Review Paper

Impact of COVID-19 lockdown on smoking and vaping: systematic review and meta-analysis

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A B S T R A C T

Objectives: COVID-19 and the implementation of lockdowns have impacted daily lives worldwide. This systematic review and meta-analysis aimed to investigate the impact of lockdowns on the smoking and vaping behaviours of adults during the pandemic.
Study design: This was a systematic review and meta-analysis.
Methods: A systematic literature search was conducted up to 28 April 2022 in the following databases: PubMed, Embase and Web of Science.
Results: In total, 77 studies met the inclusion criteria for this review. In 34 studies, an increase in smoking behaviour was reported for the majority of participants; however, in 21 and 18 studies, 'no change' and 'decrease' in smoking were the predominant responses, respectively. The results from the meta-analysis, which examined the change in the number of cigarettes smoked per day, showed no difference between the pre- and post-lockdown periods: 0.81 weighted mean difference (95% confidence interval, −0.59 to 2.21). Regarding vaping, three of seven studies reported an increase in smoking for the majority of participants, whereas 'no change' and 'decrease' were the predominant answers in the other four studies.
Conclusions: The results show that lockdowns led most participants to increase smoking/vaping, whereas a decrease or cessation of smoking/vaping was only reported in the minority of participants. Attention should be given to the non-communicable diseases that could arise as a result of the increase in smoking/vaping during lockdowns, and further research in this area is needed.

Introduction

The novel COVID-19 was initially detected in Wuhan, China, near the end of 2019. On 11 March 2020, a pandemic was declared by the World Health Organization.[1] COVID-19 spread quickly because of its extended incubation period and highly infectious characteristics, as well as significant worldwide networking and significant global travel activities.[2] By April 2022, COVID-19 had infected over 300 million individuals and resulted in over 6.2 million deaths.[3] Although the global response to COVID-19 has been far from uniform, most countries have implemented self-isolation, homestay (or lockdown) requirements, social distancing or quarantine measures to reduce COVID-19 transmission and ease the burden on healthcare services until the vaccine became available; however, lockdowns also led to unexpectedly serious health repercussions.[4] Even after the approval and distribution of the vaccines, several countries continued to impose lockdowns when they deemed it essential; these lockdowns have impacted the everyday lives of many people and constituted a severe threat to individuals with addictive behaviours.[5] Evidence on the risk of contracting COVID-19 based on smoking status remains inadequate and conflicting, underlining the need to increase quantitative research with more rigorous study designs.[6−8] Smoking appears to be connected to higher COVID-19 hospitalisation and mortality, even if the linkage for current smokers is still ambiguous.[6,9,10]

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COVID-19 preventive approaches, such as social distancing and stay-at-home mandates, had a significant impact on interpersonal dynamics.[11,12] Many people were confined to their homes during lockdown periods, either alone, with family members or with other housemates, in addition to participating in fewer social and physical activities.[13−15] These modifications might be especially important for those who smoke in public places or who live with children or other vulnerable people.[16] Pandemic-related issues might also induce increased stress, which is known to lead to increased smoking on an individual basis.[17,18] Notably, after disasters or traumatic events in the United States, such as the September 11th terrorist attacks and Hurricane Katrina, smoking behaviours increased.[19] On the other hand, for some people, a respiratory illness epidemic (such as COVID-19) could be regarded as an ideal moment to decrease or quit smoking because of health concerns.[20] As a result, smoking behaviours could differ from pre-COVID-19 routines in terms of where, when and with whom people smoke; however, the results of current quantitative studies investigating the COVID-19 effects on smoking have shown conflicting results.[21−25]

It is therefore essential that data from existing quantitative research on the influence of COVID-19 on smoking and/or vaping behaviours are collected and analysed to get a more accurate conclusion of the impact of the pandemic on smoking and vaping habits. This study attempted to present an overview of the current data regarding the impact of COVID-19 lockdowns on smoking and vaping behaviours.

Methods

Search strategy and study selection

A systematic literature search was conducted in PubMed, Web of Science and Embase databases up to 28 April 2022. A combination of the key terms ((smoking) OR (tobacco) OR (vaping) OR (cigarette) OR (lifestyle)) AND ((Covid-19) OR (Covid) OR (Covid-19) OR (Sars-cov-2) OR (lockdown)) was used as a search string for PubMed and was modified accordingly for the other databases. The search strategy of this study can be found in Supplementary File S1. The studies identified through the literature search were added into reference manager software (Endnote X9; Thomson Reuters, for Windows) and were screened independently for eligibility by two reviewers (D.B. and K.E.). Any disagreement was solved by consensus. Reference lists of the eligible studies were also screened for additional relevant studies.

The present study was conducted according to the registered protocol in the OSF platform (https://osf.io/vj586/). Eligible studies were observational studies (prospective, retrospective cohort studies and cross-sectional studies) that examined the change in smoking and/or vaping behaviour of adults during the COVID-19 lockdowns. Retrospective studies that were started before the COVID-19 lockdowns were excluded to avoid any other confounding factors. Moreover, studies in which there was a statement that the results referred to combined smoking and vaping change were excluded. Studies that included children (aged <18 years) as a population of interest were also excluded. Editorials, letters to the editor, reviews and studies in languages other than English, French or Spanish were not included in this review.

Data extraction

Information from eligible studies was extracted independently by two authors (D.B. and K.E.) using a standardised data extraction form. Any discrepancies were resolved by consultation with a third author (M.C.) who was not involved in the initial procedure. Study identity (first author, year of publication), country of origin, sex, age and subgroups of participants (if applicable), period when the survey was conducted and information regarding smoking and/or vaping habit before and during/after the COVID-19 lockdown periods were recorded. Specifically, increase, decrease, no change, as well as initiation and cessation of smoking and/or vaping behaviour as a result of COVID-19 restriction measures were examined. Corresponding authors of articles with missing data were contacted and given a 2-week period to respond.

Quality assessment of the studies was conducted independently by two authors (D.B. and K.E.), and any disagreement was solved by consensus. The Joanna Briggs Institute Critical Appraisal tools for cross-sectional studies[26] was used as an instrument for quality assessment.

This systematic review and meta-analysis was completed in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines 2020[27] (Supplementary Table S1), and its registered protocol was submitted to the OSF platform (https://osf.io/vj586/).

Statistical analyses

A meta-analysis was conducted for studies in which the number of cigarettes before and during/after the COVID-19 lockdown was reported. Random effects in the meta-analytic model were used to estimate the differences of assessment effects in studies because of the high heterogeneity observed between studies. Furthermore, the weight of each study was calculated using the inverse variance method. Weighted mean difference was used because the outcome (number of cigarettes) was calculated using the same measurement scale (mean number of cigarettes and standard deviation). Assessment of the statistical heterogeneity between studies was calculated by the tau-squared and I^2 test. I^2 <25% indicated a low degree of heterogeneity, 25%−50% indicated moderate heterogeneity, and >50% to 70% showed significant heterogeneity. Percentages represented absolute changes in individuals' behaviours before and during/after lockdown. All statistical analyses were performed using the Review Manager (Version 5.4.1).

Results

Search results

A total of 14,848 studies were identified in the literature search up to 28 April 2022. After duplicate removal ($n = 6905$), 7943 studies were screened for eligibility. Subsequently, the application of inclusion and exclusion criteria led to 77 studies being included in this systematic review.[28−104] A flowchart of this process is presented in Fig. 1.

The characteristics of the included studies can be found in Tables 1 and 2. In total 207,841 adults from a significant geographical section of the globe (Albania, Australia, Bangladesh, Belgium, Brazil, Canada, China, Croatia, Cyprus, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, India, Italy, Israel, Jordan, Kuwait, Libya, Norway, Poland, Portugal, Romania, Russia, Slovenia, South Africa, Spain, Sweden, the Netherlands, Turkey, United Arab Emirates (UAE), The United Kingdom, Ukraine, The United States and Vietnam) were examined about their smoking and/or vaping behaviour. All the included studies had a cross-sectional design, except for one, which was a prospective cohort study.[77] The included studies assessed smoking/vaping behaviour using self-assessment questionnaires (online or not),[28−39,41−43,45,46,48−55,57−59,61−72,75−77,79,81,82,84,86−105] telephone interviews[40,44,47,56,73,78,80] or in-person interviews.[53,83,85,106]
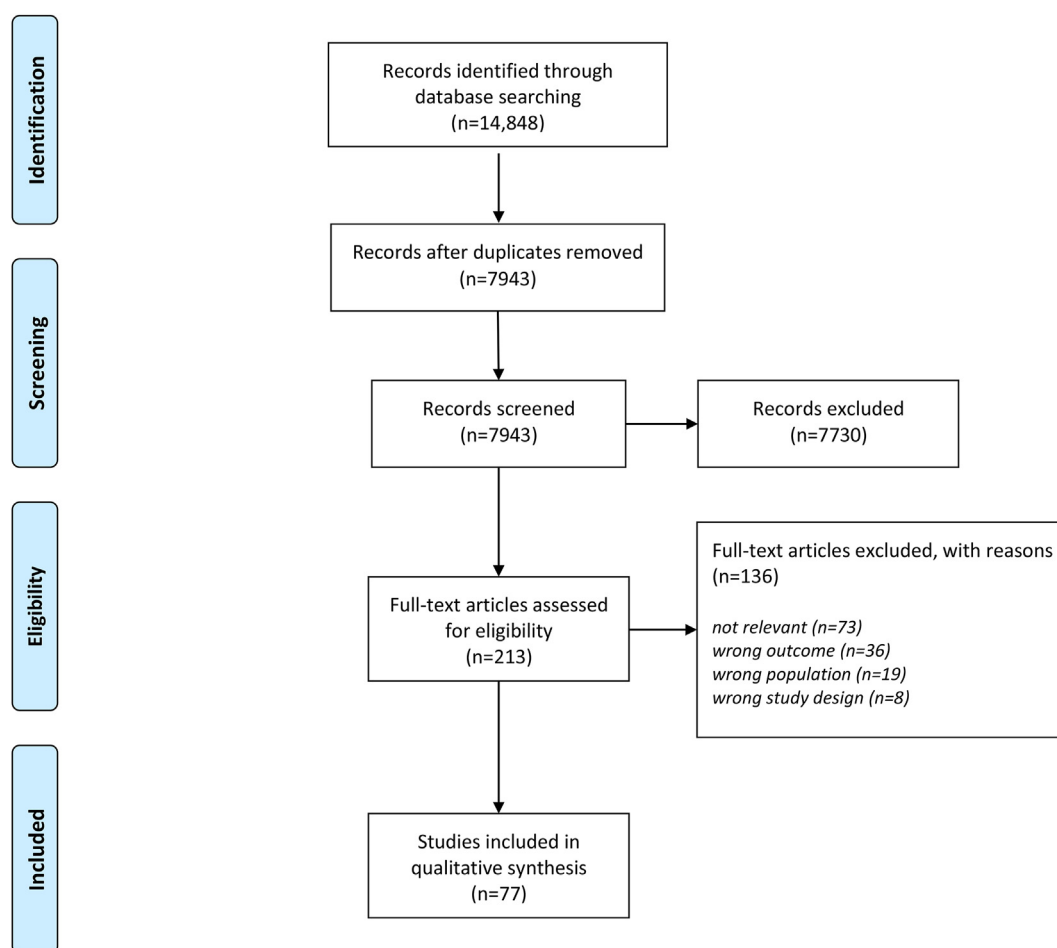
Fig. 1. Flow diagram of the study selection process.

Quality assessment

According to the Joanna Briggs Institute checklist for cross-sectional studies,[26] five of the 77 studies were characterised as 'best' in terms of quality, achieving high ratings in all domains.[64,73,82,87,99] All studies had appropriately defined inclusion criteria, and only two studies did not describe the subjects and settings in detail.[80,97] In most studies, biases and/or unclear statements were detected with reference to validation of exposure measures, criteria for measurement, identification of confounding factors and strategies to deal with the confounding factors.[28–63,65–72,75–81,83–86,88–98,100–105] With regard to outcome measurement, unclear information was provided in three studies,[45,78,101] and unclear statistical analyses were used in four[56,70,79,80] of 77 studies. Supplementary Table S2 provides full-quality assessment results.

Smoking behaviour

In 75 of 77 studies, information about smoking behaviour were reported[28–36,38–62,64–73,75–105] and can be found in Table 1. An increase in smoking habit was stated for most participants in 34 studies.[28,30–33,36,38,40,43,44,47–49,52,53,55,58,62,65,66,71,72,77,78,80,84,86,89,92,93,96,98,99,104,105] The change in smoking behaviour ranged from an increase of 0.4% in France[61] to 79.8% in Libya.[62] Countries that showed a clear increase in smoking habit were Belgium,[28,98]

Cyprus,[65] Croatia,[48] Israel,[32] Jordan,[30] Libya,[62] Romania[105] and Turkey.[31,53,96] Moreover, in the study by Manthey et al. that included a population from 21 European countries, an increase in smoking habit was reported in 43.3% of participants.[71]

A decrease in smoking behaviour was reported for the majority of participants in 18 studies.[29,39,42,45,46,54,57,59,60,67,76,79,83,85,87,90,100–102] Countries that showed a clear decrease or cessation of smoking were Poland,[54] UAE[87] and Vietnam.[83] Data about the percentages of participants who quit smoking were available from Belgium,[28,98] Brazil,[45] France,[61,86] Germany,[66] India,[60,76] Italy,[38] Japan,[69,94] Romania,[105] Spain[39] and Turkey[96,101] and ranged from 1% to 73% of participants.

For 21 studies, the majority of participants reported no change in smoking behaviour.[34,35,41,50,51,56,61,64,68–70,73,75,81,82,89,91,94,95,97,103] Countries where smoking behaviour remained stable included Albania,[50] Canada,[95,103] Japan,[69,94] Kuwait[88] and the Netherlands.[51,97]

Within-country variations in the change of smoking behaviours were reported in Australia,[55,91,92] Bangladesh,[29,73] Brazil,[45,70,84] China,[99,100] France,[36,40,44,59,61,75,86] Germany,[66,81] India,[42,60,67,76,90,93] Italy,[38,43,46,47,52,78] Spain,[33,34,39,82] Sweden,[35,49] the United Kingdom[58,77,79,80] and the United States.[41,56,57,64,68,72,85,89,102,104]

Data regarding the change in the number of cigarettes smoked per day varied between countries. In India, 10% of participants stated that they smoked 4-6 cigarettes per day before the COVID-19 lockdown, whereas during/after the lockdown the percentage was 0.5%.[42] On the contrary, in one study from Brazil, despite the fact

Table 1
Baseline characteristics and smoking behaviour before and after/during COVID-19 lockdowns.

First author, year (country)	Subjects (F/M/O) type	Age (years)	Time of survey conduction	Smoking: increase	Smoking: decrease	Smoking: No change	Smoking: quit	No smokers	Initiation of smoking	Efforts to reduce smoking	Smoking before the COVID-19 lockdowns	Smoking after/during the COVID-19 lockdowns
Adriaens 2021 (Belgium)[28]	202 (50/150/2)	≥18/39 (9.89)[a]	25 May to 8 June 2020	42.4%	16.9%	10.2%	30.5%					
Ahmed 2021 (Bangladesh)[29]	1222 (466/750)	18–82/ 30.8 (12.1)[a]	27 June to 20 July 2020	6.4%	48.6%	45%						
Al Domi 2021 (Jordan)[30]	4388 (3086/1302)	NA	March to April 2020	13.3%				71.4%				
Ayran 2021 (Turkey)[31]	503 (234/269)	21.6 (2.5)[a]	May to June 2020	32.4%						Yes: 41.9% No: 58.1%		
Bar-Zeev 2021 (Israel)[32]	660 (397/263)	40.2 (14.55)[a]	6–28 April 2020	44.3%	21.2%	34.5%				Yes: 16%		
Biviá-Roig 2021 (Spain)[33]	124 (124/0)	18–38/ 33.5 (3.7)[a]	28 October 2020	27.5%				72.5%				
Blithikioti 2021 (Spain)[34]	303 (186/113) Subjects with substance use disorders	49.3 (15.6)[a]	June to July 2020	5.4%	9.5%	85.1%					Never: 42.9% 1–2 times/year: 3.1% Monthly: 1% Weekly: 3.4% Daily: 49.7%	Never: 47.5% 1–2 times/year: 4% Monthly: 1.3% Weekly: 2.6% Daily: 44.6%
Blom 2021 (Sweden)[35]	5599 (2800/2800)	46.3 (11.0)[a]	21 April to 2 December 2020	1st wave (April to June): 0.8% 2nd wave (September to December): 0.5%	1st wave (April to June): 3.8% 2nd wave (September to December): 2.5%	1st wave (April to June): 95.4% 2nd wave (September to December): 97%						
Bourion-Bedes 2021 (France)[36]	3928 (2771/1154)	21.7 (4)[a]	7–17 May 2020	7.2%	6.3%	3%		83.5%				
Carreras 2021 (Italy)[38]	1400 (677/724) Current smokers	18–74	27 April to 3 May 2020	36.3%	15%		8.6%					
Celorio-Sardà 2021 (Spain)[39]	321 (256/65)	≥18	22 May to 3 July	22%	30%		15%	87.5%				
Chagué 2020 (France)[40]	124 (49/75) Subjects with congestive heart failure	71.0 (14.0)	17–24 March 2020	44.4%				92.7%				
Chertok 2020 (USA)[41]	180	≥18	Initiation on 7 April 2020	18.3%	21.3%	43.3%						
Chopra 2020 (India)[42]	995	18-85/ 33.3 (14.5)[a]	15–30 August 2020								No: 94.4% Yes, 1-3 cigarettes/day: 3.7% Yes, 4-6 cigarettes/day: 10% Yes, 7-9 cigarettes/day: 0.7% Yes, >10 cigarettes/day: 0.2%	No: 95.3% Yes, 1-3 cigarettes/day: 3.9% Yes, 4-6 cigarettes/day: 0.5% Yes, 7-9 cigarettes/day: 0.0% Yes, >10 cigarettes/day: 0.3%
Cirilo 2021 (Italy)[43]	140 Infertile women	18–49/ 39.4 (5)[a]	20 April to May 2020	27.3% (of smokers)								

Table 1 (continued)

First author, year (country)	Subjects (F/M/O) type	Age (years)	Time of survey conduction	Smoking: increase	Smoking: decrease	Smoking: No change	Smoking: quit	No smokers	Initiation of smoking	Efforts to reduce smoking	Smoking before the COVID-19 lockdowns	Smoking after/during the COVID-19 lockdowns
Cransac-Miet 2020 (France)[44]	195 Patients with chronic coronary syndromes	65.5 (11.1)[a]	April 2018 to April 2019	Smoking increase (>25%): 24.1%								
da Silva Leonel 2021 (Brazil)[45]	1515 (1120/395)	18−80/ 31.8 (11.5)[a]	June to July 2020				29.8%	90.5%	0.7% of non-smokers		>10 cigarettes/day: 11.9% 1−10 cigarettes/day: 51.5% No: 74.9% <5 cigarettes/day: 8.9% 5−10 cigarettes/day: 8.3% >10 cigarettes/day 7.9%	>10 cigarettes/day: 29.7% 1−10 cigarettes/day: 35.6% P < 0.001 No: 78.2% <5 cigarettes/day: 8.2% 5−10 cigarettes/day: 6.3% >10 cigarettes/day 7.3%
Di Renzo 2020 (Italy)[46]	3533 (2689/844)	40.03 (13.53)[a]	5−24 April 2020									
Di Santo 2020 (Italy)[47]	126 (102/24) Subjects with mild cognitive impairment or subjective cognitive decline	≥60/ 74.29 (6.51)[a]	21 April to 7 May 2020	33.3%	11.1%			85.71%				
Dogas 2020 (Croatia)[48]	3027 (1989/506)	40 (30-50)[b]	25 April to 5 May 2020								Number of cigarettes: 12.3 (7.8)[a]	Number of cigarettes: 14.3 (10.3)[a]
Ekstrom 2021 (Sweden)[49]	1064 (996/648)	25.3 (0.8)[a]	10 August to 10 November 2020								No: 68.8% Former smokers: 12.3% Occasionally: 12.4% Daily: 6.5%	No: 71.7% Former smokers: 13.6% Occasionally: 11% Daily: 3.7%
Elezi 2020 (Albania)[50]	1678 (1229/449)	26.49 (8.07)	4−29 April 2020	20.8%	39.1%	40.1%		87.7%				
Elling 2020 (The Netherlands)[51]	340 (207/133) Smokers willing to quit smoking	21−80 49 (13)[a]	26 March to 3 April 2020	13.8%	18.5%	67.7%						
Ferrante 2020 (Italy)[52]	7847	48.6 (13.9)[a]	21 April to 7 June 2020	29.5%								
Fidanci 2021 (Turkey)[53]	104 (50/54)	37.4 (10.7)[a]	May to November 2020								Very low dependence: 26.9% Low dependence: 16.3% Moderate dependence: 15.4% High dependence: 18.3% Very high dependence: 23.1%	Very low dependence: 14.4% Low dependence: 20.2% Moderate dependence: 14.4% High dependence: 23.1% Very high dependence: 27.9%
Fila-Witecka 2021 (Poland)[54]	980 (733/247)	22.24 (2.46)[a]	12 May to 30 June 2020	11%	16%							
Gendall 2020 (Australia)[55]	261 (128/133)	≥18	15−18 April 2020								Daily smokers: 11.1% Weekly smokers: 9.1%	Daily smokers: 13% Weekly smokers: 9.5%
Gonzalez 2021 (USA)[57]	2571	≥18	March to May 2020								Number of cigarettes: 13 (8.91)[a]	Number of cigarettes: 11.8 (7.8)[a]
Giovenco 2021 (USA)[56]	44 (24/20) Smokers	≥18	14−24 April 2020	18.2%	13.6%	68.2%						
Grogan 2020 (UK)[58]	132 (73/55/4) Smokers	25 (19-52)[b]	22 May to 22 June 2020	12%								
Guignard 2021 (France)[59]	2003 (1049/954)	≥18	30 March to 1 April 2020	26.7%	38.3%			78.9%				
Gupte 2020 (India)[60]	650 Smokers		14−28 May 2020				34%					
Hansel 2021 (France)[61]	5280 (2677/2587/16)		23−28 April 2020	0.4%	3.3%	90.1%	2.3%					

Jahan 2021 (Libya)[62]	683 (399/284)	≥18	10 October to 10 November 2020	79.8%				85.6%			
Knell 2020 (USA)[64]	1809 (1220/589)	35–49	15 April to 5 May 2020	30.5%	19.2%	50.3%		74.7%			
Kolokotroni 2021 (Cyprus)[65]	745 (550/195)	39 (13)[a]	10 April to 12 May 2020	43.8%	28.1%						
Koopmann 2021 (Germany)[66]	3116	≥18	8 April to 11 May 2020	45.8%	9.0%	31.3%	9.9%	75.7%	4.0%		
Kovil 2020 (India)[67]	343 (110/233) Subjects with T2DM	55 (13.0)[a]	10–16 April 2020							12.2%	8.4%
Kowitt 2020 (USA)[68]	777 (380/389)	39.9 (13.4)[a]	23 April to 7 May 2020	40.9%	17.8%	41.3%				Yes: 46.5%	
Koyama 2021 (Japan)[69]	5120 (2505/2615) Smokers		27 May to 14 June 2020	32.1%	11.3%	44.8%	11.9%				
Malta 2021 (Brazil)[70]	45,161 (26,206/18,955)	≥18	24 April to 24 May 2020	34% (6.4% increase 1-5 cigarettes, 22.5% increase 10 cigarettes, 5.1% increase >20 cigarettes)	12.1%	53.9%		88%			
Manthey et al., 2021 (21 European countries)[71,c]	9816 (4574/5114/128) Smokers	18–98	24 April to 22 July 2020	43.3%	39.6%	17.1%					
Matsungo 2020 (USA)[72]	507 (283/166)	≥18	11–25 May 2020	6.6%	4%	3.7%		85.7%			
Mistry 2021 (Bangladesh)[73]	1032(676/356)	≥60	October 2020	15.9%		84.1%		54.4%			
Mititelu 2021 (Romania)[74]	805 (158/647)	≥20	8–26 July 2020	17.8% (of smokers)			1.8%	70.1%			
Mounir 2021 (France)[75]	702 (564/138)	≥18	18 May to 6 June 2020	24%	4.1%	71.5%					
Naik 2021 (India)[76]	116 (10/106)	>18	December 2020		60.3%	24.1%	27.6%	67.4%			
Naughton 2021 (UK)[77]	1044 (747/279/2)	≥18	8 April to 18 May 2020					63.8%		9.6%	10.8%
Odone 2021 (Italy)[78]	6003	18–74	27 April to 3 May 2020	44%	24%	28%					
O'Donnell 2021 (UK)[79]	25 (12/13)	22–73	September to November 2020							23.3%	21.9%
Osinibi 2021 (UK)[80]	50		January to February 2021	32%	34%	34%					
Palmer 2021 (Germany)[81]	827 (622/205)	18–29	12 March to 3 May 2020	4.9%	5.4%	89.7%					
Pérez-Rodrigo. 2021 (Spain)[82]	1036 (735/301)	≥18	21 April to 8 May 2020	14.1%	14.7%	16.5%					
Pham 2020 (Vietnam)[83]	8291 (4890/3401)	18–85	14 February to 31 May 2020								Never, stopped, or smoke less: 91% Unchanged or smoke more: 9%
Prezotti 2021 (Brazil)[84]	275 (26/249)	30 years (28-31)[b]	11–19 June 2020	53.6% (of smokers)	7.1%			88.6%			
	694 (414/280)	≥18		32%		31%					

Table 1 (*continued*)

First author, year (country)	Subjects (F/M/O) type	Age (years)	Time of survey conduction	Smoking: increase	Smoking: decrease	Smoking: No change	Smoking: quit	No smokers	Initiation of smoking	Efforts to reduce smoking	Smoking before the COVID-19 lockdowns	Smoking after/during the COVID-19 lockdowns
Rigotti 2021 (USA)[85]			18 May to 16 July 2020		37% (including 8% quit)							
Rossinot 2020 (France)[86]	1454 (924/523/7)	24–65	23 April to 7 May 2020	11.2%	6.3%	10.2%	72.3%					
Saddik 2021 (UAE)[87]	1469 (1216/253)	≥18	24 March to 15 May 2020	Started/increased: 13%	Stop/decreased: 49%							
Salman 2021 (Kuwait)[88]	679 (393/286)	≥21	19 June to 15 July 2020	9.1%	5%	10.3%		75.6%				
Sharma 2020 (USA)[89]	542 (436/106)	18–25/ 22 (2.1)[a]	April to May 2020	8.3%	16.2%			75.5%				
Singh 2021 (India)[90]	10,008	18–81	20 May 2020								I don't smoke: 87%/party smoker: 6.5%/at least 1 cigarette/day: 6.4%	I don't smoke: 94.3%/party smoker: 2.4%/at least 1 cigarette/day: 3.3%
Stanton 2020 (Australia)[91]	4183 (999/484)	50.5 (14.9)[a]	9–19 April 2020	6.9% (negative change)	3.4% (positive change)	89.7%						
Stubbs 2021 (Australia)[92]	317 (227/89/1)	>18	Mid-March 2020 to the end of May 2020	56%	10%	33%		88.9%				
Sujatha 2021 (India)[93]	729 (132/597)	44.1 (14.4)[a]	NA	69%	49%	22%						
Suka 2021 (Japan)[94]	8000 (4000/4000)	25–64	November 2020	2.2%	3.8%	81.5%	12.4%					
Tavolacci 2021 (Canada)[95]	3671 (2676/995)	20.9 (2.47)[a]	13–31 May 2020	2% (unfavourable change)	5.8% (favourable change)	92.2%					Regular: 14% Occasional: 4.5%	Regular: 12.4% Occasional: 2.4%
Uysal 2021 (Turkey)[96]	615 (422/193)	18–90	30 June to 30 September 2020	18.2% (initiation) 15.9% increase	14.5%		12.2%					
Van der Werf 2021 (The Netherlands)[97]	1004 (509/495)	≥18	22–27 May 2020	3.7%	8.3%	59.3%		Unknown: 28.8%				
Vanderbruggen. 2020 (Belgium)[98]	3632	42,1 (14.6)[a]	9–29 April 2020	0.9% *(initiation)* 7.4% *(increase)*	2.5%		1%					
Yan 2020 (China)[99]	9016 (5177/3839)	≥18	25 April to 11 May 11 2020	49.2%	28.5%	22.3%						
Yang 2021 (China)[100]	11,500 (5635/5865)	36.79	October 2020	14.9%	18.5%	8.7%		57.9%				
Yenibertiz 2021 (Turkey)[101]	105 (42/63)	39.80 (12.66)[a]	March to June 2020				13.3%					
Yingst 2021 (USA)[102]	291 (216/75)	47.3 (11.6)[a]	23 April 2020								93.1%	90.4%
Zajacova 2020 (Canada)[103]	4319 (2202/2117)	≥25	29 March to 3 April 2020	3%	4%	93%						
Zhang 2021 (USA)[104]	1276 (517/724)	45.0 (17.0)[a]	13 April to 8 June 2020	41%	20.1%	38.9%						

F, female; M, male; NA, not applicable; O, other; T2DM, type 2 diabetes mellitus.
All studies were cross-sectional except for the Naughton 2021, which was a prospective cohort study. Percentages represent absolute changes.
[a] Mean (standard deviation).
[b] Median (interquartile range).
[c] Albania, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Ukraine and the United Kingdom.

Table 2
Characteristics of vaping habit before and after/during COVID-19 lockdowns.

Study ID (country)	Subjects (F/M/O) Type	Age (years)	Time of survey conducting	Vaping: increase	Vaping: decrease	Vaping: no change	Vaping: quit	Vaping before COVID-19 lockdown	Vaping after/during COVID-19 lockdown
Adriaens 2021 (Belgium)[28]	202 (50/150/2)	≥18/39 (9.89)[b]	25 May to 8 June 2020	25.4%	27.1%	40.7%	6.8%[a]		
Caponnetto 2020 (Italy)[37]	1825 (683/1142)	34.7 (14.11)[b]	2–26 April 2020	22.3%	6.5%	34.8%			
Giovenco 2021 (USA)[56]	44 (24/20) Smokers	≥18	14–24 April 2020	2.3%	6.8%	4.5%			
Kale 2021 (UK)[63]	2792 (1452/1340)	NA	30 April to June 2020	42.1%	9.5%				
Odone 2021 (Italy)[78]	6003	18–74	27 April to 3 May 2020						
Yingst 2021 (USA)[102]	291 (216/75)	47.3 (11.6)[b]	23 April 2020					8.1%	9.1%
Zhang 2021 (USA)[104]	1276 (517/724)	45.0 (17.0)[b]	13 April to 8 June 2020	45.9%	18.2%	35.9%		16.2%	13.1%

F, female; M, male; O, other.
All studies were cross-sectional. Percentages represent absolute changes.
 a All, ran out of e-liquid.
 b Mean (standard deviation).

that 29.9% of smokers quit smoking, the percentage of subjects who smoked >10 cigarettes per day increased from 11.9% before the COVID-19 lockdown to 29.7% during/after the COVID-19 lockdown (*P* < 0.001).[45]

Meta-analysis results, where data from five cross-sectional studies were analysed,[32,48,57,98,102] showed a tendency towards an increase in the number of cigarettes smoked per day; however, this change was not significant (0.81 weighted mean difference [95% confidence interval, −0.59 to 2.21]), and there was high heterogeneity among studies ($I^2 = 94\%$). The results of the meta-analysis can be seen in the forest plot in Fig. 2.

Vaping behaviour

Vaping behaviour was reported in seven of 77 studies.[28,37,56,63,78,102,104] In two studies, from Belgium[28] and Italy,[37] most of the participants stated that their vaping behaviour was not changed during/after the COVID-19 lockdown. An increase in vaping habit during/after COVID-19 lockdown was observed in three studies, led by Kale,[63] Odone[78] and Zhang.[104] On the other hand, a decrease in vaping habit was recorded in the studies by Giovenco et al.[56] and Yingst et al.[102] Information regarding vaping cessation was only provided by one study from Belgium, where 6.8% of participants quit this habit during/after COVID-19 lockdown.[28]

Discussion

Smoking and vaping behaviours are impacted by the COVID-19 lockdown. To the best of the authors' knowledge, this is the first systematic literature review and meta-analysis that aimed to investigate the impact of the COVID-19 lockdowns on smoking and vaping behaviour.

Regarding smoking behaviour during/after lockdown, an 'increase' was the predominant answer (*N* = 35), followed by the statement of 'no change' (N = 21). A decrease in smoking behaviour by the majority of participants was found in 19 studies.

Different results regarding smoking behaviour change during/after lockdown have been observed in France.[36,40,59,61,75,86] An increase in smoking was reported for participants in the studies by Borion-Bédès et al.[36] and Rossinot et al.,[86] which included the general population. Similarly, an increase in smoking behaviour was the predominant answer in the study by Chagué et al. in which participants with congestive heart failure were the target population[40] and in the study by Cransac-Miet et al.[44] that investigated a population of individuals with chronic coronary syndromes. On the other hand, the fact that more than one-third of participants decreased their smoking behaviour in the study by Guignard et al.[59] and that 'no change' was the predominant answer in the studies led by Hansel[61] and Mounir[75] reflects the heterogenous populations that were included in the French studies. It is important to highlight the fact that participants with coronary syndromes increased their smoking behaviour during/after lockdown, thus also increasing their risk of acute coronary events and complications.[107]

With regard to Germany, in one study that was conducted over a 1-month period (April to May 2020), an increase in smoking behaviour was reported for almost half of the participants.[66] However, the study led by Palmer that was conducted for a more representative period of the first lockdown indicated that the 'no change' answer was the predominant response, and this could be more representative for the country.[81]

Most studies from Italy showed an increase in smoking behaviour during/after lockdown.[38,43,47,52,78] The populations in these studies varied significantly, including the general population,[78] current smokers,[38] infertile women[43] and elderly individuals with
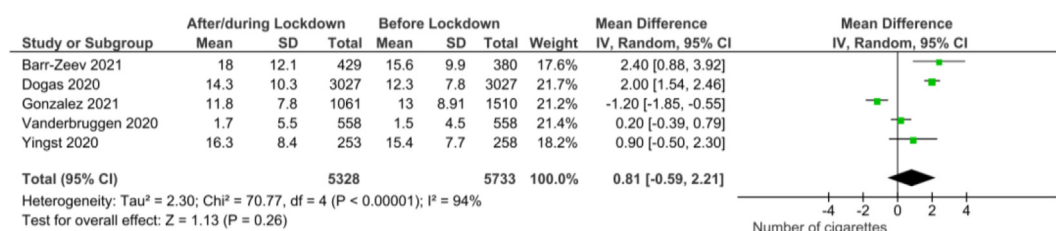
Study or Subgroup	After/during Lockdown			Before Lockdown				Mean Difference	Mean Difference
	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Barr-Zeev 2021	18	12.1	429	15.6	9.9	380	17.6%	2.40 [0.88, 3.92]	
Dogas 2020	14.3	10.3	3027	12.3	7.8	3027	21.7%	2.00 [1.54, 2.46]	
Gonzalez 2021	11.8	7.8	1061	13	8.91	1510	21.2%	-1.20 [-1.85, -0.55]	
Vanderbruggen 2020	1.7	5.5	558	1.5	4.5	558	21.4%	0.20 [-0.39, 0.79]	
Yingst 2020	16.3	8.4	253	15.4	7.7	258	18.2%	0.90 [-0.50, 2.30]	
Total (95% CI)			5328			5733	100.0%	0.81 [-0.59, 2.21]	

Heterogeneity: Tau² = 2.30; Chi² = 70.77, df = 4 (P < 0.00001); I² = 94%
Test for overall effect: Z = 1.13 (P = 0.26)

Fig. 2. Forest plot of the number of cigarettes smoked per day before and after/during the COVID-19 lockdown.

cognitive impairment.[47] Of special interest is the fact that infertile women increased their smoking behaviour, whereas it is already known that smoking has a negative impact in female fertility.[108] Only one study from Italy reported a decrease in smoking behaviour. This study included the general adult population, but further information regarding the sample was missing.[46]

Information regarding change in smoking behaviour during/after lockdown in Spain came from four studies.[33,34,39,82] An increase in smoking was reported for almost one-third of participants in the study by Biviá-Roig. This study took place during the second lockdown (October 2020) with a small sample (n = 124 women);[33] therefore, the results might not be representative for the whole country. A decrease in smoking was stated in the cross-sectional study led by Celorio-Sardà,[39] where 30% of smokers reduced their smoking habit and 15% reported having quit smoking. In the study by Perez-Rodrigo, information regarding more than half of the participants' smoking habits was missing, and the interpretation of the results of this study cannot be accurate.[82] In addition, in the study by Blithikioti et al., where a subgroup of participants with substance use disorder from Spain were examined, approximately 85% of participants stated that they did not change their smoking behaviour and almost 10% reduced this habit.[34] These results are in accordance with a study from England that examined drinking and smoking changes during the COVID-19 lockdown, where an increase in smoking cessation attempts was found.[25] A possible explanation could be that this vulnerable population group could be more motivated and focussed to overcome addictions during the lockdown.

The results from Sweden showed that when it came to both the first and second wave of lockdowns, smoking habit was not changed for the majority of participants. In contrast, in a study that was conducted between August and November 2020, a decrease in smoking was observed.[49] However, Sweden was not under restriction measures during this whole period; therefore, lockdown might not be the only factor that had an impact on the decrease in smoking behaviour.

In the United Kingdom, three of four studies showed an increase in smoking behaviour for the majority of participants,[58,77,80] whereas smoking prevalence was found to decrease in the study led by O'Donnell.[79] The difference in these results could be explained by the fact that the study by O'Donnell et al. was conducted between September and November 2020 when there were periods with and without lockdown;[79] therefore, the results from this study might not be representative for the lockdown period.

In the United States, most participants stated that they did not change their smoking behaviour during the lockdown.[41,56,64,68] An increase in smoking behaviour was observed for most of the smokers in the studies by Matsungo et al.,[72] Sharma et al.[89] and Zhang et al.[104] On the contrary, 'decrease' was the predominant answer in the studies led by Rigotti[85] and Yingst.[102] All the US studies included general adult populations.[41,56,64,68,72,85,89,102] The heterogeneity between the results could be explained by the fact that each study included populations that may not be representative for the whole country; however, the results provide some initial evidence about smoking behaviour in the United States.

In Brazil, heterogeneity in the results between studies was observed.[45,70,84] The period that the surveys were conducted was not the same among these three studies and could explain the difference in the results. Most of the participants stated that they did not change their smoking behaviour early in lockdown (April to May 2020).[70] However, 1 month later (June 2020), an increase was observed for more than half of the smokers, showing June as the period of the greatest impact of lockdown.[84] Between June and July 2020, when lockdowns were reduced and daily life seemed to get back to normal, cessation of smoking was seen in almost one-third of smokers, and smoking initiation was observed for <1% of the participants.[45] Nevertheless, the number of cigarettes smoked per day was found to increase, and this could mean that subjects who increased smoking either continued their harmful habit or quitted smoking with a view to limit factors that could worsen any potential COVID-19 infection.[45]

Heterogenicity in results was also observed in studies from Bangladesh.[29,73] The study by Ahmed et al.,[29] which was conducted during the period of the first lockdown (27 June to 20 July 2020) showed that smoking habit decreased for most participants, whereas in the study by Mistry et al.,[73] which was conducted during the second lockdown (October 2020), 'no change' was the predominant response. This could be because people tried to decrease their smoking habits at the start of the pandemic, possibly due to the fear of this respiratory disease, whereas the second lockdown did not have the same impact on the lifestyles of participants.

Moreover, in China, during April and May 2020, almost half of the participants increased their smoking behaviour,[99] whereas a decrease was observed for most participants during October 2020, which reflected the beginning of the second COVID-19 lockdown.[100] The difference between the two lockdowns showed that the first lockdown negatively influenced the daily life of people, possibly due to the fear and stress of the COVID-19.[109]

All studies from India[42,60,67,76,90] reported a decrease and/or cessation of smoking for most participants, except one showed, which showed an increase.[93] According to Gupte et al.,[60] the reasons that participants decreased their smoking behaviour included the increased price, the unavailability of tobacco and the concerns about COVID-19. From another point of view, the high rate of increase in smoking reported in Sujatha et al.[93] was explained by the fact that smokers bought more smoking products due to the fear that stores would run out of stock and the lockdown would be extended. However, the period when the survey was conducted in this study was not reported, and therefore, it was difficult understand the disagreement of the results compared with the other studies from India.[93]

In the studies from Australia, an increase in smoking habit was stated in two of three studies,[55,92] and the 'no change' answer was the most predominant in the study by Stanton et al.[91] Studies led by Gendal and Stanton were both conducted during April 2020;

however, in the Gendal et al. study, data from almost 80% of participants were missing, meaning that the impact of lockdown during April 2020 in Australia was not clear in the results.[55,91] Taking into account the fact that the study led by Stubbs was conducted from mid-March until the end of May 2020, which was a more representative period of lockdown, the increase in smoking behaviour for most smokers may be the most accurate results for change in smoking behaviour in Australia.[92]

In general, lockdowns changed smoking behaviour. Smoking, which in most cases was found to increase during/after lockdown, has been associated with more severe COVID-19 infection and worse outcomes according to recent systematic reviews.[110,111] In addition to the risk of a more severe COVID-19 infection, the increase of smoking can lead to smoking-related illnesses, such as cancer,[112] heart diseases,[113,114] lung impairments[115] and diabetes mellitus type 2.[116] Smoking can also increase the risk eye diseases[117] and immune system disorders, such as rheumatoid arthritis.[118]

Meta-analysis results of the number of cigarettes smoked per day showed a tendency towards an increase, but this was not statistically significant (Fig. 2). Interpretation of these results could be that there is a trend towards increase. However, the high heterogeneity among the studies included in the meta-analysis cannot lead to firm conclusions.

The results on vaping behaviour showed a tendency towards an increase during/after lockdown in most studies.[63,78,104] Information regarding vaping behaviour reflected only the first COVID-19 lockdown (April to June 2020).[28,37,56,63,78,102,104] Studies from the United States showed different results for vaping behaviour.[102,104] The study of Yingst et al.[102] showed a decrease in vaping prevalence, although it should be noted that this was a 1-day survey with a small sample ($N = 291$). The results from the study by Zhang et al.,[104] which took place over almost 3 months and included a larger sample ($N = 1276$), could be more representative of the United States. An increase in vaping behaviour, which is promoted as a safer alternative to smoking, could also lead to detrimental health effects due to the fact that electronic cigarette use has been associated with severe acute and chronic lung injuries.[119,120]

The present study has several strengths. First, to the best of the authors' knowledge, this is the first systematic review and meta-analysis to examine the impact of the COVID-19 lockdown on smoking and vaping. The 77 studies included are from a large geographical section of the globe, results reflect both COVID-19 lockdowns, and provide a representative impact of the pandemic on smoking and vaping behaviour, as more than 207,000 adults were included. Moreover, the quality of included studies was sufficient, which strengthens the present study results.

Among the limitations of the present study is the missing information about the representativeness of each study sample. In addition, the level of statistical significance and the level of change in smoking behaviour were not reported in most of the studies included in the systematic review. Moreover, this study did not investigate the impact of lockdowns on heated tobacco, and it is not known whether the term 'smoking' in some studies included heated tobacco or not. In addition, the fact that different measures were used to assess smoking/vaping behaviour may influence the accuracy of the existing data. Furthermore, only studies in English, French and Spanish languages were included in this analysis; thus, relevant studies in other languages were missing.

Conclusions

According to most included studies, smoking and vaping habits increased during the lockdowns.

However, for a minority of participants, the fear of COVID-19 was a motivation to quit smoking/vaping. The increase in smoking and

vaping behaviours could have a detrimental health impact in both the short and long term. If such changes remain for a long time or become permanent, the prevalence of non-communicable diseases is expected to increase. Therefore, in addition to strategies advocating for healthier lifestyles overall, further research is needed in this field. Awareness of the benefits of smoking/vaping cessation may be important for the reversal of this unhealthy habit.

Author statements

Ethical approval

Ethics approval was not required for this study. This study is a review, and data were freely available in the literature.

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Competing interests

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Authors' contributions

D.B., K.E and A.S. searched the databases. D.B, K.E, A.S. and M.C. wrote the article. D.B., J.B., and M.C. made the necessary recommendations. and D.B., J.B., and M.C. revised the article. All authors have read and approved the final version of article.

Appendix A. Supplementary data

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