



Published in final edited form as:

Addiction. 2017 December ; 112(12): 2180–2181. doi:10.1111/add.14051.

RESPONSE TO COMMENTARIES: NEW DATA SOURCES FOR UNDERSTANDING CANNABIS MARKETS

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Changes in cannabis policy have produced a legal cannabis market that differs greatly from its illicit predecessor. They have also produced new data sources with strengths complementary to those used traditionally to study cannabis use and markets.

We thank Carlini [1] and Williams *et al.* [2] for their comments. We agree with all of them.

Carlini [1] observes that the changes we document are just one dimension of a suite of innovations in cannabis industry practice. One myth of legalization is that things would remain more or less as before, but without the arrests. Instead, using language from the industrial organization literature, the ‘structure, conduct and performance’ of an industry is shaped by its environment. When that environment was prohibition for cannabis, a key objective was avoiding detection. Post-legalization, a key objective is product differentiation.

Carlini [1] notes that marijuana has become a ‘profitable commodity’. That is true in the lay sense of the term. Economists have a technical definition of ‘commodity’ that is also relevant: a good or service that is effectively interchangeable, regardless of who produces it. Producers of commodities must compete on price, potentially driving prices down to the marginal cost of production. Firms seek to avoid that by making their product look different to their competitors’ offerings. Advertising plays a key role in this process, and a developing literature is beginning to examine the role of marketing and advertisements in the legal cannabis industry [3–5]. We reported on two other salient aspects of product differentiation: a race to sell higher-potency flower and expanding the product mix to include extract-based products.

Our paper advertises the potential utility of a novel data source, and Williams *et al.* [2] rightly observe that the data have limitations and should be improved. This relates to a recurring theme in the age of big data analytics [6]. Compared to large administrative data sets, ‘traditional’ data collected by scientists for research purposes tend to be ‘cleaner’, have greater construct validity and offer greater comparability across jurisdictions and over time; surveys of users are a paradigmatic example. The new data afforded by the information

Declaration of interests
None.

revolution have complementary strengths and weaknesses. Administrative data are often richer, in this case capturing the universe of all legal activity, but must be learned and cleaned for research purposes beyond their initial design. Both sources provide useful insights about cannabis markets, and we suspect that a law of diminishing returns may apply to the milking of any particular data source.

We predict that within 10 years a third type of data will prove useful: firms' loyalty or 'frequent buyer' programs (akin to airlines' frequent flyer programs) [7,8]. Neither traditional surveys nor current seed-to-sale databases are strong at understanding market segmentation, trajectories of purchasing or individual-level responses to changes in price, marketing or availability. Eventually, researchers might embed within firms to mine data on their A/B testing and leverage experimental designs to understand how a product's price, advertised potency, position on the firm's web page, etc. affect sales—not just in aggregate but by individual and market segment. Yet another promising data source may come from 'smart' vaporizer pens that meter and track doses and are being prototyped by several companies. The data they collect could help researchers understand more clearly the consumption patterns and potential health consequences of cannabinoids.

We are still in the opening stages of legalization and the opening stages of determining how to exploit the new types of data that legalization creates.

Acknowledgments

This research was supported by the National Institute on Drug Abuse (R01DA039293).

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