



Key points

- Cannabis smoking has increased and is likely to increase further with relaxation of legalisation and medicinal use of cannabinoids.
- Chronic marijuana smoking often produces symptoms similar to those of chronic tobacco smoking such as cough, sputum production, shortness of breath and wheeze.
- Cessation of marijuana smoking is associated with a reduction in respiratory symptoms and no increased risk of chronic bronchitis.
- Spirometry changes seen in chronic marijuana smokers appear to differ from those in chronic tobacco smokers. In chronic marijuana smokers there is an increase in FVC as opposed to a definite decrease in FEV₁.
- Multiple case series have demonstrated peripheral bullae in marijuana smokers, but no observational studies have elucidated the risk.
- There is currently no clear association between cannabis smoking and lung cancer, although the research is currently limited.

Educational aims

- To update readers on legalisation of recreational and medicinal cannabis.
- To summarise the evidence base surrounding the respiratory effects of inhaled marijuana use.
- To provide clinicians with an understanding of the main differences between cannabis and tobacco to be able to apply this to patient education.
- To highlight common respiratory problems among cannabis users and the need for recreational drug history taking.



Luis Ribeiro¹, Philip W. Ind²



luis.iau.ribeiro@gmail.com



¹Imperial College London Institute of Clinical Sciences, National Heart and Lung Institute, London, UK.

²Respiratory Medicine, Hammersmith Hospital, London, UK.

Marijuana and the lung: hysteria or cause for concern?

Increasing cannabis use and legalisation highlights the paucity of data we have on the safety of cannabis smoking for respiratory health. Unfortunately, concurrent use of tobacco among marijuana smokers makes it difficult to untangle individual effect of marijuana smoking. Chronic cannabis only smoking has been shown in large cohort studies to reduce forced expiratory volume in 1 s/forced vital capacity *via* increasing forced vital capacity in chronic use contrary to the picture seen in tobacco smoking. The cause of this is unclear and there are various proposed mechanisms including respiratory muscle training secondary to method of inhalation and acute anti-inflammatory effect and bronchodilation of cannabis on the airways. While cannabis smoke has been shown to increase symptoms of chronic bronchitis, it has not been definitively shown to be associated with shortness of breath or irreversible airway changes. The evidence surrounding the development of lung cancer is less clear; however, preliminary evidence does not suggest association. Bullous lung disease associated with marijuana use has long been observed in clinical practice but published evidence is limited to a total of 57 published cases and only one cross-sectional study looking at radiological changes among chronic users which did not report any increase in macroscopic emphysema. More studies are required to elucidate these missing points to further guide risk stratification, clinical diagnosis and management.

Cite as: Ribeiro L, Ind PW. Marijuana and the lung: hysteria or cause for concern? *Breathe* 2018; 14: 196–205.



@ERSpublications

Chronic cannabis smoking develops a different respiratory picture compared to tobacco. The mechanism behind this is unclear; however, given the increasing prevalence and legalisation it is important to keep in mind the differences in clinical practice.

<http://ow.ly/kcv930I1sG1>

Cannabis is the most widely used illicit substance, and the second most widely smoked, in the world. Cannabis refers to products of the cannabis plant including marijuana (the flowers and tops of the plant; bud) and the resin (hash). Other terms in common use include “weed”, “dope”, “grass”, “hemp”, “ganga”, “reefer”, “spliff”, “toke” and “blunt”.

Although alcohol, caffeine and tobacco indulgence are more widespread, illicit recreational drug use polarises opinion more. Cannabis is seen as harmless on the one hand and as a gateway to hard

drug use on the other. Dependence is associated with cannabis use disorder which is increasing in prevalence. Cannabis as a public health issue has risen up the political agenda. With an aim to disrupt an illicit industry funding organised crime, Canada began regulating tetrahydrocannabinol (THC) content in July 2018 in an attempt to improve safety and protect the young. Not surprisingly, there are vocal critics and cries for much more research [1].

As healthcare professionals, we deal with tobacco all the time but we also need to know about the



© ERS 2018

respiratory effects of marijuana to be able to advise our patients and colleagues. This brief review aims to summarise what is known and how concerned we should be, particularly with regards to the lungs.

The cannabis genus includes three species: *Cannabis sativa*, *Cannabis indica* and *Cannabis ruderalis*. Each species contains varying concentrations of the two major psychoactive compounds: delta-9-THC and cannabidiol [2]. The concentrations of psychoactive compounds in recreational marijuana also vary over time, with concentrations higher now than they were 50 years ago due to selective breeding. Positive psychoactive effects of cannabis include euphoria and relaxation [3]. However, negative psychological side-effects range from anxiety to psychosis [3]. Commonly available high potency cannabis, dubbed skunk (based on its distinct smell), is associated with a high risk of psychosis due to its high concentration of delta-9-THC [2, 3].

Pharmacology

The high number of cannabinoids recognised (perhaps over 90) means that cannabis pharmacology is necessarily complex; and a full discussion is not warranted here.

Traditional CB1 receptors, belonging to the G-protein coupled family, were identified in 1988 and cloned in 1990. The concept of an endogenous cannabinoid system was developed after the discovery of an endogenous arachidonic acid metabolite ligand (N-arachidonylethanolamide (anadamide) and subsequently a much more selective agonist 2-arachidonylglycerol). delta-9-THC and synthetic derivatives are CB1 agonists. The CB2 receptor subtype was originally described in differentiated myeloid cells and shows 44% amino acid homology with CB1 but a distinct, though similar, binding profile. Five classes of cannabinoid compounds show activity at CB1 and CB2 receptors with minor selectivity for the agonists delta-9-THC and cannabidiol but major selectivity (>1000-fold) and nanomolar affinity shown by antagonists [4]. Other cannabinoid receptor subtypes have been postulated but not confirmed [5].

Cannabis use is increasing

Recent data from the 2016 Crime Survey for England and Wales on drug misuse suggest that around 2.1 million adults have used cannabis in

the past year [6]. In addition, one-third of those surveyed thought it was acceptable for people of their own age to use cannabis occasionally. These figures are unsurprising given the global shift in attitudes towards cannabis and the growing number of countries relaxing legislation on both medical and recreational marijuana use (table 1).

Epidemiology

While we know that marijuana use is increasing, legality remains a major problem for epidemiological studies. In the UK, it is a class B drug meaning it is illegal for UK residents to possess cannabis in any form.

Cannabis can be smoked in a variety of ways, usually without a filter and burned at a higher temperature, and with users generally holding their breath for longer periods of time, compared to tobacco smokers [2]. Joints can be made using just cannabis leaves or can be mixed with tobacco in spliffs. Many cannabis users also concurrently smoke tobacco cigarettes. Routes of administration vary by geographical region as well, with European countries mostly smoking spliffs while the Americans largely smoke cannabis only joints [7]. Aside from joint smoking, users may also use water bongs, pipes and, more recently, vaporisers [7, 8].

It follows that the long-term health effects of marijuana smoking are less understood compared to traditional cigarette smoking.

Chronic respiratory effects

Tobacco smoking is well known to increase the risk of chronic bronchitis, emphysema and small airways disease (all components of chronic obstructive pulmonary disease; COPD), as well as the development of various forms of lung cancer. It might be expected that chronic cannabis smoking would have similar sequelae considering that the contents and properties of tobacco and cannabis smoke are similar [2]. However, observational studies tell a different story.

Symptoms

Respiratory symptoms such as cough, sputum production and wheeze are increased in current cannabis users [2, 9, 10]. Importantly, associations

Table 1 Increasing legalisation of cannabis

Decriminalised possession	Argentina, Australia, Austria, Belgium, Bolivia, Cambodia, Chile, Colombia, Costa Rica, Czech Republic, Ecuador, Estonia, Georgia, Germany, Jamaica, Luxembourg, Malta, Mexico, Moldova, Netherlands, Paraguay, Peru, Portugal, Russia, Slovenia, Switzerland, Ukraine
Legalisation	India (West Bengal, Gujarat, Bihar, Odisha, North East), South Africa, Spain, USA (Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, Washington, District of Columbia), Uruguay

with shortness of breath were not found in larger studies [9, 10]. This suggests that cannabis smoke causes chronic bronchitis in current smokers but not shortness of breath or irreversible airway damage.

This is supported by studies examining the effect of quitting marijuana smoking. They show a significant reduction in morning cough, sputum production and wheeze compared to those who continue to smoke [2, 10]. Quitters also had no increased risk for developing chronic bronchitis compared with nonsmokers at follow-up 10 years later [2, 10].

Vaping cannabis is increasingly popular among young adults [8]. While we don't know the long-term respiratory health effects of e-cigarette use, for either tobacco or cannabis, it has been suggested that vaping may reduce the symptoms associated with smoking [8].

Lung function

COPD is conventionally diagnosed when a patient has an irreversible reduced forced expiratory volume in 1 s (FEV₁) compared with forced vital capacity (FVC) on spirometry. Several large, recently published observational studies (table 2) have reported that long-term marijuana only users have an increase in their FVC with little or no change in FEV₁, even after 20 joint-years of smoking (1 joint-year is equivalent to 365 joints per year) [2, 27, 29]. A reduced FEV₁/FVC ratio due to increased FVC clearly differs from the classical spirometric changes seen in tobacco smoking. The cause of this increase in FVC is unclear. Respiratory muscle training by the breath-holding techniques used during marijuana smoking has been proposed as a cause; however, there is little evidence that training can increase FVC [2, 30]. Additional lung function measurements have only been examined in smaller studies [2]. Very small changes in total lung capacity have been reported in several studies. Small effects on specific airways conductance and resistance have been interpreted as consistent with central airways inflammation. The transfer factor of the lung for carbon monoxide has been reported to be reduced only in smokers of cannabis and tobacco. Interestingly marijuana use within 0–4 days of lung function measurement showed a 13% reduction in exhaled nitrous oxide, though the clinical manifestation of this acute effect is unknown [29].

Acute airway effects of cannabis

Experimentally, the acute bronchodilator effect of inhaled cannabis is well described as an effect of THC [2]. However, since cannabinoids can have partial agonist, or even antagonist, effects little is known about differences in airway effects from different strains of cannabis containing varying concentrations of cannabinoids.

We do not know why cannabis smoking does not produce COPD. Possible explanations include a persistent bronchodilator effect (offsetting airway narrowing) or anti-inflammatory or immunomodulatory effects of THC [2].

Bullous lung disease

Bullous lung disease, usually presenting with pneumothorax, is widely recognised as a possible consequence of marijuana smoking. However, while well-established anecdotally, there is actually a paucity of relevant data [2]. As of 2018, there have been seven case series and 11 case reports published. A total of only 57 individual cases were described. Concurrent tobacco smoking was recorded in all but four of the cases. Patient details are summarised in table 3. The majority were heavy marijuana users, up to 149 joint-years. Most of the cases had predominantly upper lobe involvement with added peripheral emphysema and most presented with pneumothorax, presumably due to rupture of a bulla. They are therefore not representative of the general marijuana smoking population. We have found only a single cross-sectional study (n=339) looking at radiological changes among marijuana smokers in New Zealand [23]. Interestingly they reported an increase in macroscopic emphysema in tobacco smokers compared with nonsmokers but not in cannabis only smokers. Low-density lung regions on high-resolution computed tomography in cannabis smokers were interpreted as hyperinflation rather than microscopic emphysema. This is in contrast to a case series of 10 patients which found asymmetrical bullous changes on CT among chronic marijuana smokers but with normal spirometry and chest radiographs [37]. A study looking at smoking status and the presence of emphysematous computed tomography changes of spontaneous pneumothorax patients found no difference in emphysema prevalence among tobacco smokers and tobacco plus cannabis smokers (there were no cannabis only smokers); however, concurrent smokers were significantly younger [49]. While the authors have suggested that cannabis added to tobacco leads to emphysema at a younger age, there are too many confounders such as the subject population, to come to a definitive conclusion.

Various mechanisms have been proposed to explain an observed association [2, 23]; the main one relating to breath-holding techniques employed during smoking, resembling a Valsalva manoeuvre. It is suggested that this could precipitate barotrauma increasing bulla formation and predisposing to pneumothorax. There is currently no direct evidence for this hypothesis.

It is possible that the lack of published data on bullous lung disease in marijuana smokers relates to its widespread recognition and familiarity. However, it is difficult to draw any firm conclusions on an

Table 2 Summary of observational studies on marijuana exposure and lung function

Author [ref.]	Subjects n	Study design	Outcomes measured	Results
CRUICKSHANK [11]	60	Cross-sectional	FEV ₁ , FVC, P _{O2} , P _{CO2}	No significant differences found in FEV ₁ and FVC among cannabis smokers.
TASHKIN [12]	74	Cross-sectional	Respiratory symptoms, FEV ₁ , FVC, FEF _{25-75%} , R _{aw} , CV, ΔN ₂ 750-1250	No differences in spirometry results. A significant increase was noted in R _{aw} and decrease in sG _{aw} . FVC was raised compared to both controls but not significant.
HERNANDEZ [13]	23	Cross-sectional	FEV ₁ , FVC, FEF _{25-75%} , R _{aw} , PD ₅₀ R _{aw}	Spirometry results of marijuana smokers were not significantly different to controls. No significant difference in histamine reactivity.
TILLES [14]	68	Cross-sectional	FEV ₁ , FVC, PEFR, FRC, T _{lco}	Cannabis smoking±tobacco smoking was associated with a reduction in T _{lco} . In marijuana and marijuana±tobacco smokers, both the FEV ₁ and FVC were significantly increased compared to nonsmokers.
BLOOM [15]	990	Cross-sectional	Respiratory symptoms, depth of inhalation, FEV ₁ , FVC, V _{max}	Significant increase in respiratory symptoms of phlegm and wheeze, but not cough or shortness of breath, in non-tobacco cigarette smokers regardless of tobacco smoking status. Significant decrease in FEV ₁ /FVC compared to controls. No significant changes in FEV ₁ in any non-tobacco smoking category.
TASHKIN [16]	446	Cross-sectional	Respiratory symptoms, FEV ₁ , FVC, FEF _{25-75%} , R _{aw} , sG _{aw} , DLCO	Smokers of marijuana±tobacco had significantly increased rates of chronic cough, wheeze and sputum production. FEV ₁ and FVC of marijuana smokers not significantly different from controls.
SHERRILL [17]	856	Observational cohort	Respiratory symptoms, FEV ₁ , FVC, V _{max50}	Non-tobacco smoking was associated with chronic cough, chronic phlegm and wheeze. Significant reduction in FEV ₁ and FEV ₁ /FVC with previous non-tobacco smoking but not with current smoking.
SHERMAN [18]	63	Cross-sectional	Macrophage oxidant release, small airway integrity, FEV ₁ , FVC, T _{lco}	Macrophage oxidant release, small airway integrity, and alveolar gas exchange similar in both nonsmokers and marijuana smokers. No significant difference in lung function between marijuana only smokers and nonsmokers. Marijuana and tobacco concurrent smokers showed a decrease in FEV ₁ , FVC and T _{lco} .
TASHKIN [19]	542	Cross-sectional	AHR	No significant difference in AHR to methacholine found in nonsmokers and marijuana smokers without tobacco. However, logistic regression showed a significant response to methacholine with marijuana smoking. No dose-response relationship was found between AHR and lifetime marijuana use.
TASHKIN [20]	394	Observational cohort	FEV ₁	Marijuana smoking was not associated with FEV ₁ decline.
TAYLOR [21]	1037	Observational cohort	Respiratory symptoms, AHR, FEV ₁ , FVC	Cannabis users had an increase in wheezing, exercise-related shortness of breath, nocturnal waking with chest tightness and morning sputum production. Cannabis users had decreased FEV ₁ /FVC compared to nonsmokers. No significant increase in AHR in tobacco or cannabis users.

Continued

Table 2 Continued

Author [ref.]	Subjects n	Study design	Outcomes measured	Results
TAYLOR [22]	1037	Observational cohort	FEV ₁ , FVC	After stratifying by use of cannabis, at each age increasing cannabis use was associated with a decline in FEV ₁ /FVC. After adjustments of other covariates, cannabis as a predictor was only marginally significant.
MOORE [9]	6728	Cross-sectional	Respiratory symptoms, examination, FEV ₁ , FVC	Marijuana use was significantly associated with chronic bronchitis symptoms, coughing on most days, phlegm production, wheezing, and chest sounds without a cold. Cannabis smoking was not associated with an FEV ₁ /FVC ratio <70%.
ALDINGTON [23]	339	Cross-sectional	Emphysema by CT, FEV ₁ , FVC, TLC, FRC, MMEF, SVC, RV, Tlco, sGaw, VA	Both cannabis and tobacco smoking groups showed a reduction in the FEV ₁ /FVC. Tobacco reduced FEV ₁ , while cannabis smoking had no effect on FEV ₁ . Tobacco smoking was associated with macroscopic emphysema by CT, but not cannabis-only smoking.
TAN [24]	878	Observational cohort	Respiratory symptoms, COPD by spirometry	Marijuana only smokers had no significant increase in risk of COPD as defined by symptoms and spirometry. However, tobacco and marijuana concurrent use produced an increased risk of respiratory symptoms and COPD.
HANCOX [25]	1037	Observational cohort	FEV ₁ , FVC, TLC, RV, VA, Tlco, Raw, sGaw	Cannabis exposure was associated with increased FVC and TLC, but no significant association with FEV ₁ or FEV ₁ /FVC. Marijuana smoking associated with increased Raw and lower sGaw.
PLETCHER [26]	5119	Observational cohort	FEV ₁ , FVC	Marijuana exposure was non-linearly associated with lung function, unlike tobacco. Cannabis exposure showed an increase in FEV ₁ over time at up to 7 joint-years and declining thereafter. FVC was significantly elevated in users up to 20 joint-years. Both FEV ₁ and FVC were increased at all exposure levels.
KEMPKER [27]	7716	Cross-sectional	FEV ₁ , FVC	For cannabis smokers with 1–5 and 6–20 joint-years, there was no association with an FEV ₁ /FVC <70%. Those with >20 joint-years did have an association. Use of marijuana in the past month was associated with increased FVC (0.13±0.03%, p=0.0001) for each additional day but no decrease in FEV ₁ .
MACLEOD [28]	500	Observational cohort	Respiratory symptoms, FEV ₁ , FVC	Cannabis and tobacco use together was associated with increased cough, sputum production and wheeze. After adjustment for tobacco use, age, sex and deprivation, each additional joint year of cannabis was associated with 0.3% increase in prevalence of an FEV ₁ /FVC <70%.

Po₂: oxygen tension; Pco₂: carbon dioxide tension; FEF_{25–75%}: forced expiratory flow at 25–75% of FVC; Raw: airway resistance; CV: closing volume; ΔN₂750–1250: percentage change in nitrogen concentration between 750 and 1250 mL of expired volume; PD_{50Raw}: provocative dose required to achieve a 50% increase in airway resistance; PEFR: peak expiratory flow rate; FRC: functional residual capacity; Tlco: transfer factor of the lung for carbon monoxide; V_{max}: oxygen uptake; sGaw: specific airway conductance; DLCO: diffusing capacity of the lung for carbon monoxide; V_{max50}: flow rate at 50% of the expired FVC; AHR: airway hyperresponsiveness; CT: computed tomography; TLC: total lung capacity; MMEF: maximum mid-expiratory flow; SVC: slow vital capacity; RV: residual volume; VA: alveolar volume. Reproduced with modification from [2].

Table 3 Summary of cannabis-associated bullous lung disease case reports

Author [ref.]	Subjects n	Mean age years	Quantification of marijuana use	Tobacco smoking pack- years	Radiology	Comments
FELDMAN [31]	1	24	14–28 g per week for 10 years	14	Spontaneous pneumothorax	Microscopy showed ruptured bulla, serosal adhesions and focal atelectasis
JOHNSON [32]	4	38	Two joints per week to three joints per day	3 to 15	Bilateral upper zone peripheral bullae in all four cases	One patient had paraseptal bullae, two had apical
RAWLINS [33]	2	29	NA	Yes	Bilateral giant lung bullae and severe upper lobe emphysema	No further investigations documented
THOMPSON [34]	3	39	Moderate for 10 years to heavy for 24 years	9 to 20	Large upper lobe bullae	Normal α_1 -antitrypsin levels
PHAN [35]	1	26	10 pipes a day for 5 years	1	Bilateral cystic and bullous changes in lower lobes	Microscopy showed fibrosis and macrophage infiltration
BESHAY [36]	17	27	53 joint-years	0 to 25	Multiple apical bullae or bullous emphysema in upper lobes	Histology showed macrophages
HUI [37]	10	41	11 to 149 joint-years	1 to 27	Asymmetrical bullae peripherally and centrally in upper and mid zones on CT	Lung function normal in five patients
REECE [38]	1	56	10 cigarettes per day for 25 years	>1	Multiple giant lung cysts on CT scan, no lobe predominance	Normal α_1 -antitrypsin levels
GAO [39]	1	23	NA	0	Bilateral large upper lobe bullae, recurrent pneumothorax	Cystic fibrosis
ALLEN [40]	1	18	1 oz weekly for 4 years	3	Bilateral apical bullae up to 3 cm	Histology showed pigmented macrophages and DIP-like changes
SHAH [41]	1	27	Heavy use for 10 years	20	Large left apical bulla and right apical blebs	Normal α_1 -antitrypsin levels
SOOD [42]	1	33	Off and on for 10 years	15	VLS on the left side	In both patients, bullae contained <i>Aspergillus</i>
GARGANI [43]	2	41	NA	NA to 39	One patient had left apical bullae, the other had right upper and middle lobe bullae	
GOLWALA [44]	1	25	24 joint-years	1	Bilateral bullae with upper lobe predominance	Previous untreated sarcoidosis but no current clinical/radiological features
TASHTOUSH [45]	1	65	Heavy use for 20 years	0	Bilateral large lung bullae characteristic of VLS	Poorly controlled AIDS and previous intravenous heroin use
FIORELLI [46]	8	30	7 joints per week to 6 joints per day	15 to 40	Eight out of 13 marijuana smokers with spontaneous pneumothorax had bullae, six had paraseptal bullae (two with upper lobe involvement)	Increased intralveolar pigmented lymphocytes
CARY [47]	1	48	86 joint-years	25	Bilateral upper and mid zone bullous disease	Sputum grew only <i>Candida</i> , no clinical signs of infection
MISHRA [48]	1	30	Daily use for 5 years	None	Spontaneous pneumothorax, apical bullae in the right lung	Normal homocysteine, RF and HIV tests

NA: not applicable; CT: computed tomography; DIP: desquamative interstitial pneumonia; VLS: vanishing lung syndrome; RF: rheumatoid factor. Reproduced with modification from [2].

association, its frequency, other epidemiological characteristics, mechanisms, *etc.* More studies, preferably prospective series, are required to gather epidemiological data. It falls to health professionals to recognise possible cognitive bias, and to fully investigate pneumothorax and bullous disease rather than simply relating it to drug history.

Lung cancer

The clear association of tobacco smoking and lung cancer and the similar carcinogens present in burning cannabis plant material have long raised the possibility of an association of marijuana use and lung cancer. Furthermore, premalignant changes in bronchial biopsies from marijuana smokers have been shown histologically [2]. However, as with chronic lung disease, there is currently little evidence of a definite link. A Swedish cohort study of almost 50000 army conscripts reported a two-fold increased risk of lung cancer among marijuana smokers, compared with nonsmokers after 40 years. Unfortunately, and critically, smoking history was only assessed at the time of conscription and there was no data on smoking status before conscription or in the 40 years afterwards [50]. A pooled analysis of six case-control studies found no increased risk of cannabis compared to non-habitual smokers [51]. Other epidemiological studies investigating cancer risk suffered from methodological limitations including small sample sizes or short follow-up [2].

We do not know why cannabis smoking does not appear to be carcinogenic. Various factors might contribute, *e.g.* potential anti-inflammatory and anti-neoplastic properties of THC and other cannabinoids [52].

Pneumonia

Cannabis has been shown to have immunosuppressive effects on alveolar macrophages and to cause loss of ciliated bronchial epithelium [53]. An increased incidence of pneumonia in cannabis users might be expected. One cross-sectional study surveyed current marijuana users regarding a diagnosis of pneumonia within the previous 12 months and found no increased risk compared to nonsmokers [9]. Otherwise, we have found only isolated case series and studies on immunocompromised patients [53].

Self-evaluation questions

- Which of the following countries have legalised marijuana?
 - Austria
 - Japan
 - Romania
 - Thailand
 - Uruguay
- Which of the following statements on the pharmacology of cannabis is true?
 - All strains of cannabis contain the same concentrations of compounds
 - THC is the only psychoactive compound in cannabis
 - The endogenous agonist of the CB1 receptor is cannabidiol
 - Cannabis has been shown to have an acute bronchodilator effect
 - The currently used measure of joint-years takes into account varying sizes of joints
- Which of these is not associated with chronic cannabis smoking?
 - A decrease in FEV1/FVC to <70% pred
 - An increase in FVC
 - Increased airway resistance and increased airway conductance
 - FVC and FEV1 have a non-linear association with lifetime cannabis exposure
 - Former cannabis smokers have been shown to have a decreased FEV1/FVC ratio
- What type of bullae distribution is most commonly seen among cannabis-associated bullous lung disease?
 - Mediastinal
 - Apical
 - Basal
 - Paraseptal
 - Lingular

Such cases include invasive aspergillosis from spores which were found in contaminated leaves and *Pseudomonas* associated with bong smoking [54, 55].

Interstitial lung disease

Reports of cannabis-associated interstitial lung disease are few and far between. There are occasional reports of eosinophilic pneumonia (as with smoking generally) and a case of pneumoconiosis associated with talc-adulterated marijuana [52].

Table 4 Licensed cannabinoid medication

Name	Drug	Manufacturer	Description	Licensed indication
Sativex	Nabiximols	GW Pharma plc	THC+cannabidiol	Multiple sclerosis spasticity and pain
Cesamet	Nabilone	Meda Pharma Inc	Synthetic THC-like	Chemo-induced nausea and vomiting
Marinol	Dronabinol	AbbVie	Synthetic THC	Anorexia and weight loss
Syndros		Insys Therapeutics	Oral capsules/solutions	AIDS

Medical use of cannabis

Medical use of cannabis by mouth/orally dates back to 2737 BC in China [56]. Raw herbal cannabis, cannabis oil extracts including products prepared in a pharmacy (magistral preparations), and cannabinoids are all used. There has been increasing recent interest with wide acceptance and authorisation of use of herbal preparations in many European countries and even more widespread authorisation of oral cannabinoid medications in most European countries and the USA and Canada (table 4). The most accepted indications include chronic pain, spasticity in multiple sclerosis, certain rare epilepsy syndromes, and chemotherapy-induced nausea and vomiting [57]. There has also been experimental evidence in the anti-neoplastic effect of cannabinoids [19], as well as in palliative care. It has been recommended in a large variety of other conditions and for improving sleep quality including in obstructive sleep apnoea, although with limited evidence [58].

Conclusions

The long-term respiratory effects of cannabis differ from traditional tobacco smoking; however,

we do not know why and this may be a fruitful area for research. We need to know more about cannabis pharmacology and anti-inflammatory and anti-cancer effects as well as endocannabinoids. Cannabis use has been increasing and is likely to increase more but this should not foster hysteria. Chronic cannabis use is associated with chronic bronchitis but an increase in FVC with no change in FEV₁ and not with COPD. The clinical implications and causes of these spirometric changes are currently unknown. Larger prospective longitudinal studies are needed, in particular comparing spirometric changes with bullous/emphysematous changes on high-resolution computed tomography scans. Monitoring symptoms among cannabis users, particularly breathlessness, is paramount. Reducing or eliminating cannabis smoking benefits patients suffering from symptoms of cough and phlegm.

Detailed inhalational drug history taking should be part of the standard assessment of patients in both primary and secondary care. This could support better epidemiological data collection and also foster better patient communication about respiratory and psychological health risks. No medicinal role for cannabinoids has been established as regards the lungs and more research is needed relating to safety.

Conflict of interest

None declared.

References

1. Webster P. Debate over recreational cannabis use legalisation in Canada. *Lancet* 2018; 391: 725–726.
2. Ribeiro LiG, Ind PW. Effect of cannabis smoking on lung function and respiratory symptoms: a structured literature review. *NPJ Prim Care Respir Med* 2016; 26: 16071.
3. Morgan CJA, Noronha LA, Muetzelfeldt M, *et al.* Harms and benefits associated with psychoactive drugs: findings of an international survey of active drug users. *J Psychopharmacol* 2013; 27: 497–506.
4. Console-Bram L, Marcu J, Abood ME. Cannabinoid receptors: nomenclature and pharmacological principles. *Prog Neuropsychopharmacol Biol Psychiatry* 2012; 38: 4–15.
5. Morales P, Reggio PH. An update on non-CB1, non-CB2 cannabinoid related G-protein-coupled receptors. *Cannabis Cannabinoid Res* 2017; 2: 265–273.
6. Home Office. Drug Misuse: Findings from the 2015/16 CSEW second edition. www.gov.uk/government/statistics/drug-misuse-findings-from-the-2015-to-2016-csew Date last updated: July 28, 2016. Date last accessed: May 31, 2018.
7. Russell C, Rueda S, Room R, *et al.* Routes of administration for cannabis use – basic prevalence and related health outcomes: a scoping review and synthesis. *Int J Drug Policy* 2018; 52: 87–96.
8. Tashkin DP. How beneficial is vaping cannabis to respiratory health compared to smoking? *Addiction* 2015; 110: 1706–1707.
9. Moore BA, Augustson EM, Moser RP, *et al.* Respiratory effects of marijuana and tobacco use in a U.S. sample. *J Gen Intern Med* 2005; 20: 33–37.
10. Hancox RJ, Shin HH, Gray AR, *et al.* Effects of quitting cannabis on respiratory symptoms. *Eur Respir J* 2015; 46: 80–87.
11. Cruickshank EK. Physical assessment of 30 chronic cannabis users and 30 matched controls. *Ann N Y Acad Sci* 1976; 282: 162–167.
12. Tashkin DP, Calvarese BM, Simmons MS, *et al.* Respiratory status of seventy-four habitual marijuana smokers. *Chest* 1980; 78: 699–706.
13. Hernandez MJ, Martinez F, Blair HT, *et al.* Airway response to inhaled histamine in asymptomatic long-term marijuana smokers. *J Allergy Clin Immunol* 1981; 67: 153–155.
14. Tilles DS, Goldenheim PD, Johnson DC, *et al.* Marijuana smoking as cause of reduction in single-breath carbon monoxide diffusing capacity. *Am J Med* 1986; 80: 601–606.
15. Bloom JW, Kaltenborn WT, Paoletti P, *et al.* Respiratory effects of non-tobacco cigarettes. *Br Med J (Clin Res Ed)* 1987; 295: 1516–1518.
16. Tashkin DP, Coulson AH, Clark VA, *et al.* Respiratory symptoms and lung function in habitual heavy smokers of marijuana alone, smokers of marijuana and tobacco, smokers of tobacco alone, and nonsmokers. *Am Rev Respir Dis* 1987; 135: 209–216.
17. Sherrill DL, Krzyzanowski M, Bloom JW, *et al.* Respiratory effects of non-tobacco cigarettes: a longitudinal study in general population. *Int J Epidemiol* 1991; 20: 132–137.
18. Sherman MP, Roth MD, Gong HJ, *et al.* Marijuana smoking, pulmonary function, and lung macrophage oxidant release. *Pharmacol Biochem Behav* 1991; 40: 663–669.
19. Tashkin DP, Simmons MS, Chang P, *et al.* Effects of smoked substance abuse on nonspecific airway hyperresponsiveness. *Am Rev Respir Dis* 1993; 147: 97–103.
20. Tashkin DP, Simmons MS, Sherrill DL, *et al.* Heavy habitual marijuana smoking does not cause an accelerated decline in FEV₁ with age. *Am J Respir Crit Care Med* 1997; 155: 141–148.

21. Taylor DR, Poulton R, Moffitt TE, *et al.* The respiratory effects of cannabis dependence in young adults. *Addiction* 2000; 95: 1669-1677.
22. Taylor DR, Fergusson DM, Milne BJ, *et al.* A longitudinal study of the effects of tobacco and cannabis exposure on lung function in young adults. *Addiction* 2002; 97: 1055-1061.
23. Aldington S, Williams M, Nowitz M, *et al.* Effects of cannabis on pulmonary structure, function and symptoms. *Thorax* 2007; 62: 1058-1063.
24. Tan WC, Lo C, Jong A, *et al.* Marijuana and chronic obstructive lung disease: a population-based study. *CMAJ* 2009; 180: 814-820.
25. Hancox RJ, Poulton R, Ely M, *et al.* Effects of cannabis on lung function: a population-based cohort study. *Eur Respir J* 2010; 35: 42-47.
26. Pletcher MJ, Vittinghoff E, Kalhan R, *et al.* Association between marijuana exposure and pulmonary function over 20 years. *JAMA* 2012; 307: 173-181.
27. Kempker JA, Honig EG, Martin GS. The effects of marijuana exposure on expiratory airflow. A study of adults who participated in the U.S. National Health and Nutrition Examination Study. *Ann Am Thorac Soc* 2015; 12: 135-141.
28. Macleod J, Robertson R, Copeland L, *et al.* Cannabis, tobacco smoking, and lung function: a cross-sectional observational study in a general practice population. *Br J Gen Pract* 2015; 65: e89-e95.
29. Papatheodorou SI, Buettner H, Rice MB, *et al.* Recent marijuana use and associations with exhaled nitric oxide and pulmonary function in adults in the United States. *Chest* 2016: 1428-1435.
30. Freitas DA, Holloway EA, Bruno SS, *et al.* Breathing exercises for adults with asthma. *Cochrane Database Syst Rev* 2013; 10: CD001277.
31. Feldman AL, Sullivan JT, Passero MA, *et al.* Pneumothorax in polysubstance-abusing marijuana and tobacco smokers: Three cases. *J Subst Abuse* 1993; 5: 183-186.
32. Johnson MK, Smith RP, Morrison D, *et al.* Large lung bullae in marijuana smokers. *Thorax* 2000; 55: 340-342.
33. Rawlins R, Carr CS, Brown KM, *et al.* Minerva. *BMJ* 2001; 323: 1012.
34. Thompson CS, White RJ. Lung bullae and marijuana. *Thorax* 2002; 57: 563.
35. Phan TD, Lau KKP, Li X. Lung bullae and pulmonary fibrosis associated with marijuana smoking. *Australas Radiol* 2005; 49: 411-414.
36. Beshay M, Kaiser H, Niedhart D, *et al.* Emphysema and secondary pneumothorax in young adults smoking cannabis. *Eur J Cardio Thoracic Surg* 2007; 32: 834-838.
37. Hii SW, Tam JDC, Thompson BR, *et al.* Bullous lung disease due to marijuana. *Respirology* 2008; 13: 122-127.
38. Reece AS. Severe multisystem dysfunction in a case of high level exposure to smoked cannabis. *BMJ Case Rep* 2009; [http://doi.org/10.1136/bcr.08.2008.0798].
39. Gao Z, Wood-Baker R, Harle R, *et al.* "Bong lung" in cystic fibrosis: a case report. *J Med Case Rep* 2010; 4: 371.
40. Allen RKA. Bullectomy for "bong lung" in an 18 year-old male presenting with spontaneous pneumothorax. *Pneumon* 2010; 23: 301-303.
41. Shah A, Paramlall M. The importance of an illicit drug history in the evaluation of suspected spontaneous pneumothorax. *BMJ Case Rep* 2011; [http://doi.org/10.1136/bcr.01.2011.3693].
42. Sood N, Sood N. A rare case of vanishing lung syndrome. *Case Rep Pulmonol* 2011; 2011: 957463.
43. Gargani Y, Bishop P, Denning DW. Too many mouldy joints - marijuana and chronic pulmonary aspergillosis. *Mediterr J Hematol Infect Dis* 2011; 3: e2011005.
44. Golwala H. Marijuana abuse and bullous emphysema. *Lung India* 2012; 29: 56-58.
45. Tashtoush B, Gonzalez-Ibarra F, Memarpour R, *et al.* Vanishing lung syndrome in a patient with HIV infection and heavy marijuana use. *Case Rep Pulmonol* 2014; 2014: 285208.
46. Fiorelli A, Accardo M, Vicidomini G, *et al.* Does cannabis smoking predispose to lung bulla formation? *Asian Cardiovasc Thorac Ann* 2014; 22: 65-71.
47. Cary RM, Bragg C, Mukherjee J. Pleuritic chest pain and fluid levels on imaging in a heavy cannabis smoker. *BMJ Case Rep* 2015; [http://doi.org/10.1136/bcr-2014-208064].
48. Mishra R, Patel R, Khaja M. Cannabis-induced bullous lung disease leading to pneumothorax: CASE report and literature review. *Medicine (Baltimore)* 2017; 96: e6917.
49. Ruppert AM, Perrin J, Khalil A, *et al.* Effect of cannabis and tobacco on emphysema in patients with spontaneous pneumothorax. *Diagn Interv Imaging [Internet]* 2018; 99: 465-471.
50. Callaghan RC, Allebeck P, Sidorchuk A. Marijuana use and risk of lung cancer: a 40-year cohort study. *Cancer Causes Control* 2013; 24: 1811-1820.
51. Zhang LR, Morgenstern H, Greenland S, *et al.* Cannabis smoking and lung cancer risk: pooled analysis in the International Lung Cancer Consortium. *Int J Cancer* 2015; 136: 894-903.
52. Yasmin-Karim S, Moreau M, Mueller R, *et al.* Enhancing the therapeutic efficacy of cancer treatment with cannabinoids. *Front Oncol* 2018; 8: 114.
53. Tashkin DP. Increasing cannabis use: what we still need to know about its effects on the lung. *Respirology* 2014; 19: 619-620.
54. Szyper-Kravitz M, Lang R, Manor Y, *et al.* Early invasive pulmonary aspergillosis in a leukemia patient linked to aspergillus contaminated marijuana smoking. *Leuk Lymphoma* 2001; 42: 1433-1437.
55. Kumar AN, Soo CI, Ng BH, *et al.* Marijuana "bong" pseudomonas lung infection: a detrimental recreational experience. *Respirol Case Reports* 2018; 6: e00293.
56. Barney W. High points: an historical geography of cannabis. *Geogr Rev* 2014; 104: 414-438.
57. Bar-Lev Schleider L, Mechoulam R, Lederman V, *et al.* Prospective analysis of safety and efficacy of medical cannabis in large unselected population of patients with cancer. *Eur J Intern Med* 2018; 49: 37-43.
58. Ramar K, Rosen IM, Kirsch DB, *et al.* Medical cannabis and the treatment of obstructive sleep apnea: an American Academy of Sleep Medicine Position Statement. *J Clin sleep Med* 2018; 14: 679-681.

Suggested answers

1. e.
2. d.
3. c.
4. b.