoked who reported use of a non-combustible nicotine product compared with those reporting no use of any nicotine product, but this varied by product use; only use of NRT was associated with higher distress among those who formerly smoked.

A review on the longitudinal effects of smoking cessation on mental health concluded that cessation was associated with improvements in mental health symptoms compared with continued smoking.(Taylor GMJ, Lindson N, Farley A, Leinberger-Jabari A, Sawyer K, te Water Naudé R, et al. Smoking cessation for improving mental health. Cochrane Database of Systematic Reviews., 2021) Results from our current study suggest that these improvements may appear after at least one year abstinence from smoking. This finding held after separating out those who had quit up to one month ago - a group more likely experiencing the acute phase of withdrawal from smoking.(Gorniak et al., 2021) Improvements in physical health,(Spears et al., 2020 Jul) perceptions of own health and general health-related quality of life(Stewart et al., 1995 Dec 1) associated with smoking cessation often manifest in the medium to long-term after cessation. The associated benefits of these improvements on mental health likely occur with time. Importantly, if the association was driven by improvements in mental health that precede smoking cessation, we might expect to see lower levels of distress among past 6-month and 6–12 month former-smokers (who are unlikely to still be experiencing nicotine withdrawal). Rather our results show that there are similar levels of distress among smokers, past 6-month and 6–12 month former-smokers, and lower levels among > 1y former-smokers and never smokers. However, it remains plausible that of shorter-term (i.e. past-year) former-smokers, those with better mental health are more likely to stay quit. In this case although short-term quit success may not be driven by improved mental health, staying quit in the longer term (>1 year) may be. Public health messaging supporting

smoking cessation generally focuses on the physical health effects of smoking (e.g. cancers, respiratory illness(Durkin et al., 2012; [32]). Considering the persistent socioeconomic and mental health gradient in smoking prevalence, messaging on smoking cessation to improve mental health(Action on Smoking and Health. Public mental health and smoking: A framework for action - Action on Smoking and Health [Internet]., 2020) after a year of staying quit may appeal to the third of smokers with mental health problems and those who are aware of the physical effects but continue to smoke or who struggle to quit.(Costello et al., 2012 Sep).

Ever diagnosis with a mental health condition was associated with much higher odds of past-month distress. Similar findings have been highlighted in other populations and reflect the increased likelihood of experiencing mental health symptomology among those with a previous episode or diagnosis.(Nishi et al., 2020 Mar; Segal et al., 2003 Nov 1; Seimyr et al., 2013 Feb 1) Our results suggest that those with a history of mental health disorder(s) may experience greater improvements in mental health than those without a previous diagnosis. This is supported to an extent by our exploratory analysis of distress according to years since quit, where distress was persistently higher among those reporting ever diagnosis with a mental health condition but may have declined modestly and gradually over time. However, these findings must be viewed as exploratory given the uncertainty in estimates and the potential for a 'floor effect' of distress among those who do not report ever being diagnosed with a mental health condition, with declines among those with a diagnosis due to a higher starting point and 'regression to the mean' rather than persistent abstinence from smoking.

It is possible that some individuals in our sample have a mental health condition that is undiagnosed, and that we may therefore be underestimating the true prevalence of diagnoses. Unfortunately, this is not something that we could adjust for as individuals may not themselves know how to clinically categorise their own mental health. Our analysis adjusts for ever diagnosis with a mental health condition, rather than the actual experience of a mental health condition, and therefore provides an approximation of the proportion of the population who have ever experienced a mental health condition. Nonetheless the effects of including ever diagnosis in our analysis are nonetheless very clear, and it is unlikely that these findings would be drastically altered by having (potentially) more accurate approximation of experienced mental health conditions. Finally, the primary outcome - the Kessler (K6) diagnostic screening tool - is a validated measure that identifies individuals with a high likelihood of being diagnosed with mental illness and its associated effects (Kessler et al., 2010), and those with high scores in the K6 will to a degree represent those who may not have been diagnosed by a clinician.

We found higher odds of distress among people who formerly smoked and were using any non-combustible nicotine product compared with no use. When assessing by type of nicotine product used, our associations held for NRT, but not other product use (e-cigarettes, HTP/pouches). Importantly, we cannot infer the direction of this association. People who previously smoked with symptoms of poor mental health and higher nicotine dependence may be more likely to seek treatment and use nicotine as a form of self-medication or coping strategy,(Benowitz, 2009 Feb; van der Heijden et al., 2022) and thus self-select into our sample of former-smokers.(Spears et al., 2020 Jul; McNeill et al., 2019 Oct 15) Adjustment for relevant sociodemographic covariates appeared to attenuate all estimates, suggesting some potential for self-selection. The respective *E*-values of 1·42 (for any nicotine product use) and 1·85 (for NRT use specifically) indicate that an unmeasured confounder would need to have an association with both nicotine product use and psychological distress of at least these effect sizes to explain the association. Research examining the role of nicotine dependence among cigarette smokers and smokeless tobacco users has found positive associations between product use and mental disorders in the region of AORs 1–1.9 (depending on product). It is plausible that unmeasured nicotine dependence among respondents in our current study explains the observed associations.

It is possible that nicotine users experience symptoms of distress due to the ongoing effects of nicotine withdrawal.(Hughes, 2007 Mar 1) Nonetheless, quitting nicotine entirely should be weighed against the possible benefit of using nicotine products to prevent relapse to smoking, and the potential improvements in mental health following smoking cessation. Future research should use longitudinal methods to regularly track changes in mental health outcomes before, during and after a smoking cessation attempt into the long term, compared with continued smoking, or use of a nicotine containing product.

Limitations of this study include the inability to infer directionality in the associations between smoking status, nicotine product use and mental health. It is possible that some participants with previous history of mental illness, or that those with past-month distress, did not report it. Participants underreporting their experience of distress in the survey may also be those who underreport previous history of mental illness. This would be particularly important in our current analysis if there was a pattern of underreporting such that former smokers were less likely to report mental health information (thus selecting a sample of former smokers who had better mental health). Reassuringly, although missing, the pattern of missingness appears similar between our groups of interest and unlikely to bias the results. Moreover, the list of mental health diagnoses in the "ever diagnosis" variable included obsessive compulsive disorder, and autism which have been associated with lower likelihood of smoking.(Abramovitch et al., 2015; Bejerot and Nylander, 2003) Given that only ~ 1.5 % of cases report these conditions each wave it is unlikely that these impacted are overall results given that all other included mental health conditions are associated with smoking.

Due to small case numbers and restriction of the question to only those who had smoked in the past year, we were unable to include frequency and duration of nicotine use since quitting smoking. Results may be impacted due to data collection coinciding with several waves of the COVID-19 pandemic, and its associated impact on mental health. (Kock et al., 2021; Daly et al., 2020) Qualitative research into the specific stressors that people who formerly smoked experience in the months and years after quitting may help us understand the potential relationship between cessation and improved mental health. It remains possible that some people quit smoking for health reasons that remained distressing during the immediate period of abstinence, but which attenuated with time.

In conclusion, among adults in Great Britain, people who had never smoked and not smoked for > 1 year had lower levels of distress compared with those who currently smoked and or had quit in the past year, suggesting that improvements in mental health following cessation are possible after a year or more of abstinence. Nicotine use among people who formerly smoked is associated with higher levels of distress, but due to the potential for selection bias and confounding more research is needed to determine causality.

CRediT authorship contribution statement

Loren Kock: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Jamie Brown:** Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. **Sharon Cox:** Conceptualization, Methodology, Writing – review & editing. **Ann McNeill:** Conceptualization, Methodology, Writing – review & editing. **Debbie Robson:** Conceptualization, Methodology, Writing – review & editing. **Lion Shahab:** Conceptualization, Methodology, Writing – review & editing. **Harry Tattan-Birch:** Conceptualization, Methodology, Writing – review & editing. **Leonie S. Brose:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Statistical code and data for variables used in the analysis are available at https://osf.io/n6v97

Acknowledgements

All authors conceived of the study and contributed to the study analysis plan. LK conducted the analysis and write up. All authors contributed to the final manuscript. LK is the guarantor of this work and, as such, had full access to all the data and take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

Funding for STS data collection in England is supported by Cancer Research UK (PRCRPG-Nov21\100002). This work is also supported by the UK Prevention Research Partnership (MR/S037519/1), which is funded by the British Heart Foundation, Cancer Research UK, Chief Scientist Office of the Scottish Government Health and Social Care Directorates, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Health and Social Care Research and Development Division (Welsh Government), Medical Research Council, National Institute for Health Research, Natural Environment Research Council, Public Health Agency (Northern Ireland), The Health Foundation and Wellcome.

Declaration of interests

LB, LK, and SC have none to declare. JB reports receiving grants from Cancer Research UK during the conduct of the study and receiving unrestricted research funding from pharmaceutical companies who manufacture smoking cessation medications to study smoking cessation outside the submitted work. LS reports receiving honoraria for talks, receiving an unrestricted research grant and travel expenses to attend meetings and workshops by pharmaceutical companies that make smoking cessation products (Pfizer and Johnson & Johnson), and acting as a paid reviewer for grant-awarding bodies and as a paid consultant for health care companies. DR is funded by National Institute for Health Research (NIHR) South London Applied Research Collaboration. AM is NIHR Senior Investigator. The views expressed in this article are those of the authors and not necessarily those of NIHR or the UK Department of Health and Social Care.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2022.107570.

References

Office for Health Improvement and Disparities. Public health profiles - Smoking [Internet]. 2021 [cited 2022 Feb 17]. Available from: https://fingertips.phe.org.uk/search/smoking.

Wootton, R. E., Richmond, R. C., Stuijfzand, B. G., Lawn, R. B., Sallis, H. M., Taylor, G. M. J., et al. (2020). Evidence for causal effects of lifetime smoking on risk for depression and schizophrenia: A Mendelian randomisation study. *Psychol Med., 50*(14), 2435–2443.

Fluharty, M., Taylor, A. E., Grabski, M., & Munafò, M. R. (2017). The association of cigarette smoking with depression and anxiety: A systematic review. In *Nicotine and Tobacco Research* (Vol. 19, pp. 3–13). Oxford University Press.

Leung, J., Gartner, C., Hall, W., Lucke, J., & Dobson, A. (2012). A longitudinal study of the bi-directional relationship between tobacco smoking and psychological distress in a community sample of young Australian women. *Psychol Med., 42*(6), 1273–1282.

Treur, J. L., Munafò, M. R., Logtenberg, E., Wiers, R. W., & Verweij, K. J. H. (2021). Using Mendelian randomization analysis to better understand the relationship between mental health and substance use: A systematic review. *Psychol Med., 1–32*.

Spring, B., Pingitore, R., & McChargue, D. E. (2003 Feb). Reward value of cigarette smoking for comparably heavy smoking schizophrenic, depressed, and nonpatient smokers. *Am J Psychiatry., 160*(2), 316–322.

Le Moal, M., & Koob, G. F. (2007). Drug addiction: Pathways to the disease and pathophysiological perspectives. *European Neuropsychopharmacology., 17*(6–7), 377–393.

Benowitz NL. Nicotine Addiction. Schwartz RS, editor. New England Journal of Medicine. 2010 Jun 17;362(24):2295–303.

Benowitz, N. L. (2009 Feb). Pharmacology of Nicotine: Addiction, Smoking-Induced Disease, and Therapeutics. *Annu Rev Pharmacol Toxicol., 49*(1), 57–71.

Mansvelder, H. D., & McGehee, D. S. (2002). Cellular and synaptic mechanisms of nicotine addiction. *J Neurobiol., 53*(4), 606–617.

Taylor, G. M. J., Itani, T., Thomas, K. H., Rai, D., Jones, T., Windmeijer, F., et al. (2020). Prescribing prevalence, effectiveness, and mental health safety of smoking cessation medicines in patients with mental disorders. *Nicotine and Tobacco Research., 22*(1), 48–57.

Taylor GMJ, Lindson N, Farley A, Leinberger-Jabari A, Sawyer K, te Water Naudé R, et al. Smoking cessation for improving mental health. Cochrane Database of Systematic Reviews. 2021 Mar 9;2021(3).

Wootton R, Sallis H, Munafò M. Is there a causal effect of smoking on mental health? A summary of the evidence. 2022.

Nishi, D., Imamura, K., Watanabe, K., Ishikawa, H., Tachimori, H., Takeshima, T., et al. (2020 Mar). Psychological distress with and without a history of depression: Results from the World Mental Health Japan 2nd Survey (WMHJ2). *J Affect Disord., 15*(265), 545–551.

Segal, Z. V., Pearson, J. L., & Thase, M. E. (2003 Nov 1). Challenges in preventing relapse in major depression: Report of a National Institute of Mental Health Workshop on state of the science of relapse prevention in major depression. *J Affect Disord., 77*(2), 97–108.

McNeill A, Brose L, Calder R, Simonavicius E, Robson D. Vaping in England: An evidence update including vaping for smoking cessation, February 2021. Public Health England: London, UK. 2021;1–247.

Kock, L., Shahab, L., Moore, G., Beard, E., Bauld, L., Reid, G., et al. (2021 Mar). Protocol for expansion of an existing national monthly survey of smoking behaviour and alcohol use in England to Scotland and Wales: The Smoking and Alcohol Toolkit Study. *Wellcome Open Res., 29*(6), 67.

Fidler, J. A., Shahab, L., West, O., Jarvis, M. J., McEwen, A., Stapleton, J. A., et al. (2011 Jun). "The smoking toolkit study": A national study of smoking and smoking cessation in England. *BMC Public Health., 18*(11), 479.

Jackson, S. E., Beard, E., Kujawski, B., Sunyer, E., Michie, S., Shahab, L., et al. (2019). Comparison of trends in self-reported cigarette consumption and sales in England, 2011 to 2018. *JAMA Netw Open., 2*(8), e1910161–e.

Kessler, R. C., Andrews, G., Colpe, L. J., Hiripi, E., Mroczek, D. K., Normand, S.-L., et al. (2002). Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychol Med., 32*(6), 959–976.

Kessler, R. C., Green, J. G., Gruber, M. J., Sampson, N. A., Bromet, E., Cuitan, M., et al. (2010). Screening for serious mental illness in the general population with the K6 screening scale: Results from the WHO World Mental Health (WMH) survey initiative. *Int J Methods Psychiatr Res., 19*(S1), 4–22.

Prochaska, J. J., Sung, H., Max, W., Shi, Y., & Ong, M. (2012). Validity study of the K6 scale as a measure of moderate mental distress based on mental health treatment need and utilization. *Int J Methods Psychiatr Res., 21*(2), 88–97.

NHS Digital. Adult Psychiatric Morbidity Survey: Survey of Mental Health and Wellbeing, England [Internet]. 2014 [cited 2022 Oct 18]. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/adult-psychiatric-morbidity-survey/adult-psychiatric-morbidity-survey-survey-of-mental-health-and-wellbeing-england-2014.

Tattan-Birch, H., Brown, J., Shahab, L., & Jackson, S. E. (2021). Trends in use of e-cigarette device types and heated tobacco products from 2016 to 2020 in England. *Sci Rep., 11*(1), 1–11.

NRS. National Readership Survey - Social Grade [Internet]. 2017 [cited 2017 Nov 24]. Available from: http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/.

Groenwold RHH, Donders ART, Roes KCB, Harrell FE, Moons KGM. Dealing With Missing Outcome Data in Randomized Trials and Observational Studies. Am J Epidemiol [Internet]. 2012 Feb 1 [cited 2022 Oct 24];175(3):210–7. Available from: https://academic.oup.com/aje/article/175/3/210/105550.

Vanderweele, T. J., & Ding, P. (2017). Sensitivity Analysis in Observational Research: Introducing the E-Value. *Ann Intern Med., 167*, 268–274.

Gorniak, B., Yong, H., Borland, R., Cummings, K. M., Thrasher, J. F., McNeill, A., et al. (2021). Do post-quitting experiences predict smoking relapse among former smokers in Australia and the United Kingdom? Findings from the International Tobacco Control Surveys. *Drug Alcohol Rev.*

Spears, C. A., Jones, D. M., Weaver, S. R., Yang, B., Pechacek, T. F., & Eriksen, M. P. (2020 Jul). Use of and perceptions about electronic nicotine delivery systems (ENDS) among people with mental health conditions or serious psychological distress, 2018. *Drug Alcohol Depend., 1*(212), Article 108049.

Stewart, A. L., King, A. C., Killen, J. D., & Ritter, P. L. (1995 Dec 1). Does smoking cessation improve health-related quality-of-life? *Annals of Behavioral Medicine., 17*(4), 331–338.

Durkin, S., Brennan, E., & Wakefield, M. (2012). Mass media campaigns to promote smoking cessation among adults: An integrative review. *Tob Control., 21*(2), 127–138.

[32] National Health Service (NHS). What are the health risks of smoking? [Internet]. 2022 [cited 2022 Aug 19]. Available from: https://www.nhs.uk/common-health-questions/lifestyle/what-are-the-health-risks-of-smoking/.

Action on Smoking and Health. Public mental health and smoking: A framework for action - Action on Smoking and Health [Internet]. 2020 [cited 2022 Aug 18]. Available from: https://ash.org.uk/information-and-resources/reports-submissions/reports/public-mental-health-and-smoking-a-framework-for-action/.

Costello, M. J., Logel, C., Fong, G. T., Zanna, M. P., & McDonald, P. W. (2012 Sep). Perceived Risk and Quitting Behaviors: Results From the ITC 4-Country Survey. *Am J Health Behav., 36*(5), 681.

Seimyr, L., Welles-Nyström, B., & Nissen, E. (2013 Feb 1). A history of mental health problems may predict maternal distress in women postpartum. *Midwifery., 29*(2), 122–131.

van der Heijden, H. S., Schirmbeck, F., Berry, L., Simons, C. J. P., Bartels-Velthuis, A. A., Bruggeman, R., et al. (2022). Impact of coping styles on substance use in persons with psychosis, siblings, and controls. *Schizophr Res., 241*, 102–109.

McNeill, A., Driezen, P., Hitchman, S. C., Cummings, K. M., Fong, G. T., & Borland, R. (2019 Oct 15). Indicators of cigarette smoking dependence and relapse in former smokers who vape compared with those who do not: Findings from the 2016 International Tobacco Control Four Country Smoking and Vaping Survey. *Addiction., 114*(S1), 49–60.

Hughes, J. (2007 Mar 1). Effects of abstinence from tobacco: Valid symptoms and time course. *Nicotine & Tobacco Research., 9*(3), 315–327.

Abramovitch, A., Pizzagalli, D. A., Geller, D. A., Reuman, L., & Wilhelm, S. (2015). Cigarette smoking in obsessive-compulsive disorder and unaffected parents of OCD patients. *European Psychiatry., 30*(1), 137–144.

Bejerot, S., & Nylander, L. (2003). Low prevalence of smoking in patients with autism spectrum disorders. *Psychiatry Res., 119*(1–2), 177–182.

Kock, L., Brown, J., Shahab, L., Moore, G., Horton, M., & Brose, L. (2021). Smoking, distress and COVID-19 in England: Cross-sectional population surveys from 2016 to 2020. *Prev Med Rep., 23*, Article 101420.

Daly M, Sutin A, Robinson E. Longitudinal changes in mental health and the COVID-19 pandemic: Evidence from the UK Household Longitudinal Study. 2020.