human behavior, including cognition, motivation, and psychosis: a review. *JAMA Psychiatry* 2016; **73**: 292–7.

5. National Academies of Sciences, Engineering, and Medicine. In: *The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research*. Washington, DC: National Academies Press; 2017.

6. Meier M. H., Caspi A., Ambler A., Harrington H., Houts R., Keefe R. S. *et al.* Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proc Natl Acad Sci USA* 2012; **109**: E2657–E2664.

7. Orr C., Spechler P., Cao Z., Albaugh M., Chaarani B., Mackey S. *et al.* Grey matter volume differences associated with extremely low levels of cannabis use in adolescence. *J Neurosci* 2019; **39**: 1817–27.

8. Scott J. C., Rosen A. F. G., Moore T. M., Roalf D. R., Satterthwaite T. D., Calkins M. E. *et al.* Cannabis use in youth is associated with limited alterations in brain structure. *Neuropsychopharmacology* 2019; **44**: 1362–9.

9. Volkow N. D., Koob G. F., Croyle R. T., Bianchi D. W., Gordon J. A., Koroshetz W. J. *et al.* The conception of the ABCD study: from substance use to a broad NIH collaboration. *Dev Cogn Neurosci* 2018; **32**: 4–7.

10. Chandra S., Radwan M. M., Majumdar C. G., Church J. C., Freeman T. P., ElSohly M. A. New trends in cannabis potency in USA and Europe during the last decade (2008–2017). *Eur Arch Psychiatry Clin Neurosci* 2019; **269**: 5–15.

11. ElSohly M. A., Ross S. A., Mehmedic Z., Arafat R., Yi B., Banahan B. F. III. Potency trends of delta9-THC and other cannabinoids in confiscated marijuana from 1980–1997. *J Forens Sci* 2000; **45**: 24–30.

12. Volkow N. D., Baler R. Emergency department visits from edible versus inhalable cannabis. *Ann Intern Med* 2019; **170**: 569–70.

13. Arterberry B. J., Treloar Padovano H., Foster K. T., Zucker R. A., Hicks B. M. Higher average potency across the United States is associated with progression to first cannabis use disorder symptom. *Drug Alcohol Depend* 2019; **195**: 186–92.

14. Di Forti M., Quattrone D., Freeman T. P., Tripoli G., Gayer-Anderson C., Quigley H. *et al.* The contribution of cannabis use to variation in the incidence of psychotic disorder across Europe (EU-GEI): a multicentre case–control study. *Lancet Psychiatry* 2019; **6**: 427–36.

STANDARD TETRAHYDROCANNABINOL UNITS: AN IDEA WHOSE TIME HAS COME

The increasing diversity of cannabis products represents a challenge for measuring and reporting potency. Freeman & Lorenzetti's proposal for a standard tetrahydrocannabinol (THC) unit has considerable potential as a tool for reporting potency with respect to market surveillance and sales data, as well as in research studies. Although no standard unit can fully capture the qualitative differences across modes of administration, a 5-mg THC unit represents an appropriate threshold for communicating the potency of cannabis products.

This commentary discusses a proposal from Freeman & Lorenzetti on the use of standard units of tetrahydrocannabinol (THC) for cannabis products [1]. With the advent of legal cannabis markets, regulatory authorities and the industry have a shared responsibility to ensure that consumers have adequate information regarding the potency and appropriate dose of products [2]. Effective consumer guidance is particularly important, given the proliferation of cannabis products and the wide range of tetrahydrocannabinol (THC) levels, which range from less than 1% to more than 90% [3]. Within this context, there is a need to standardize how cannabis potency is reported.

Freeman & Lorenzetti propose a 'standard THC unit' of 5 mg of THC for all cannabis products. The authors point to the use of standard alcohol units as a framework; however, the nicotine market provides a more appropriate reference point given the diverse modes of administration for both cannabis and nicotine products, which include transdermal, oral ingestion, vaporized aerosol and smoke inhalation. A key question raised by Freeman & Lorenzetti is whether a 5-mg THC unit has the same meaning among these modes of administration, given inherently different pharmacological effects. Ultimately, there may be no way of reconciling these differences within a standard quantitative unit: modes of cannabis use differ not only with respect to the onset and duration of 'peak' THC effects, but also in the qualitative effects of THC. Nevertheless, even an imperfect standard unit would represent a considerable improvement on the *status quo*, in which consumers typically depend upon word of mouth and references to cannabis 'strains', which are unreliable indicators of cannabis potency [4,5].

HOW WOULD STANDARD THC UNITS BE USED IN PRACTICE?

Standard THC units have the potential to serve as a common metric for reporting market-based data among different product categories, such as sales volumes and prices paid per unit. Standard THC units could also be integrated into product labelling as a consumer information tool. Currently, few consumers understand the THC numbers that serve as the basis of potency labelling in legal cannabis markets, in part because THC numbers are communicated using different units among different products, including dried herb, oils and edibles [1]. Although these practices are technically sound, consumers have little idea of how to interpret and apply these numbers to guide consumption levels. Alternatively, regulators could label the number of standard THC units in a particular product, such as a joint, edible or unit of oil, which is likely to be more intuitive for consumers [6]. Standard units could also enhance the way cannabis consumption is reported in epidemiological and clinical studies, most of which rely upon crude measures of frequency of use,

without an established means of comparing different modes of administration.

IS 5 MG THE RIGHT LEVEL FOR STANDARD THC UNITS?

Freeman & Lorenzetti pose the question of whether 5 mg is the appropriate threshold for a standard THC unit. As the authors note, there are regulatory precedents in several US states for using 5 mg of THC as a standard 'serving size' for cannabis edibles, while other states and Canada use 10 mg of THC as a standard unit for serving size and packaging regulations. There is a compelling argument for a standard THC unit to be at, or below, the point of intoxication for most consumers [2]. For example, the amount of alcohol in a 'standard drink' is below the level that would induce intoxication or impairment for most consumers. A standard of 5 mg rather than 10 mg THC is more consistent with this principle and allows consumers to 'titrate' up to their desired level of consumption.

Overall, Freeman & Lorenzetti's proposal for a standard THC unit has considerable merit and represents an opportunity to harmonize the ways in which cannabis potency is reported across the increasing number of jurisdictions with legal cannabis markets

Declaration of interests

None.

DAVID HAMMOND (iD)

School of Public Health and Health Systems, University of Waterloo, ON, Canada

References

1. Freeman T. P., Lorenzetti V. 'Standard THC units': a proposal to standardize dose across all cannabis products and methods of administration. *Addiction* 2019; https://doi.org/10.1111/add.14842.
2. Hammond D. Communicating THC levels and 'dose' to consumers: implications for product labelling and packaging of cannabis products in regulated markets. *Int J Drug Policy* 2019; https://doi.org/10.1016/j.drugpo.2019.07.004.
3. Caulkins J. P., Bao Y., Davenport S., Fahli I., Guo Y., Kinnard K. *et al.* Big data on a big new market: insights from Washington State's legal cannabis market. *Int J Drug Policy* 2018; **57**: 86–94.
4. Jikomes N., Zoorob M. The cannabinoid content of legal cannabis in Washington state varies systematically across testing facilities and popular consumer products. *Sci Rep* 2018; **8**: 4519.
5. Mudge E. M., Murch S. J., Brown P. N. Chemometric analysis of cannabinoids: chemotaxonomy and domestication syndrome. *Sci Rep* 2018; **8**: 13090.
6. Leos-Toro C., Fong G. T., Meyer S. B., Hammond D. Cannabis labelling and consumer understanding of THC levels and serving sizes. *Drug Alcohol Depend* 2020; https://doi.org/10.1016/j.drugalcdep.2020.107843.

MOVING FORWARDS WITH THE STANDARD THC UNIT

There is international support for a standard tetrahydrocannabinol (THC) unit, which could improve the precision with which we understand, regulate and communicate dose-related risks and benefits to consumers. Implementing the standard THC unit in legal recreational cannabis markets would represent an important step forward.

We appreciate the commentaries [1–4] which support our proposal for a standard THC unit [5] and raise insightful points for progressing with this initiative.

Chester *et al.* [1] outline the importance of experimental cannabinoid studies for informing the standard tetrahydrocannabinol (THC) unit. Our proposal for a 5-mg THC unit was informed by experimental studies showing that this low dose produces intoxication in infrequent users with minimal risk of adverse acute effects [5]. Moving forward, experimental cannabinoid studies can quantify dose–response effects of THC unit consumption on acute harms and benefits, such as driving performance [6]. Experimental studies should include a wide range of THC unit doses to capture real-world consumption and contrasting directions of effect at low and high doses [2].

Volkow & Weiss [3] and the NIDA Cannabis Policy Research Workgroup [7] highlight the value of a standard THC unit for advancing the understanding of the long-term effects of cannabis use. Large-scale longitudinal cohort studies (e.g. the Adolescent Brain Cognitive Development study) are now enhancing time-line follow-back methods using pictorial assessment of cannabis type and quantity [8]. Where available, legal cannabis products with known standard THC unit content could increase precision when estimating the long-term effects of cannabis use on brain, cognitive and mental health outcomes throughout the life-span.

Filbey [2] and Volkow & Weiss [3] suggest that standard units of dose could also be applied to medicinal use of cannabis and cannabinoids. We agree that this could be helpful for informing patients and clinicians if supported by robust scientific evidence. As the safety and efficacy of