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1. Introduction

On 15th July 2022, the Ministers (or high representatives) in the fields of drug supply and demand of the governments of Germany, Luxembourg and Malta issued a joint statement on the regulation of cannabis for non-medical and non-scientific uses. The document states that “*there is a need to re-assess our policies on cannabis and to take into account recent developments in this area, to further strengthen and develop health and social responses, such as prevention programs, treatment and harm reduction interventions and to find new approaches beyond prohibition-based drug policies*”. This statement is a

step forward, in Europe, towards the adoption of adult-use cannabis regulation as an alternative policy vis-a-vis prohibition.

In this paper, *regulation-based* drug policy refers to a health-oriented policy involving the establishment of state laws that regulate or control cannabis cultivation and production, possession and use, distribution and sale, similar to that which typically applies to tobacco and alcohol. It is an alternative to prohibition-based policies, which criminalize simple illicit drug possession, that is, the possession with no intent or attempt to supply of substances listed in the schedules of the United Nations 1961 Single Convention on Narcotic Drugs and its successor conventions (Stevens *et al.* 2022).

Jurisdictions where adult-use cannabis regulation was adopted include Uruguay, Canada and several US States (such as Alaska, Arizona, California, Colorado, Maine, Massachusetts, Michigan, Montana, Nevada, New Jersey, Oregon, South Dakota and Vermont). Portugal, the Czech Republic and the Netherlands are not included, given that the simple possession of cannabis is *de jure* illegal, although being *de facto* tolerated (in the Netherlands), or sanctioned by civil penalties (in Czech Republic), or dealt with by measures that divert people towards dissuasion commissions (in Portugal).

Given the foreseen discussion, in Europe, of new bills advancing the legalization of adult-use cannabis, the time is ripe for looking at the evidence regarding adult-use cannabis regulation. Using the scoping review method, this paper aims to answer the following questions: What is the evidence provided regarding research on cannabis substances, types of uses, extractions and administration routes? What is the evidence provided regarding reported cannabis use effects, both general and specific? What are the results obtained from crossing evidence on reported cannabis effects with the legal frameworks concerning cannabis use? What is the evidence provided regarding the assessment of adult-use cannabis regulation? Although the public debate of drug policy has been said to be “only minimally informed by scientific evidence” (Strang *et al.*, 2012, p. 71), Colson & Bergeron (2017) note a growing commitment with scientifically grounded policy debates, which is important to minimize the sense of “entering uncharted territory” mentioned by Cox (2018) in the context of Canada’s legalization of recreational

cannabis. This paper aims at contributing to scientifically grounded drug policies, by mapping recent scientific evidence on cannabis regulation.

The structure of this paper is as follows: after this introduction, it introduces the method of scoping review of literature and details its planning and implementation; then it maps the literature reviewed at the light of the research questions, revealing findings and uncovering knowledge gaps; it then discusses the results and concludes by advancing recommendations for policy.

2. Materials and methods

The general purpose for conducting scoping reviews is to identify and map the available evidence (Arkey & O'Malley, 2005; Munn *et al.*, 2018). Scoping reviews of literature aim at identifying knowledge gaps, clarify concepts, investigate research conduct, and serve as precursors to systematic reviews (Munn *et al.*, 2018; Pollock *et al.*, 2022). Our choice of this method to address the research questions emerged from the perception that cannabis regulation is a growing subject of interest in health policy, that would benefit from a mapping of evidence. This review aims to identify the types of available evidence regarding adult-use cannabis in the clinical, social, economic and legal fields; examine how research is conducted; uncover knowledge gaps; and identify key policy factors related to research in this field.

2.1. Planning: research questions and study selection

Planning the review entailed delimitating the subject area, selecting directories, databases and journals for literature search, defining keywords to guide the identification of papers, and establishing filtering criteria. The research involved the retrieval of English written, blind, peer-reviewed full-text scientific articles (excluding editorial articles, commentaries, conference proceedings, case reports, letters of opinion or criticism, and news) and grey literature (restricted to assessment and consultation reports). The period of publication considered was 1st January 2016 to 30th June 2020: the start date allows the

inclusion of literature assessing preliminary results of the implementation of adult-use cannabis regulation in Uruguay (the first jurisdiction to adopt this policy, in 2013), and the end date allows the results of the scoping review to contribute to parliamentary debates on cannabis policy expected to occur in Europe.

The subject area was delimited as ‘cannabis regulation’. For scientific papers’ selection, the directories, databases and journals chosen were: the EMCDDA (European Monitoring Center for Drugs and Drug Addiction) and the ISAJE (International Society of Addiction Journal Editors) directories of drug addiction journals (excluding all journals not listed on SJR-Scimago Journal & Country Rank); the SJR, for Q1 and Q2 journals listed in the fields of law, economics and social justice; and the PubMed database - options “Core Clinical Journals” and “Humans”, following expert advice - for Q1 journals not listed in the EMCDDA and ISAJE directories. The keywords used for article search, based on professional judgment, were ‘cannabis’, ‘marijuana’, ‘pot’ (a street-name used to explore whether non-scientific expressions appeared in titles and/or abstracts), ‘THC’, ‘tetrahydrocannabinol’, ‘CBD’ and ‘cannabidiol’ (except for the search in PubMed, where only the keyword ‘cannabis’ was used). A total of 920 publications were retrieved for subsequent analysis. Regarding grey literature, the search involved the retrieval of reports published in countries and/or regions that implemented some form of cannabis regulation, produced by governmental entities, health commissions and/or parliamentary commissions and presented in the first two initial Google results search pages, according to the retrieval keywords ‘country/region + cannabis + regulation + report + evaluation + impact’. A total of 41 publications were retrieved for subsequent analysis.

Filtering criteria were applied to reach a refined selection. For scientific articles, the following exclusion criteria were used: (a) studies conducted exclusively on animal models; (b) studies considering only synthetic cannabinoids; (c) studies focused exclusively on medical cannabis; (d) studies examining different treatments for cannabis use disorders (CUD), or the impact of cannabis in the treatment of particular diseases (e.g. “impact of cannabis use in the outcome of HIV treatment”); (e) studies comparing cannabis health-effects with those of other illicit substances (of note, studies evaluating the

impact of cannabis on the use of other substances were not excluded). All publications that were not related with the subject matter were also discarded (for instance, all publications where CBD was used as an abbreviation for “Central Business District”). The total amount of scientific articles selected for analysis was 531. Regarding grey literature, the exclusion criteria, which were already taken into consideration in the initial Google search, were as follows: a) reports exclusively focused on medicinal and/or therapeutic use of cannabis; b) by entities/NGOs known for their drug policy advocacy activities; c) that presented cannabis regulation models without focusing on evidence concerning their impact and/or effects. Given that one report was published outside the interval period considered, the total amount of grey literature reports selected was 40. In summary, a total of 571 publications were considered for analysis.

2.2. Analysis: exploring publications with Nvivo®

To explore and analyse the full-text publications, we used the qualitative data analysis software Nvivo11®. This software facilitates the management of large amounts of data and is considered useful to analyse, synthesize and write up literature reviews (Bandara *et al.*, 2015). Nvivo® allows papers to be stored with their meta-attributes (e.g. source, authors, year, etc.) and has advanced search features to query these attributes as well as the content of the papers. It enables the analysis process by allowing extraction and synthesizing of aspects from the data both deductive and inductively, guaranteeing the link to the original data. Because of these possibilities, coding and reporting are made easier, since researchers can systematically capture, code, and analyse the literature.

All 571 publications were inserted in Nvivo® as individual data files. Each file was globally coded in a classification system that included a group of meta-attributes such as *publication year, country and/or region, disciplinary domain* and *cannabis component*. The results from this classification can be consulted in appendix 1. Then each file was coded for its content. At this stage, a semi-inductive thematic and open coding strategy was applied. Prior to Nvivo® coding of the content, a preliminary categorization system was derived from the research questions and research aims that thus represented

a pre-defined, deductive coding scheme. Afterwards, coding allowed new codes and categories to emerge inductively from the raw data, which were added to the initial categorization system. For the process of coding data files more specifically for their content, a thematic coding strategy was followed. The file content was identified and coded to specific codes and categories in order to manifest organized and descriptive emerging patterns of data (Braun & Clarke, 2006). Key themes and processes were captured for their relevance for the research purpose, and portions of text/files were assigned to codes and wider categories with which they shared meanings with (Bandara et al, 2015). An open-coding approach was followed, involving a data coding strategy that splits data and associates them with all codes and categories applicable to that file/unit in terms of shared meaning (Saldaña, 2016). Codes and categories were refined and collapsed numerous times at research meetings, resulting in a detailed categorization system.

3. Results

3.1. Preliminary analysis

We first analysed the selected 571 publications alongside four general characteristics: disciplinary domain (elicited from the publication's content), methodology used, and target groups and participants considered. We found that social sciences are the predominant *disciplinary domain* (66.7%, n=381), followed by medical and biomedical sciences (45%, n=257) and behavioural sciences (42%, n=240). Contributions in law and economics are less represented (11.7%, n=67 and 7.3%, n=42, respectively). Among the social sciences domain, the field of health policy is the most salient one (43.6%, n=249), whereas social justice, for instance, represents only 3.1% (n=18). Looking at *methodology* from the perspective of hierarchy of evidence (e.g. Nutley *et al.*, 2013), we found that the type that gathers the largest group of research is case reports and case series designs (representing 18.7%, n=107). The three groups of methodologies in the top of the hierarchy are considerably less present: meta-analysis and systematic reviews account for just 3.6% (n=21), randomized controlled clinical trials correspond to 3.8% (n=22) and non-randomized clinical trials account for 4.5% (n=26). There seems to be a lack of

studies based on the strongest types of evidence, but also a concern for contextualization studies via the use of qualitative methods.

As for *target groups and participants*, (coded according to social and developmental roles associated to cannabis), research is reporting results on *cannabis social roles* (with research on cannabis users representing 34.5%, n=197), but a lot less on cannabis-related professions (2.9%, n=17), lawmakers, politicians, and justice professionals (2.1%, n=12), and former users (1.9%, n=11). All other target groups and participants considered - health professionals, dealers and other parallel economy activities, teachers, and parents – are residual (corresponding to 0.1%, n=1, or, in the latter case, to none). As for *gender*, it is a widely present category, but almost exclusively focused on cis-male and cis-women gender identities (65.6%, n=375); cis-women and cis-man correspond to, respectively, 2.8% (n=16) and 2.6% (n=15). Regarding *developmental categories*, 66.9% (n=382) of publications specify a developmental stage over life span, being young adults the most present one (40.9%, n=234), closely followed by adults (36.9%, n=211) and adolescents (24.8%, n=142). Elders, pregnant women, and children are the least reported groups, with respectively 4.9% (n=28), 2.4% (n=14) and 2.1% (n=12). Finally, regarding *vulnerable groups*, we found that they are reported in only 4% (n=23) of the publications, with ethnic and racial vulnerability corresponding to 2.8% (n=16). There is a generalized gap regarding research on vulnerable groups such as at-risk youth (0.7%, n=4), cannabis related young offenders (0.7%, n=4), rural communities (0.3%, n=2) and sexual minorities (0.1%, n=1).

3.2. Evidence on cannabis substances, types of uses, extractions and administration routes

Regarding the research question “what is the evidence provided regarding research on cannabis substances, types of uses, extractions and administration routes”, the main finding is that research lacks rigour. We found that 39.23% (n=224) publications concerned THC, and that 13.65% (n=78) concerned cannabidiol (CBD). Given that over 400 compounds can be synthesized by cannabis, more than 100 are phytocannabinoids (the main ones being THC and CBD) and they are associated with different effects (Santos, Hallak & Crippa, 2021; Micalizzi *et al.*, 2021; Legare, Raup-Konsavage & Vrana, 2022), we

find that research is widely general at this level of *cannabis substances*. This has implications for the study of cannabis effects, mostly regarding health-related effects. The literature also presents limitations in what concerns the *types of cannabis use* (for example, problematic, recreational), given that only 12.08% (n=69) of the literature considers this analytical dimension. As to cannabis *extractions* (flower, hashish and resin, oils and drops), they are mostly irrelevant as a research dimension, with only 4.55% (n=26) of the literature reviewed making a reference to it. References to *administration routes* (for example, edibles, smoking, and vaping) are also very scarce: few publications refer edibles (5.25%, n=30), smoking (blunts) (1.05%, n=6), smoking without tobacco (3.33%, n=19), smoking with tobacco (4.38%, n=25) and vaping/dabbing (4.38%, n=25). This scarcity of references to extractions and administration routes is a serious limitation, since use experience and effects are affected by cannabis extractions and administrations routes (Russell *et al.* 2018; Chye *et al.*, 2020; Micalizzi *et al.*, 2021). These limitations within research on cannabis are not new: for example, they have been stated in a NASEM-National Academies of Sciences, Engineering, and Medicine report on health effects of cannabis published in 2017 (NASEM, 2017).

3.3. Evidence on reported cannabis use effects

The question “what is the evidence provided regarding reported cannabis use effects, both general and specific” aims to uncover the effects of cannabis use reported in the literature that are independent of the legal framework, and that exist regardless of cannabis drug policy. The effects are classified here in two categories: general and specific.

3.3.1. Evidence on general effects

Based on the EMCDDA’s guidelines on risk assessment (EMCDDA, 2009), general effects of cannabis use are sub-divided in risk-related effects, protective effects and neutral effects. A classification in the *risk* category implies that the literature reports some type of effect that associates the use of cannabis with any type of harm, or that cannabis is directly responsible for increasing that type of harm, whereas

a classification in the *protection* category means that the literature reports the relationship of cannabis use with the emergence of an active well-being and health promoting effect (physical or mental), and/or the presence of effects that seem to protect the population from initiating cannabis use and/or the protection from the emergence of more serious consequences associated with progression of use. Finally, a classification in the category of *neutral effects* means that the literature does not allow any conclusions about the implications of cannabis use for risk or protection, and it also includes research in which the effects investigated do not confirm the association with risk.

The scoping review indicates that cannabis research focuses predominantly on evidence about risks, accounting for 60.78% (n=347). Research on protective effects accounts for only 13.49% (n=77) - with 5.78% (n=33) referring to cannabis being protective of well-being and/or health and 7.71% (n=44) to cannabis having effects that protect from cannabis use/onset- and on neutral effects corresponds to 10.86% (n=62). Nonetheless, this predominance of evidence about risks may be in part due to the exclusion, in the scoping review, of research solely focused on medical cannabis.

3.3.2. Evidence on specific effects

The semi-inductive strategy used in the scoping review led to the identification of the following specific effects: *physical health effects*; *problematic use, dependence and intervention effects*; *epidemiological effects*; *mental health effects*; *psychological effects*; *social and social justice effects*; *driving under influence effects*; *prevention and harm reduction effects*; *crime, deviance and victimization effects*; and a residual category of *non-specifiable effects* (see appendix 2 for more detail on specific effects corresponding to $n \geq 100$). Although health-related effects should be considered integrally, for analytical purposes we followed Ohrnberger, Fichera & Sutton (2017) and separated between physical health effects and mental health effects.

Looking at the specific effects reported in the literature reviewed, to how far they are related to the general effects and also to what trends the findings elicit, our main conclusions are that health-related

effects and epidemiological effects are the most researched, whereas other effects of cannabis – most notably those related to prevention and harm reduction, and crime, deviance and victimization - are neglected; that research on physical health effects focuses on risks, not on protective or neutral effects; and that the effects that are reported as protective and neutral are part of the research that is also reporting cannabis use risks.

Physical health effects account for 23.99% (n=137) of the literature reviewed, followed by problematic use, dependence, and intervention effects (23.82%, n=137), epidemiological effects (22.60%, n=129) and mental health effects (21.02%, n=120). By contrast, the other effects considered are less reported, with psychological effects accounting for 11.38% (n=65), social/social justice for 8.93% (n=51), driving under influence for 4.73% (n=27), prevention and harm reduction for 1.05% (n=6), and crime, deviance and victimization effects for less than 1% (namely 0.88%, n=5).

Concerning *physical* health effects, we considered developmental effects (corresponding to 11.90%, n=68), systemic/peripheral effects (8.41%, n=48), central effects (3.85%, n=22), central physiologic and sensorial functions effects (2.80%, n=16), and a residual category of other health effects (2.80%, n=16). Within *developmental* effects, pre and perinatal cannabis effects are the most reported (5.43%, n=31). When we explored the relation between developmental effects and general effects, we concluded that the effects of cannabis use are almost exclusively reported in terms of increased risk, and when a protective or neutral effect is reported, it is part of research that also reports risk effects for developmental health. Within *systemic/peripheral effects*, the most reported regard blood and cardiovascular system (2.98%, n=17), musculoskeletal system and motricity (2.63%, n=15), respiratory system (2.45%, n=14) and digestive system (including mouth and teeth) (1.40%, n=8). Once more, the systemic/peripheral effects of cannabis use are almost exclusively reported in terms of increased risk, and when protective or neutral effects are reported, they are part of the research reporting risk. The exception is hepatic function, where only protective effects (related to protection against steatosis in alcoholic patients and those suffering from chronic infection by hepatitis C) are reported. All other effects in this category (that is, central effects, central physiologic and sensorial functions effects, and

other health effects) correspond to less than 4% of the literature. Despite the lower presence of these other physical health effects, some aspects are worth mentioning: the publications selected did not include any study on central effects regarding glial impact, myelination and brain metabolism, which was surprising, given that these are frequently reported in research on psychoactive drugs; and within central physiologic and sensorial functions effects, although most effects are reported in terms of increased risk (such as low level of visual processing, with possible impact on driving safety), there is also cumulative reporting of protective effects such as the reduction of sleep onset, appetite stimulation, relief from chronic pain and muscle spasm and lower odds of obesity.

As to *problematic use, dependence and intervention* effects, considerable attention is devoted to the research on cannabis addiction. Our coding method led us to identify effects related to problematic use phenomena (e.g. dependence and dependence syndrome, co-dependence, withdrawal), problematic use patterns (e.g. heavy use, regular use, daily use), problematic use diagnosis (e.g. cannabis use disorder, substance use disorder) and problematic use interventions (e.g. prevention, substance abuse treatment, cognitive behavioral therapy). However, the diverse terminology used and the lack of consensus on how to identify, classify and define problematic cannabis use impairs the advancement of knowledge.

Regarding *epidemiological* effects, the theme that gathers the most frequent coding is use onset (corresponding to 11.38%, n=65), followed by polyuse (5.95%, n=34). By contrast, themes such as ethnicity and religion are almost non-existent (corresponding to 0.70%, n=4 and 0.18%, n=1, respectively). The evidence reported seems to uncover a complex relation between cannabis use onset, accessibility and regulation initiatives: only one study reports that the decriminalisation of cannabis does not affect age of onset use of cannabis; however, studies that report an association between regulatory policy models and cannabis use onset are cautious to establish a causal relation between more liberal policies and cannabis use onset, and recommend additional longitudinal research to determine the role of pre-existing secular trends. As to polyuse, most studies report an association between cannabis use and use of other substances, most notably alcohol, tobacco, and intravenously used substances.

Within *mental* health effects, we considered three analytical categories regarding the relation between cannabis use and: diagnosis (which corresponds to 9.28%, n=53); symptoms and psychopathology (11.91%, n=68); and a residual category of other mental health effects (9.98%, n=57). Regarding diagnosis, research is reporting a relation between cannabis use and depressive syndrome (6.13%, n=34) and psychosis and schizophrenia (5.08%, n=29). The other two categories (namely attention deficit and hyperactivity disorder, and post-traumatic stress disorder) are very rarely researched for their relation with cannabis use. As to symptoms and psychopathology, anxiety is the symptom most frequently researched, accounting for 6.30% (n=36). All other effects coded in this category – namely cognitive effects (on memory, decision making, intelligence, awareness and attention, and unspecified cognitive effects), emotions, suicidality and self-harm, anhedonia and others - amount to less than 1.8% (n=10). Finally, within other mental health effects, the most salient are general mental health effects. Most studies report an association between cannabis use and impairments in mental health, but a few studies (n=3) report a link between cannabis use and relief of stress and anxiety. The relation between mental health effects and general risk effects is more frequent than with protective or neutral effects, in particular regarding depression, psychosis and schizophrenia, anxiety and behavioural disorders.

Psychological effects correspond to 11.38% (n=65) publications. Among these, the most frequently mentioned are risk perception and risk taking (5.25%, n=30) and psychoactive experience (2.80%, n=16). All other effects coded as psychological are seldom mentioned. Finally, we also considered other effects – namely social justice and social effects, and other effects such as driving under the influence, crime, deviance and victimization effects, prevention and harm reduction effects, and a residual category of non-specifiable effects- but amongst these, only driving under the influence effects are more frequently reported, accounting to 4.73% (n=27).

Overall, we concluded that more and higher quality research is needed on the effects of cannabis. We note a focus on individual-related effects, especially on health effects. Social effects are largely neglected, although they may have a considerable impact on society, such as social justice effects

(particularly dimensions such as sources of economic inequality), crime, deviance and victimisation effects, as well as effects related to intervention strategies to implement prevention and harm reduction.

3.4. Evidence on legal frameworks and cannabis general effects

After looking at the evidence on general and specific effects of cannabis use, we explored the question “what are the results obtained from crossing evidence on reported cannabis effects with the legal frameworks concerning cannabis use?”. Our aim was to uncover how far the research analysed is investigating the relation between the legal status of cannabis and general effects of cannabis use. The coding of the literature into legal frameworks considered the following legal statuses, based on Stevens *et al.* (2022): regulation of adult cannabis use; regulation of medical/medicinal use (although the scoping review excluded publications focusing *exclusively* on medical cannabis, it included publications that covered medical cannabis and other cannabis uses and/or legal models); decriminalization; prohibitionism; tolerance; depenalization; diversion. An additional coding – ‘unspecified’ - was created to code publications that refer to multiple legal frameworks, and/or to countries/regions that have more than one legal framework, and/or do not specify a particular legal framework.

Approximately half of the literature reviewed (49.21%, n=281) explicitly refers to multiple legal frameworks, or to countries that have more than one legal status of cannabis use, or does not make any reference to the legal status of cannabis. Thus, no conclusions can be drawn from it on the relation between the legal status of cannabis and general effects of cannabis use. However, if we consider the remaining literature, we find that the most extensively researched legal framework is *regulation*. The combined frequency of publications referring to ‘regulation’ counts n=164 publications referring to ‘regulation of adult cannabis use’ and n=64 publications referring to ‘regulation of medicinal cannabis use’, both corresponding to recent legal frameworks applicable to illicit substances. This suggests that it is in the countries/regions where regulation (adult use or medicinal use) is being implemented that most of the research is being produced. *Decriminalization*, *prohibitionism* and *tolerance* are referred in 5.08% (n=29), 5.08% (n=29) and 1.40% (n=8) of the literature reviewed, respectively, whereas there is

only one publication referring to *depenalization*, and none referring to *diversion*. It is interesting to notice that prohibitionism, which is historically the most extensively adopted legal status for cannabis use, is scarcely mentioned in comparison to regulation.

When evidence on legal frameworks is crossed with that on general effects of cannabis use (excluding *depenalization* and *diversion*, which are almost absent in the literature, and the coding *unspecified*), we find that most research is reporting some type of risk-related effect. Although this is more salient in research referring to legal frameworks of tolerance (n=7, for a total of n=8 publications coded on this legal framework) and prohibitionism (n=23, for a total of n=29 publications coded on this legal framework), the most predominant effect emerging from the analysis is undoubtedly the risk-related one. This may be interpreted as risk being objectively the widest general effect to be expected from cannabis, but also as a biased tendency of science to consistently ask risk-related questions, neglecting protection-related ones.

3.5. Evidence on the assessment of adult-use cannabis regulation

The final question guiding the scoping review is “what is the evidence provided regarding the assessment of adult-use cannabis regulation?”. Our purpose was to look at which dimensions of regulation were covered by research, how research that evaluates adult-use cannabis regulation translated into positive versus negative effects, what is the positioning of the research that evaluates adult-use cannabis regulation, and finally whether research addresses aspects to consider when implementing adult-use cannabis regulation.

Findings show that the various dimensions of regulation - ‘cultivation and production’, ‘distribution and sale’, ‘control, licensing and certification’ and ‘taxation policy’ - are not uniformly covered in the literature focused specifically on adult-use cannabis regulation. The most studied dimension is distribution and sale (accounting for 14.01%, n=80) and, within it, the element ‘context for sale’, which accounts for 9.63% (n=55) and refers to the various sites for selling cannabis, for example, licensed

establishments, dispensaries, social clubs, coffee shops, state-held pharmacies, and online vending sites. 'Potency' is also considerably covered in the literature reviewed, corresponding to 6.30% (n=36). However, there is scarce research on other elements related to this dimension, namely location of vending sites (1.40%, n=8), staff training and responsibility (1.23%, n=7), tracking (1.23%, n=7) and promotions (1.05%, n=6). Comparatively, taxation policy is the least addressed regulatory dimension (accounting for 3.85%, n=22), which is surprising, given that taxes affect cannabis prices, thus influencing consumer choice and the success of any drug policy based on regulation.

When publications are focused on assessing the impact of adult-use cannabis regulation, the most studied group of effects is that of health (including mental health) effects: a total of n=53 publications address this groups of effects. Then follows the judicial and criminal effects (n=30), economic effects (n=26), market effects (n=25) and finally social effects (n=18). When the assessments described in this research are analysed in general, positive impacts slightly surpass the negative ones. Most of the positive effects come from economic, judicial and criminal impacts, while the domain where negative impacts surpass the positive ones is that of health effects (including mental health).

As to positioning - meaning how far the literature that refers to adult-use cannabis regulation adopts a standpoint in favour of or against this policy model – two findings must be highlighted: 72.15% (n=412) of all publication cannot be coded for positioning, given that they do not address adult-use cannabis regulation, and 19.96% (n=114) are ambiguous or uncompromising, that is, they present arguments in favour and against adult-use cannabis regulation, and do not unequivocally state whether they support or reject this policy model. If only research that presents a clear positioning is considered, the dominant positioning is in favour of adult-use cannabis regulation (7.53%, n=43), with a positioning against this legal framework accounting for just 0.52% (n=3). The motives behind the positioning adopted are diverse: the ones more frequently invoked are related to regulatory concerns, such as the need to control and regulate cannabis products and the various stages of the production chain (11.9%, n=68); health and mental health-related motives are also frequent (7.88%, n=45), as well as social justice motives such as diminished stigmatisation, protection of human rights and defence of personal choice (6.65%,

n=38); economic motives (5.95%, n=34) are associated with an increase in tax income, reduction of costs from police enforcement, employment opportunities and the emergence of a new legal market, among others; finally, judicial and criminal motives are the least frequent (4.2%, n=24), and correspond to the displacement of illegal markets by official and regulated retailers, and to meeting demands for judicial security, among others. It is worth mentioning that one motive presented in favour of adult-use cannabis regulation is that this drug policy constitutes in itself an opportunity for higher quality scientific evidence regarding the field of cannabis.

The issue of policy implications of implementing adult-use cannabis regulation is addressed in only 9.8% (n=56) of the literature reviewed. Nonetheless, four groups of policy recommendations stand out, corresponding to at least 3% of the publications reviewed: one related to prevention and intervention (corresponding to 5.77%, n=33), which includes aspects such as the establishment of guidelines towards limiting and protecting youth from using cannabis products (for example, advertising restrictions and drug education programmes); one related to policy impact evaluation (4.37%, n=25), which refers to the development of a flexible system with robust data collection and performance monitoring so as to support the assessment of adult-use cannabis regulation; a third group related to use policy regarding driving under the influence of cannabis (4.02%, n=23), and finally a group related to use policy regarding the establishment of minimum age to use cannabis (3.15%, n=18).

4. Discussion

The results above reveal several issues of concern for policy makers. First, research lacks rigour on key aspects of cannabis (such as substances or components, types of use, extractions and administration routes); this poses a serious limitation to advancing knowledge on use experience and effects of cannabis use, and it is disappointing to conclude that the recommendations of the NASEM report (NASEM, 2017), namely the standardization of terminology, methods and materials, have not been taken further. Second, more and higher quality research is needed on the effects of cannabis: in the publications selected for analysis there is a focus on individual-related effects, and a large neglect of

social effects, although the later may have considerable impact on communities, such as social justice effects (regarding vulnerability and social exclusion, for instance), and crime, deviance and victimisation effects; there were no publications within the selected publications addressing migrants and low-income urban groups, which is a disturbing finding, for it suggests a neglect, within publication in specialized and top-tier journals, of groups whose vulnerability is caused by poverty; and there is also significantly more focus on the risk-associated effects of cannabis use than on protective or beneficial effects. Third, in the publications selected for analysis, the majority of research that addresses the policy of adult-use cannabis regulation does not position itself clearly in favour or against it; however, within research that adopts a clear positioning, the dominant position is that in favour of adult-use cannabis regulation. Fourth, within research that addresses the policy implications of adult-use cannabis regulation, the most frequent recommendations point to the need for prevention and intervention planning (particularly regarding youth), for the development of a flexible data collection and performance monitorisation system to support policy assessment, and for specific attention to be paid to the risk of driving under the influence of cannabis and to the minimum age to use cannabis.

The scoping review conducted has limitations: the choice to exclude Q3 and Q4 journals in the fields of law, economics and social justice may have resulted in discarding niche journals concerned with drug policy research; the end period for the publications considered does not include more recent research on assessing health-based drug policies; and the use of content analysis software may have neglected relevant contextual factors. Nonetheless, the amount and quality of the publications reviewed and the procedure followed for mapping the literature provide evidence that is useful for policy debate and decision making.

5. Conclusions and recommendations

Policymakers in several European countries are considering the adoption of adult-use cannabis regulation. Given the findings of this scoping review, we present the following recommendations for implementing this type of policy:

- Plan and implement a data collection and performance monitorisation system regarding cannabis cultivation, production, consumption, distribution and sale for non-medical adult use, which is co-designed with on the ground professionals and scientists, allowing the implemented policy to be assessed; planning should include rules and conditions for reviewing this system.
- Design the legal framework for non-medical adult use so as to convey a clear positioning on the following key aspects:
 - prevention of cannabis use - especially regarding children, adolescents and young adults - and corresponding funding (for instance, via special taxes on cannabis products);
 - types of cultivation allowed (such as allowances for home growth; requirements for home growth - for example, minimum age, location, quantity, strain, authorisation; allowances for collective growth and corresponding requirements; allowances for industrial cultivation and corresponding requirements) and respective monitoring and enforcement system;
 - minimum age (and residence) requirements to buy, possess and use cannabis, quantities allowed to be possessed and used in public, location-related restrictions on cannabis sale, possession and use (for example near schools and hospitals) and corresponding enforcement, and rules related to driving under the influence of cannabis;
 - types of products allowed for sale (regarding extractions, potency or percentage of THC, packaging, labelling and branding), types of retailers allowed (for example, state-owned facilities, licensed pharmacies or dispensaries, coffee shops), price setting system, advertising and promotion rules on cannabis products, requirements regarding training and liability of retailers' staff, and conditions for retailers' licensing and licence renewal.
- Establish a system for monitorisation of responses to the new cannabis market, especially regarding responses at street level (for example, sale of new products, price dynamics and

substance substitution) and at business level (for example, entry into the new cannabis market by small and medium-sized firms).

- Establish rules regarding expungement of prior criminal records due to cannabis-related convictions.

In addition, we recommend that policy makers conduct an *ex ante* regulatory impact assessment according to OECD's principles and methodologies (OECD, 2020), or at least apply the multi-criterion decision analysis model advanced by Rogeberg *et al.* (2018). These methodologies take into account the complexity of cannabis-related policies, due to the variety of dimensions, costs and benefits involved regarding health, economy, justice and society, and may mitigate the risk of designing a regulatory framework that, due to its intrinsic compliance costs, makes unregulated cannabis more attractive to consumers, as alerted by Goldstein & Sumner (2022). They may also further the inclusion of neglected potential collective effects of adult-use cannabis regulation, such as the loss of income for vulnerable groups that depend on illicit drug trade to survive. Finally, given that a policy of adult-use cannabis regulation implies considerable changes in most extant legal frameworks, and the creation of a new market for legal cannabis, a strong collaboration between members of parliamentary committees in the areas of health, justice and economy is endorsed.

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Appendix 1

	n=	%
<u>Publication Year</u>		
2016	138	24.17
2017	134	23.47
2018	130	22.77
2019	110	19.26
2020 (1st semester only)	59	10.33
Total	571	100%
<u>Disciplinary Domain</u>		
Neuroscience/Biology/Psychiatry	115	20.14
Psychosocial	271	47.46
Law	24	4.20
Economics	20	3.50
Social Justice	14	2.45
Medicine	98	17.16
Not Applicable ^{a)}	27	4.73
Total	571	100%
<u>Cannabis Components</u>		
Cann Unspecified	404	70.75
THC	28	4.90
THC & CBD	26	4.55
Not Applicable ^{b)}	113	19.79
Total	571	100%
<u>Country and/or Region with ACR</u>		
Canada Ontario	6	5.26
Canada Alberta	2	1.75
Canada British Columbia	3	2.63
Uruguay	18	15.79
USA District of Columbia	21	18.42
USA California	24	21.05
USA Colorado	23	20.18
USA Massachusetts	3	2.63
USA Michigan	3	2.63
USA Oregon	3	2.63
The Netherlands	8	7.02
Total	114	100%
<u>Country and/or Region Without ACR</u>		
Africa	2	0.44
Europe	63	13.79
Middle East	6	1.31
Not Applicable ^{c)}	42	9.19
North America	293	64.11
Oceania	37	8.10
Other Multiple Regions/Countries ^{d)}	10	2.19
South America	4	0.88
Total	457	100%

^{a)}Research resulting from grey literature reports that are multi thematic, that is, that refer to several disciplinary domains;

^{b)}Research that considers THC and/or CBD indistinguishably; ^{c)}Research that refers to regulation, policy, social issues and/or other domains that don't refer cannabis compounds; ^{d)} Research that doesn't refer to a specific national/regional context (e.g. literature reviews, reviews of social network and/or online contents, etc.). Note: ACR=Adult-Use Cannabis Regulation.

Appendix 2

Physical Health Effects (n=137)
Developmental Effects (n=68)
Pre/Perinatal Exposure, Pregnancy and Birth (n=31)
Toddler and Child Exposure (edibles) (n=20)
Adolescent Exposure (n=16)
Genetic Variability and Mutations (n=15)
Systemic/Peripheral Effects (n=48)
Blood and Cardiovascular System (n=17)
Musculoskeletal System and Motor Function Motricity (n=15)
Respiratory System (n=14)
Digestive System (n=8)
Endocrinal System (n=3)
Global Systemic/Peripheral (n=3)
Hepatic Function (n=2)
Fertility and Reproductive System (n=2)
Immune Function (n=2)
Central Effects (n=22)
Brain Activity (n=12)
Brain Structure and Morphology (n=7)
Region Specific Effects (n=5)
Brain Metabolism (n=0)*
Glial Impact (n=0)*
Myelination (n=0)*
Central Physiologic/Sensorial Effects (n=16)
Sleep (n=10)
Vision (n=3)
Appetite (n=2)
Pain (n=2)
Weight Regulation and Food Intake (n=1)
Other Health Effects (n=16)
Poisoning and Intoxication (n=11)
Cancer (n=4)
Death Paliative Care and End-of-Life (n=2)

*Although a semi-inductive codification strategy was followed, we decided to include these specific central effects, according to two experts' advice.

Effects Related to Problematic Use, Dependence and Intervention (n=137)**Problematic Use Phenomena and Cannabis Effects (n=46)**

Dependence and Dependence Syndrome (n=26)

Co-Dependence (n=10)

Withdrawal (n=6)

Abstinence (n=5)

Craving (n=5)

Escalation (n=1)

Problematic Patterns and Cannabis Effects (n=45)

Problematic Habitual or Problem Drug Use (n=22)

Heavy Use (n=10)

Regular Use (n=9)

Daily or Frequent Use (n=4)

Chronic Use (n=3)

Problematic Use Interventions and Cannabis Effects (n=43)

Prevention (n=17)

SAT - Substance Abuse Treatment (n=15)

Cognitive Behavioral Therapy – CBT (n=6)

Brief Intervention (n=2)

Drug Help Lines (n=1)

Other Interventions (n=10)

Problematic Use Diagnosis and Cannabis Effects (n=36)

CUD - Cannabis Use Disorder (n=29)

SUD - Substance Use Disorder (n=14)

Epidemiological Effects (n=129)

Use Onset (n=65)

Polyuse (n=34)

Lifetime Use and Trajectories (n=18)

Age (n=23)

Academic Achievement (n=16)

Gender (n=14)

Ethnicity (n=4)

Religion (n=1)

Mental Health Effects (n=120)
Symptoms and Psychopathology (n=68)
Anxiety (n=36)
Cognitive Unspecified (n=10)
Cognitive Memory (n=9)
Cognitive Decision-Making (n=7)
Emotions (n=7)
Cognitive Intelligence (n=4)
Anhedonia (n=3)
Suicidality and Self Harm (n=3)
Cognitive Awareness and Attention (n=2)
Cognitive Motivation (n=2)
Cognitive Perception (n=2)
Mood (n=1)
Somatization (n=1)
Diagnosis (n=53)
Depressive Syndrome (n=34)
Psychosis and Schizophrenia (n=29)
Attention Deficit and Hyperactivity Disorder - ADHD (n=2)
Post Traumatic Stress Disorder- PTSD (n=1)
Other mental health effects (n=57)
General Mental Health Effects (n=37)
Behavioural Disorders (n=14)
Childhood Adversity and Trauma Effects (n=7)

